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FOOD PACKAGING DESIGN AND ITS APPLICATION IN THE BRAND MARKETING

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ABSTRACT

In the fierce market competition, only emphasized on the brand in strategy can company survive in globalization competition. As long as the company creates the persistent advantaged brand can it be in an invulnerable position. Brand strategy is the base of the company to success, but as the carrier of brand marketing, package always influence the development of brand. Based on the brand marketing, the study made analysis of the package design and came up with new direction of package design on the base of chromatics, psychology and aesthetics to emphasize on the importance of brand in the package promote the development of the brand and make the package to be better recognized. Based on the effect of package design on brand marketing, the study discussed the influence of brand marketing from different visual elements. Firstly, the study set the impact of food package design on the brand marketing, and further expounded the brand influencing factors from elements of visual communication, such as patterning, color, format, font, material and sculpt, etc. in the form of analysis and case. Secondly, the study demonstrated the package design had an effect on brand marketing in positive thinking by analyzing the different influences of package design elements to make package be more suitable for the brand positioning and requirements. At last, the study took Huapeng walnuts mill as the example and put forward the package design development prospect under the marketing influence.

1. Introduction

Nowadays, product package plays a more and more important role in the fierce market competition (Zhang, 2009). Feng HM (Feng, 2013) thought that both conceptual package and physical package of the product had a great impact on product sale and customers bought the value behind of the brand most often. Articles for everyday use, such as mobile phone, car, housing, food, drink, health care products and medical supplies, etc. are the products that customer bought for their brand value. For instance, Apple makes a new explanation of the mobile phone; it is not owe to processor screen and integrated circuit, but the new experiences given by Apple. Product package is regarded as the premise of the brand sale and also influence the results of sale (Bjelland et al., 2012). In Chinese market, quality brand products have higher premium capacity than general products. However, Sohl T et al (Sohl and Saueressig, 2009). thought that Chinese entrepreneurs highly approved the importance of brand and spared no effort to build brand, but many of them felt ability not equal to their ambition; but companies faced with a lot of strong brands in the country and

famous brands in the abroad, and suffered the huge capital pressure of promotion and the confine of brand building mistakes, which resulted in the unhealthy growth even malformed development of enterprise brand.

Brück S (Brück, 2005) pointed out that the main reason why China lacked high value-added quality brands was that most Chinese entrepreneurs knew little about the brand building and had too much misunderstanding about it. With the development of the economy, people can choose more and more commodities, and the commodity market has changed seller's market to buyer's market. Marketing concept has replaced the traditional sales concept, which transforms the product sale from product-centered to customer – centered. Therefore, marketing in today is brand-based marketing. In the event that there is only little relative information, food package design has the most direct relationship with customers. Since the 21 century, the form of market competition in China and abroad has changed and gradually developed on the direction of brand competition (Hunter and Li, 2007). Brand reflects the creativity of the company and represents market share of the brand. Only under the market controlled by brand loyalty can the enterprise get good economic benefits and occupy the large market space. Therefore, the company should adapt to the development requirements in the age of brand competition, develop the brand marketing constantly, build autonomous brands and improve the market core competitiveness (Simmons et al., 2010). Compared with China, foreign countries research the food package much earlier and have richer research results. American package association regards package as the preparation of product carting and sale; British standard institution defines the package as art for products transportation and sale, which is a preparatory work in science and technology; Canada defines the package as the instrument that keeps the product be in well condition when supplier passes the product to the customer (Huang and Mak, 2000). Al l these statements regard the package as a behavior or an instrument. Based on the above-mentioned conditions, the study expounded the package design from the brand marketing and promoted the brand by product package to boost consumption.

2. Materials and methods

Relevance research of food packaging design and brand marketing

2.1. The effects of food package design on brand marketing

(1) Package inherits brand culture.

An excellent package not only depends on the form of package, but also lies in brand culture and connotation reflects from the package design. Take Wahaha couples nutrition express as an example, its bottle style, package and heart put on the shelf all show the appeal point of the lover. Successful package design embodies cultural characteristics that the product itself contains to attract customers and make them familiar with even loyal to the brand.

(2) Package itself has ability to promote sale

Package is the base for the product to enter the circulate consumption region. With the abundance of materials and diversification of goods, people discovered the beauty and sales promotion effects of package. Chinese idiom show lack of judgment explains the effect of package sale promotion has been used in ancient time from another aspect. Successful

package can attract the customers in a minute. Combined with advertisements and public relation, the package promotes the customer cognition and motivates customers' purchasing behavior

(3) Package improves the brand value

Package not only advertises the enterprise culture, but also improves the brand value. The grade, quality and individuality of the product package will influence customers' the whole feelings about the product, which promotes the value of culture brand. For example, bottle style of the Chanel number 5 perfume combines the line of water flow and physical beauty. It further emphasizes on aesthetic perception of fluid form, highlight the fashion and taste of perfume package to promote the brand value.

2.2. The effects of food package design on brand marketing

(1) The effects of package patterning on product marketing. Patterning is the most suitable carrier for commodity to convey the information, which sends the message by its super convey capacity and attract customers to buy the product (Cao, 2009). The greatest function of patterning is to distinguish the different brands, for instance, even customer who can't read the word can he know the commodity through the concrete imagine on package. It could be better if the designer makes the patterning close to the real product. Customers will combine imagine and content, eventually purchase the products. Design of the teeth in Figure 1 not only conform to the curiosity psychological feature in child age, but also fill with interests and spirit of adventure.

Figure 1. Package of different fruity drinks

(2) The effect of color in package on product marketing. Color is the first factor that can influence the customer (Rosa, 2001). Sowden P, et al. (Sowden et al., 2005) studied that vision received most information when people accepted the messages from the outside. Color vision is the first impression given by package in front of the attention, association and imagination. In general, drug package chooses cool tone to symbolize the technology, such as blue, green, etc. However, food package chooses the color which has high lightness and purity, such as red and yellow, because these bright colors increase people's appetite.

(3) The effects of words in package on product marketing. As the most important visual communication element after the patterning and color, words in package explain the package brand, trademark, essential nutrient and other supporting contents. Some package will arrange, transform or create the words directly. Just as Figure 2 and Figure 3, the designer sets English letters as the vision center, designs the letter color and location and illustrates the semantic meaning by letters on the whole.

Figure 2. Water package design

Figure 3. Series package design

(4) The effects of package arrangement on product marketing. Format design is a constituent part of package graphic design. A good format catches customers' eyes in a minute and attracted them to buy the products. Customer may don't know the good of form, but he will feel comfortable and then purchase the product (Staniewska et al., 2008). Arrangement should follow consumer psychology and visual process. Figure 4 utilizes actual and visual, degree of tightness to reflect the theme and form rhythm and metre in harmony. In Figure 5, the designer positions the fruit in different ways. Therefore, the format has strong visual impact and the product is eye-catching on the goods shelf.

Figure 4.Package design of personality drink

Figure 5. Package design of different tastes juice

(5) The effects of package modeling on product marketing. Packaging modeling design is a three-dimensional contouring activity formed by industrialized technology processing and manufacturing, and the technical factor is extremely important (Shike, 2010). Package modeling design is closely related with material selection, manufacturing technique, etc. The two points that should be paid attention to in packaging modeling design are as follows.

① The contrast and coordination of the volume, for example, the beverage package of different standards

② The contrast and coordination of the package shape, for example, the design of ham modeling on Figure 6 is based on the Earth. Graticules on the figure can be found clearly,

which reflects that people can enjoy the world cate at home.

Figure 6. Bomb type ham package

(6) The effects of packing materials on product marketing. Different visual materials present the different visual effects. Soft fabrics like silk, etc. show the morbidezza of women, hard textures like metal, etc. reflects the fortitude of men, and nano packaging materials reflect the feeling of freshness and tidiness of products because the material can keep the shelf life of food (Calin, 2014). It's cultured to apply the material. Only choose the suitable material can the designer design the package conforming to the product features and increase purchasing desire. Material selection should consider the product characteristic and appeals of aimed consumer group. Certainly, as a responsible designer, it's necessary to consider how to make package beautiful by using materials and environmental protection at the same time.

2.3. Accurate visual design of food package

2.3.1. Vivid patterning design

(1)Representational patterning: representational graphic can associate figurative picture on the package with the real goods, which contributes to stimulate people's appetite in vision. For instance, coffee package chooses realist style of photography, which shows food texture and people's positive life attitude after the suffering.

Figure 7. Packaging bag design of the coffee

(2) Abstract patterning: in general, abstract method uses point-line-surface, color or irregular figures to design the package and shows the characteristics of the goods by description. For example, advertisement of Dove chocolate uses the feeling of silk scarf on the shoulder to describe the smooth taste of chocolate.

(3) Symbolic patterning: symbol means substituting one expression with another, which transforms the difficult object to the visual and intelligible patterning. For instance, the dove represents peace and the Five-Starred Red Flag repents China.

(4) Metaphor patterning: it means using appearance and connotative meaning to express another object, and reveal its inner essence. Metaphor has been applied to many mascots, and people can better connect the mascot with brand.

(5) Decoration patterning: there are a lot of decoration meanings in food package. Just as the scenic picture painted on wine bottle in western countries, it is the description of the original scenery and shows brand culture and connotation to customers.

2.3.2. Concise character design

The following four points should be noticed on the application of package design.

(1) Word characteristics and emotion property: in fact, Chinese character itself is the graph, and different font has its own vision individuality. During the font design, it is necessary to concern about the identifiability of font and try to manifest the brand characteristic and style by different font. Doll font can be used as vision center on child food.

(2) Brand image words: it is the center of the vision and the emphasis of the design. The designer should pay attention to the connection of the each word and make the word as vivid as possible to increase the interestingness and infection.

(3) Function description words. Declarative words mainly explain the detailed information of the product, which should be arranged regularly, readable, and font color should separate from the ground color. Pay attention to the harmony of the entire arrangement, the typical functional words is shown in Figure 8.

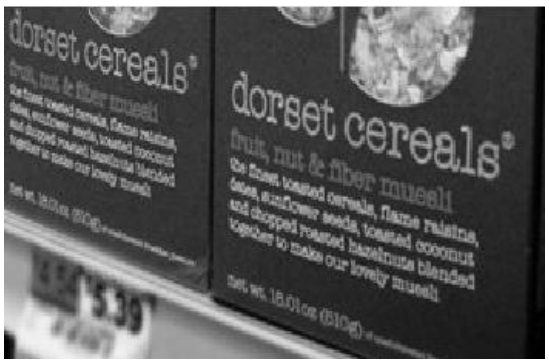

Figure 8. Functional words

(4) Advertising words. Advertising words is also called slogan, which is quite vivid. The main purpose of the advertisement is to enhance the brand identity and make people memorize the brand easily. The font design should also be flexible. Drink more six walnuts while learning and Sprite cool down to your heart all these words are popular words.

2.3.3. Attractive color design

Color has a strong implication and industry attribution function. Blue is the color of technology, red represents celebration and enthusiasm. Different color applies to different industry. The usage of package color should achieve the unity of function and form, which can tactfully, reflects the commodity contents and sale purpose. What's more, it is also necessary to consider the package identifiability, imagine color, symbol color, perception, integrity and commodity. As for the package color, there are several enactments: set the tone; color area; the application of accent color; the application of gradient color; the application of contrasting colors; the application of signal coloration; and the application of inverted-color.

2.3.4. Sense of the times

Constitution form of package format design and layout design of food package adopt the rule of beauty in form, which combines the figure, words and color together to serve the brand better and lead customer to analyze the picture information. In this way, the customer will be more loyal to the brand and promote the purchasing behavior (Debono et al., 2003). Layout design of package should comply with following three principles: ① Format should reflect industry attribute; ② Arrangement should emphasize on the age positioning of target customer. ③ Pay attention to the application of the rule of beauty in form.

2.4. Texture design showing visual impression

(1) Natural packing material: in general, natural packing material can be divided into varieties of kinds, such as original ecology materials like bamboo and wood, processed materials made from pure natural plants like stem, leaf, fiber, animal fur and leather, and practical reproducible nature materials. Reproducible nature materials have abundant sources (Shi et al., 2013), and zongzi in Figure 9 is packaged by bamboo leaves.

Figure 9. External packing of zongzi

Figure 10. External packing of fast food

(2) Edible packing material. Edible packing material refers that the material can be eaten and do no harm to health. Starch, protein and plant fiber, etc are the main composition ingredients of edible materials. As for individual package food, inner package of pastry and preserved fruit can be eaten. On the other hand, edible packing materials can make disposable beverage boxes or fast food containers to store the food conveniently. External packing of fast food is shown in Figure 10.

3. Results and discussions

The development of package design under brand marketing – take Huapeng walnuts mill brand as an example

Huapeng ground walnut cream experiences a long and scientific period from investigation to brand name, brand positioning and brand package. In order to make products be eye-catching and promote the sale, the whole package design group does a lot of preparations in the early stage.

3.1. Vegetable protein drink industry insight

Analyzing the vegetable protein beverage industry, we can find six characteristics as follows. The whole plate is small, but single category brand is highly centralized; daily consumption is less and consumption is relatively simple; market is relatively stable and walnut stands a prominent position; cognition degree of the category positioning decides its three dimensionalities: depth (level of complexity of cognition), universality (cognition acceptable range), positivity (positive and negative cognition) (Figure 3.1); melamine event of Three Deer in 2008 leads customers turn to vegetable protein consumption; only little products have specific selling point, and most products have no selling point.

Table 1. The cognition of category positioning

Savour	Positioning	Depth	Universality	Positivity
Herbal tea	Afraid to get inflamed	Traditional history of Chinese medicine	The whole nation	High
Ground walnut cream	Fill head	Traditional history	The whole nation	High
Peanut Milk	Maintain beauty and keep young	Traditional + newly developing	The whole nation	Relatively high
orange juice	Supply vitamin C	Modern concept	Young people	Relatively high
Almond milk	Maintain beauty and keep young	Traditional history	Southern / female	Relatively low
coconut juice	Maintain beauty	Modern concept	Southern / female	Low

3.2. The brand of ground walnut cream and its brand positioning

Brand strategy of the ground walnut cream should support the long-term development of Huapeng and lead the company to develop with the step of "products - reputation products – products fame". The ground walnut cream will be made as leading product of Huapeng. Therefore, the ground walnut cream should choose the mainstream price to build product or brand reputation, and further improve the corporate reputation to establish its own agencies and marketing channels. Huapeng should make tiny-innovation in ground walnut cream, supply high value-added and follow the path of differentiation category. The ground walnut cream possesses the attributive characters of vegetable protein drink. As shown in Figure 11, vegetable protein drink pass the characteristics of delicious, nutritional, light functional and gift present to the subcategory.

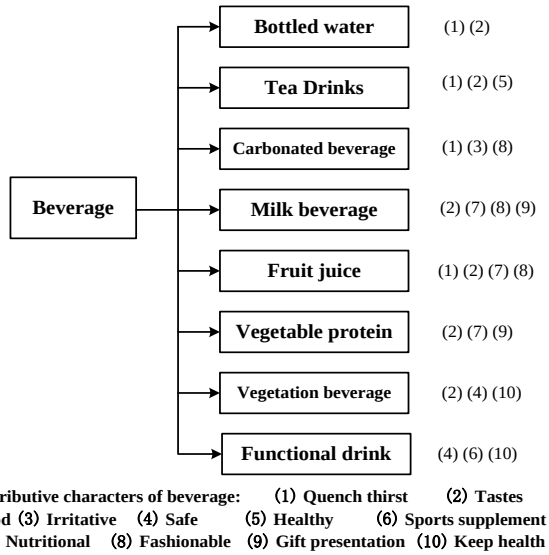

Figure 11. Beverage attributive characters

From the survey of benefits of drinking ground walnut cream shown in Figure 3.2, it can be founded that the rate related to brain fitness close to 70%. Therefore, brain fitness is

the essential attribute of the ground walnut cream category and the reason for customers to buy category rather than the brand. The function of brain fitness comes from certain nutritional ingredient.

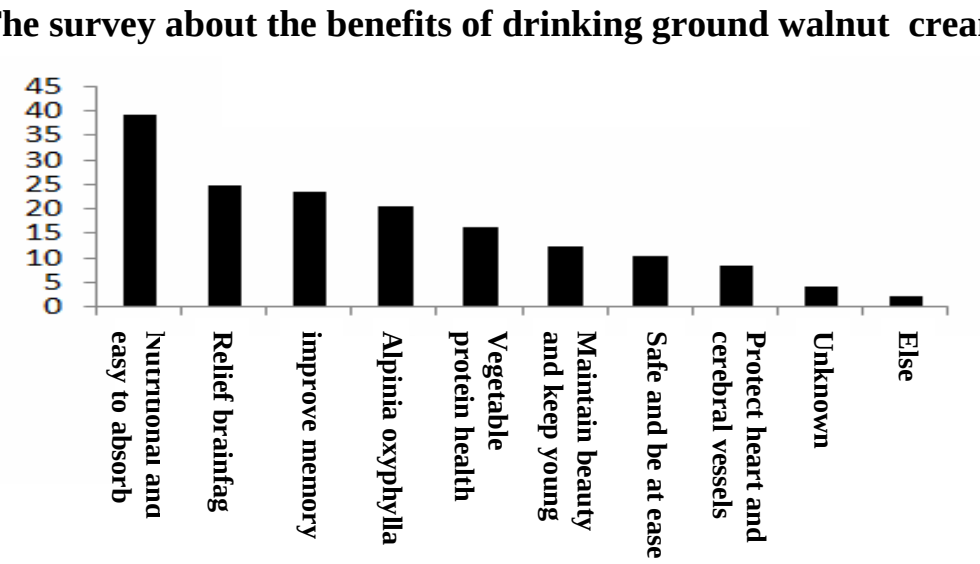

Figure 12. The survey of appeal point

Absorption degree is an important characteristic of nutrition. The function of brain fitness of ground walnut cream not only depends on nut contain but also the degree that nutritional ingredient being absorbed. Well absorption is a joint concept, losing bright spot and monopolization. People usually express the degree in three directions: height, thickness and deepness. Deep absorption is the core value that brand given to the customers. At the same time, for nutrition digestion, the design group decides to utilize fine to present deep and builds the new brand name called walnuts mill on the base of fine - finely grounded. The brand positioning of walnuts mill is shown on Figure 3.3.

Figure 13. The brand positioning of walnuts mill

3.3. Ground walnut cream package strategy and its application

After finishing the brand name and slogan, it is necessary to design the product from all around and make distinguish from packages of other brands to project its own charm. Main products packages in the market are shown as follows. In order to make Huapeng ground walnut cream different from the others, we should distinguish it from these given products to stand out the product features and appeals. After analyzing the package of Lulu almond

milk, six nuts and Dazhai ground walnut cream, package design group plans the Huapeng ground walnut cream.

1) It should get rid of blue color, which has been used in Lulu and six nuts.

2) The whole color should be unified and package of boxes and bottles should unify the theme.

3) The whole layout should be noble, and it cannot put too many auxiliary images and words to interfere the visual communication.

4) It should reflect main appeal points of the product to highlight the brand name walnuts mill, brand positioning first fine grinding mill, brand concept fine grinding of walnuts, core value deep absorption, slogan fine grind pureed and deep absorption, special odor type baked order and technology support three baked, three grinding and three steamed.

Based on the analysis, the final draft is shown in Figure 3.4. The picture adopts virtual and reality co-design, has both true-life nut image and shape of the nut on the sign. The center part utilizes the color similar to nut, which well reflects the brand positioning. Auxiliary words are arranged clearly and simply, which also reflects the theme. The whole package is clearly in color and be so attractive, which has accurate visual communication and stands out well in the same category products.

Figure 14. New product package

4. Conclusions

In modern society, the enterprise should forge a product that package can well unified with object material. Only stands out the selling points and builds brand by concept can good package catch customers' eyes. Later, the enterprise should make innovation on product appearance and color and pat attention to customers' mentality appeal. In this way, the enterprise will create new package culture to enhance enterprise connotation, brand culture and brand recognition. Package will be the direct bridge between brand and customers. Based on brand marketing, the study makes analysis of package design and puts forward new direction under chromatics, psychology and aesthetics to further emphasize on the importance of package for brand, which may promote the brand to develop better and be identified easily.

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Exploration of the Establishing of Practical Teaching Mode of the Applied Talents' Training Objective in Independent Colleges-Taking Food Science and Engineering Major for Example

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SUPPLY CHAIN RISK EVALUATION OF HOTEL AND CATERING INDUSTRY AND MODEL CONSTRUCTION OF INFORMATIZATION MANAGEMENT SYSTEM

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ABSTRACT
The accuracy of supply chain risk assessment is the decisive factor of risk management, as well as the precondition of risk prevention and control. This paper takes the hotel supply chain as the object of study, firstly, the characteristics of hotel supply chain are analyzed and structural model of hotel supply chain is constructed. Then, upstream and downstream node enterprises and their characteristics are expounded. Secondly, combined with principle of risk identification, risk factors of hotel supply chain are identified and cause of risk factors is analyzed from the five aspects of environmental risk, management risk, cooperation risk, information risk and enterprise self-dominated risk. Thus, risk evaluation index system of hotel supply chain is established. Thirdly, by applying AHP (analytic hierarchy process), the weight of risk indicators is determined and risk assessment model of hotel supply chain is established based on the fuzzy-grey comprehensive risk evaluation method. Finally, this paper selects X hotel to make an empirical analysis. According to the indicator system and evaluation model established, risk assessment of supply chain of X hotel is carried out. Thus the risk level is obtained and reasonable feasibility of the model is verified, also, corresponding strategy and advice is put forward.

1. Introduction

While hotels are applying supply chain management to improve enterprise benefits, more attention should be paid to the assessment of risk level of enterprise themselves, particularly, on how to further recognize the risk during the supply chain operation process (Ergün and Murat, 2012; Kamel et al., 2010). It will have important theoretical and practical significance on hotel supply chain management by carrying out risk assessment on hotel supply chain (Jyri et al., 2012; Kumar et al., 2013). Theoretically, study on hotel supply chain risk has an important meaning on further enriching of theory of supply chain risk management. Looking back on the previous studies, there are few contents on hotel supply chain risk management and there is no scientific system established. Therefore, an in-depth exploration on the risk factor and risk level of hotel supply chain has a positive role in enhancing the study on hotel supply chain management and expanding hotel management theory. From the practice, study on the risk management of hotel supply chain can better improve the whole supply chain benefits, meanwhile, it is conducive to promoting the development of the hotel and enhancing the core competitiveness of the industry (Ila Manuj et al., 2014).

As a variety of high technologies are applied in food catering industry (Shuying, 2014), standing on an overall and global perspective, this paper analyzes the operation pattern of hotel supply chain as well as the upstream and downstream enterprises. Based on the in-depth analysis of the structure and characteristics of hotel supply chain, each risk factor is identified. And risk level assessment is carried out based on the combination of existing methods and theories.

2. Materials and methods

2.1. Theory of supply chain risk management

Early views on supply chain is that it is a process of delivery of materials and parts purchased by suppliers from the retailer to the end user, after sales and other activities through the enterprise production and processing. Therefore, supply chain is only seen as the internal process within manufacturing enterprise. Its purpose is to optimize the enterprise internal resources and focus on their own interests. Since supply chain risk is a special case in supply chain field, related research institutions and scholars haven't formed united knowledge on the definition of supply chain risk. Supply chain risk refers to one or more of the supply chain members impact or destroy the supply chain operation, which results in failure of expected targets, or even uncertain factors and accidents that can lead to supply chain failure (Iris et al., 2015). Detailed risk category mainly concentrated in the demand risk, management risk, technology risk, information risk, supply risk, etc. in a hotel supply chain, demands of consumers are satisfied through the analysis of final consumer demand characteristics and reasonable circulation of material flow, service flow, information flow, cash flow, etc. Finally, a win-win situation of enterprises and benefit goals of the entire supply chain can be realized based on the minimum operating cost and efficient operation of the supply chain. The characteristics of the supply chain risk are shown in figure 1.

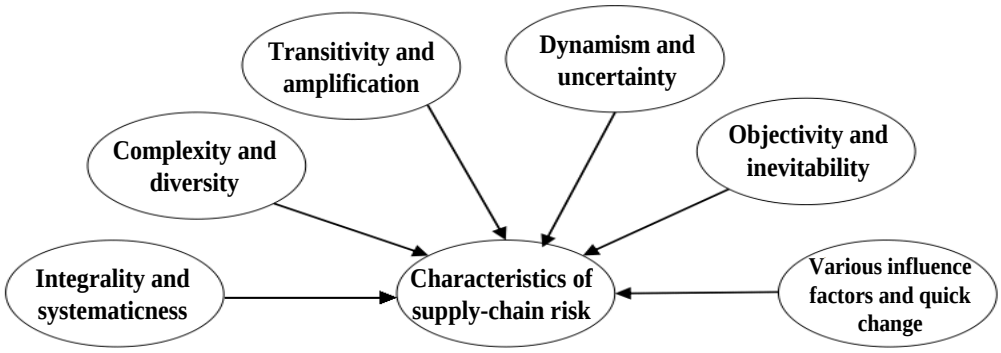

Figure 1. Characteristics of supply-chain risk

2.2. Risk identification of hotel supply chain

Hotel supply chain is a complex and systematic integration of functional organization structure. Not all the relationship between node enterprises on the supply chain are maintained and restricted through signed contractual agreement, but as the member enterprises on the supply chain, they are dependent on each other (Tanvi et al., 2004). However, since it is quite late for the hotel industry to apply supply chain management, it is in a relatively backward status of the supply chain management development. Thus the resistance ability is relatively poor against the impact of internal and external environment of supply chain. Each node enterprise on the supply chain are facing with the common risk,

which is different from the risk which is faced merely be single enterprise.

Natural disaster risk in the supply chain refers to unpredictable risk caused by natural disaster and environmental disaster which can have a serious effect once occurred. This risk is mainly caused by irresistible disasters such as flood disaster, fire disaster, earthquake, etc, which once occurred, are irresistible, and is also called uncontrollable risk. Sociopolitical risk mainly refers to corporate profit loss and target deviation caused by the impediment of enterprise management due to political instability or social changes. Policy and law risk refers to the possibility of changes on enterprise benefits due to the changes of related policies and laws. Market demand risk refers to the risk which influences the supply chain operation due to the error prediction on consumer market preference by node enterprises, facing a great challenge in the more and more competitive environment. An economic crisis is bound to cause the deceleration of entire social and economic development, lower incomes of residents, along with lower consumption level, which will influence the demand level of the hotel industry and thus result in the decrease of passenger flow.

All members on the supply chain need sufficient information to determine the direction of their next actions. With inadequate information sharing level, timely delivery will be influenced because the suppliers cannot get prompt hotel demand information. As well, the hotel cannot provide satisfied commodity to consumers if they cannot know the preference of distributors or consumers. The hotel should pay more attention to purchasing link in supply chain management, which is the weakest link and the most important link in its cooperation with suppliers. There are three risks including purchase price risk, purchase quality risk and purchasing staff risk. The fundamental supply chain competition is the competition of management level of supply chain and ability of resource acquisition and integration. In this competition, the part with competitive advantage is bound to be a threat to the part with disadvantage, thus competition risk is formed on the supply chain.

3. Results and discussions

3.1. Hotel supply chain risk assessment index system and construction of evaluation model

Risk assessment of hotel supply chain is aimed at evaluating the risks of different levels and questions on the chain. Thus, a reasonable evaluation system of supply chain must be established, to reach a comprehensive reflection of hierarchical structure and main characteristics of the assessment objectives.

3.2. The establishment of Hotel supply chain risk index system

3.2.1 The determination of risk factors

This paper applies the method of event expected value to measure the risk factors in order to reach the goal of determination of risk factors. Among which, event expected value = event probability × event consequence. Set the marking interval of risk probability as 1-x, marking interval of risk consequence as 1-y, assume there are a managers (marked as h=1, 2, 3… a), risk occurrence probability and risk consequence are denoted as P_{abc} and Q_{abc} respectively. Then through weighted average method, average score is obtained as P_{ab} and Q_{ab}, among which, $P_{ab}=\frac{\sum_{c=1}^{i}P_{abc}}{i}$, $Q_{ab}=\frac{\sum_{c=1}^{i}Q_{abc}}{i}$.Then, event expected value of occurrence of each risk can be obtained through multiplying the two values as below:

$$R_{ab}=P_{ab}\times Q_{\mathrm{ab}}=\frac{\sum_{c=1}^{i}P_{abc}}{i}\times\frac{\sum_{c=1}^{i}Q_{abc}}{i}$$

Among which, hierarchy differential method is shown in table 1.

Table 1. Hierarchy differentiation of event occurrence probability and event consequence

event	grade	Definition
event occurrence probability	Grade 1	The event can happen in rare cases, and it cannot happen in most cases
	Grade 2	The event can rarely happen, and can only happen 1-2 times in work
	Grade 3	The event can happen accidentally and can happen in work
	Grade 4	The event can often happen and can happen in work regularly
	Grade 5	The event is most likely to happen, which people has get accustomed to
event consequence	Grade 1	Can be ignored, with insignificant effect
	Grade 2	Slight effect, a small part of the supply chain is affected
	Grade 3	Medium effect, part function of the supply chain is affected but the chain can still operate
	Grade 4	Strong effect, key link in the supply chain is interrupted, which seriously affect operation
	Grade 5	Major disaster, the supply chain cannot operate, completely interrupted

3.2.2. ALARP (As low as reasonable possible) principle

When making risk decisions, one of the most common principles is the ALARP risk management and decision criteria (Paul Baybutt, 2014). ALARP principle divides risk occurrence areas into three kinds, which are widely acceptable area, reasonable and most inefficient area and unacceptable area, through the division of the two levels, as shown in figure 2. Put the event expected value, i.e. the measured value of the individual risk factors R_{ab} into the risk level areas above, based on the areas divided by ALARP principle, the risk level interval can be determined. Assume that the interval range $[1, h_1]$ is a widely acceptable area, $[h_1+1, h_2]$ is a reasonable and most inefficient area, $[h_2+1, h_3]$ is an unacceptable area, among which, $h_1 < h_2 < h_3 = x \times y$. Delete the indicators in the widely acceptable area and remain the ones in the reasonable and most inefficient area, pay attention to the risk factors in the unacceptable area, and finally determine the risk assessment index system which is suitable for hotel supply chain.

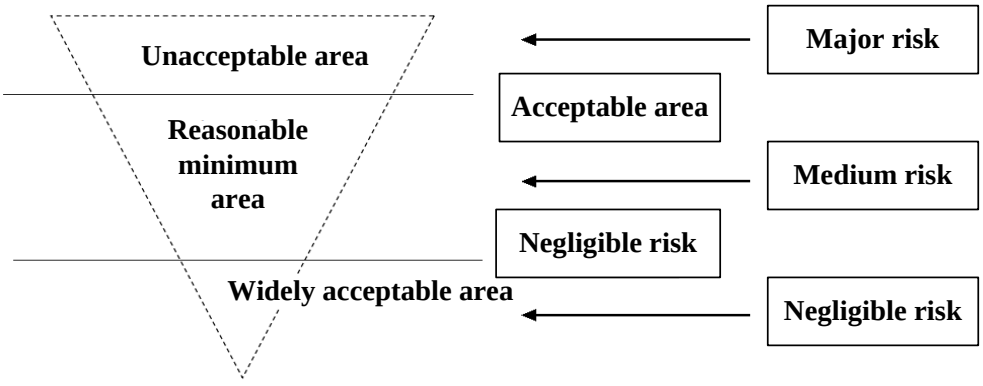

Figure 2. Risk level and ALARP principle

3.3. Construction of risk assessment model of hotel supply chain

This paper applies the AHP method and fuzzy-grey comprehensive risk evaluation method to carry out the risk assessment on hotel supply chain (Anna et al., 2014; Wilco et al., 2013; Crystal et al., 2012; KunLi, 2007). Firstly, according to the principle of AHP, calculate the weight of risk indicators of hotel supply chain by using Yaahp software. Then, risk assessment can be carried out based on the fuzzy-grey comprehensive risk evaluation method (Xiaoxing, 2015).

(1) Establish Evaluate Factors and Evaluation Set of Risks. The evaluate factors refers to the collection of risk factors, which have certain effect on the normal operation of the supply chain, and is the hierarchical structure model obtained after the summary of the risk factors. Take the overall risk level of the supply chain as the evaluation objective, denoted by F. According to the risk assessment indicator system, the evaluation factors can be divided into two levels. The first level is composed of n kind of factors, denoted by $F=\{F_1,F_2,F_3,F_4,.....,F_n\}$, assume there are m sub-factors in F_i, and the factor set of the second level is denoted by $F_i=\{F_{i1},F_{i2},F_{i3},F_{i4},.....,F_{im}\}$, among which, $F_{ij}(i=1,2,3,.....,n;\ j=1,2,3,.....,m)$ represents the sub-factor under the second level of the j kind of the first level risk factor of the I kind. Since the numbers of the second level under each first level risk factor is different, individual i correspond to individual m. Risk assessment set is composed by the evaluation results of different evaluation index factors by experts. Assume that it is composed of t kind of decisions, denoted by $V=\{V_1,V_2,V_3,.....,V_t\}$, according to the influence of risk factors on hotel supply chain and the actual situation of the supply chain, divide the risk assessment set into five levels, i.e. t=5. That is,

$$V=\{V_1,V_2,V_3,V_4,V_5\}=\{\text{ high risk, higher risk, general risk, lower risk, low risk }\}$$

, respectively give the value of 5, 4, 3, 2, 1, and the score of the two neighboring index levels is 4.5, 3.5, 2.5 and 1.5.

(2) Hotel supply chain risk assessment model Based on the grey fuzzy comprehensive evaluation method. Supply chain risk assessment refers to the risk assessment made on the supply chain by applying qualitative or quantitative evaluation method based on risks which have been identified. When making risk assessment on the supply chain, individual risk level of each risk factor should be calculated firstly and then the overall risk level can be calculated.

According to the above risk evaluation set, combined with the actual situation of the hotel, the risk level of the hotel supply chain can be divided into five categories as

$$V=\{V_1,V_2,V_3,V_4,V_5\}=\{\text{ high risk, higher risk, general risk, lower risk, low risk }\}$$

, respectively give the value of 5, 4, 3, 2, 1, and the score of the two neighboring index levels is 4.5, 3.5, 2.5 and 1.5. Invite X experts (denoted by k=1, 2, 3, … , X) to score for the risk factors, Assume that Di_{jk} represents the score made on F_{ij} by the kth expert , then the following judgment matrix D can be obtained:

$$D=\begin{bmatrix} D_{111} & D_{121} & ... & D_{211} & ... & D_{ij1} \\ D_{112} & D_{122} & ... & D_{212} & ... & D_{ij2} \\ ... & ... & ... & ... & ... & ... \\ D_{11l} & D_{12l} & ... & D_{21l} & ... & D_{ijl} \end{bmatrix} \quad (1)$$

According to the divided risk assessment set, divide the gray classes into corresponding 5 classes as: high risk, relatively high risk, moderate risk, relatively low risk, and low risk. Assume the grey class number as e=1, 2, 3, 4,

5, $f_e(D_{ijk})$ represents the weight of D_{ijk} which belongs to the e kind of evaluation standard.

According to the principle of grey evaluation [14], after determination of the above 5 classes, take the score of each expert as the grey number, η_{ije} represents the white function of the grey number, i.e. F_{ij} belongs to the gray evaluation coefficient of the eth evaluation grey class, computation formula is as follows:

$$\eta_{ije} = \sum_{k=1}^{l} f_e(D_{ijk}) \tag{2}$$

While F_{ij} belongs to the total grey evaluation coefficient, denoted by η_{ije}, the formula is as below:

$$\eta_{ij} = \sum_{e=1}^{5} \eta_{ije} \tag{3}$$

Evaluation factor F_{ij} belongs to the weight of the grey class e, denoted by S_{ije}, the formula is as below:

$$S_{ije} = \frac{\eta_{ije}}{\eta_{ij}} \tag{4}$$

Then, the grey evaluation weight vector can be obtained of risk assessment index F_{ij} on 5 grey classes, denoted by $S_{ije} = (S_{ij1}, S_{ij2}, S_{ij3}, S_{ij4}, S_{ij5})$. And the weight matrix of secondary index F_{ij} which belongs to F_{ij} on each evaluation grey class as below:

$$S_i = \begin{bmatrix} S_{i1} \\ S_{i2} \\ \cdots \\ S_{ij} \end{bmatrix} = \begin{bmatrix} S_{i11} & S_{i12} & S_{i13} & S_{i14} & S_{i15} \\ S_{i21} & S_{i22} & S_{i23} & S_{i24} & S_{i25} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ S_{ij1} & Si_{j2} & S_{ij3} & S_{ij4} & S_{ij5} \end{bmatrix} \tag{5}$$

3.4. Empirical analysis

According to the lowest feasible principle, distribute the event expected value of the risk into three intervals. Among them, event expected value of widely acceptable risk is within the range of (0, 5); reasonable acceptable risk is within the range of (6, 19); and that of the unacceptable risk is within the range of (20, 25). We delete the risk indicators which are under the negligible level, i.e. those that are in the widely acceptable area, and make statistical analysis on the risk indicators above the negligible level, and carry out selective analysis on the risk indicators with high score of event expected value. Thus, the supply chain risk evaluation indicator system which is suitable for X hotel is constructed.

Through the in-depth acquaintance of the actual operation situation of X hotel and the analysis of the risk measurement results, this paper draws the following conclusions:

(1)Among the environmental risk factors of the hotel supply chain, the scores of financial crisis risk and fluctuation risk of exchange rate are relatively low. Considering that operation of X hotel rarely involves global trade and most of the purchasing and distribution markets are at home, financial crisis risk and fluctuation risk of exchange rate which have great impact on global trade have little effect on the supply chain of X hotel, thus it is deleted. Finally, it is determined that X hotel is mainly influenced by natural disaster risk, social and political risk, policy and law risk and market demand risk among the environmental risks.

(2)Among the management risk factors, X hotel is mainly influenced by quality risk, communication channels and means, opportunism and lock-in effect of the member enterprises. And the score of quality risk is high, since the consumers have direct contact with the hotel products; any quality problem form any link can cause a series of problems, so the quality problem of hotel products and service should arise attention of the enterprise (Dongwon et al., 2012).

(3)Among the information risks, there are three risk factors scored high which are information sharing risk, information delay and deviation risk and information technology application level risk. For hotels, the level of information sharing, accuracy and timeliness of delivery have an impact on the operation of the upstream and downstream enterprises; hotel product sales can be carried out better based on the update of real-time information.

(4)Among the self-dominated risks of the hotel supply chain, the score of financial risk is low. Considering that there are rare financial risks on present stage of development, it is deleted.

Therefore, among the self-dominated risks, the hotel is mainly affected by competition risk, outsourcing risk, human resource risk and risk of operating decisions. Because the hotel plays a core role on the hotel supply chain, the risk happened in the hotel management can largely affect the operation of the supply chain, which needs more attention of the enterprise. Based on the risk assessment and analysis of the X hotel supply chain, we draw a conclusion that X hotel supply chain is at the general risk level and needs further improvement. Hotel supply chain operations should be fully aware of the risk problem. Therefore, we need to optimize the structure of the supply chain, improve the elasticity of the supply chain, and optimize partner selection of the hotel industry; build a long-term strategic cooperative partnership; strengthen the application of information technology; establish effective information transmission channel; realize information sharing; build the risk early warning mechanism of the hotel supply chain to prevent risks.

4. Conclusions

This paper puts forward the concept of hotel supply chain and its characteristics are analyzed. Also, it builds the structural model of the hotel supply chain and analyzes the composition of upstream and downstream enterprises and the characteristics of supply chain. Through the analysis of model structure and its characteristics, the risk factors and causes of the supply chain are indentified from the angle of risk source. Through the identification of hotel supply chain risks, the supply chain evaluation index system is established. And based on event expected value and ALARP, the hotel supply chain is modified. By applying AHP method, the weight of the evaluation index is determined. Therefore, hotel supply chain risk assessment model is built based on the fuzzy-grey comprehensive risk evaluation method, so as to reduce the occurrence of risks as far as possible.

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ANALYSIS OF FOOD PRODUCTION AND SERVICE SUPERVISION SYSTEM OF QINGDAO HOTEL CATERING ENTERPRISES

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ABSTRACT
Food industrial competitiveness affects economy of districts and even the whole country to a large extent. This study explores problems that occur in the process of food production and service of Qingdao hotel catering industry to find out problems that are most likely to occur. On the basis of researches, a food risk assessment micro model is constructed to prevent occurrence of various problems in food production. Besides, a game theory analysis is made on enterprises, customers and supervision organizations of Qingdao hotel catering enterprises in food market. Interest subjects that are related to service supervision include enterprises (food producers), customers and supervision organizations (government agencies), as well as relevant enterprises or individuals in food circulation link, among which enterprises, customers and supervision organizations are the most representative interest subjects. From the aspect of game theory, the study has game theory analysis on interactive decision behaviors among enterprises, customers and supervision organizations, as well as on the results. At last, some suggestions for improvement of food production and service supervision system of Qingdao hotel catering industry are put forward.

1. Introduction

Qingdao city, a coastal open city, is a famous tourism city that receives over 30 million Chinese and foreign tourists every year. Therefore, catering industry plays an important role in daily life of Qingdao residents and tourists (Shaojun and Wall, 2011). Risk analysis is an internationally accepted food security management concept and method, as well as the basis of food security supervision measure making (Ang et al., 2012; Dunn and Trojan, 2003). Developed countries established food security risk analysis system in succession to improve supervision efficiency in food production, protect customers' health and accelerate international trade of agricultural products and food. Researches of food risk assessment (Organization, 2006; Muri et al., 2009) mainly focus on set of foreign food risk assessment institutions, application of food risk analysis system to food management and studies on food risk assessment system. Food supervision system is focused on introduction of foreign food supervision system and food supervision methods, reasons of problems that occur in food production, law and regulation standards of Chinese supervision and studies on Chinese supervision system (Peng, 2010), and food risk assessment and supervision system are not systematically studied. Considering that developed countries are experienced in food security risk assessment and supervision

system, while Qingdao is deficient in both food supervision system and food security risk assessment, thus this study analyzes the current status and characteristics of food risk assessment system based on problems existing in food production and service supervision system and provides suggestions for optimizing establishment of food security supervision system.

2. Materials and methods

2.1. Problems in food production and service of Qingdao hotel catering enterprises

Most catering industry problems occur in the process of food production and food service, which can be seen in Qingdao city hotel catering industry administrative penalty cases from 2010 to 2014, as shown in table 1:

Table 1. Cases of Qingdao city hotel catering industry administrative penalties from 2010 to 2014

Illegal cases	Number of cases	Constituent ratios
No (valid) hygienic license	12	1.08%
No (valid) health certificate	74	6.65%
Unqualified environmental hygiene processing techniques	432	38.81%
Incomplete product labeling	42	3.77%
Food poisoning	59	5.30%
Unqualified hygienic quality of products	96	8.63%
Defective health facilities	295	26.50%
Workers do not wear work clothes	103	9.25%

Table 1 shows that unqualified environmental hygiene processing techniques takes the biggest proportion, which is 38.81%; and defective health facilities takes the second place, which is 26.50%. In the process of food production, problems will occur in all aspects. For example, the preliminary processing of raw-food materials of Qingdao catering industry is insufficient. Most hotel catering enterprises do not pay enough attention to raw-food materials preliminary processing, especially small and medium size catering enterprises. In rough processing, raw materials like vegetables are only washed once, thus pesticide residue or other dirty things may still left on raw materials. In fine processing, cleaning of cutting boards are often neglected. What's more, food collocations of Qingdao catering enterprises are not reasonable because some kinds of food are not supposed to be mixed for eating, which will result in loss of food nutrients as well as cause food poisoning. Besides, the process of food production exists cross contamination of food, which is mainly because cooked food and raw food are mixed together, for example, using common cooking tools to process raw food and cooked food at the same time.

2.2. Establishment of food risk assessment micro model

Food security risk assessment micro model structure usually consists of hazards identification, hazards characteristics description, exposure assessment and risk characteristics description (Nauta, 2005). Hazards identification is the first step, as well as the basis of hazards characteristics description and exposure assessment. Risk characteristics description is the last step. In assessment layer of risk assessment macroscopic model, food poisoning caused by microorganism contamination is the main influencing factor of Qingdao food security.

The most important content of micro risk assessment system is to establish an assessment

model that aims at a particular hazard (Reij and Schothorst, 2000). In quantitative risk assessment, exponential model and Beta-Poisson model have wide application. Exponential model describes simple dose-response relationship and has wide application in recent years' microorganism risk assessment. Such kind of model can generate S-shaped dose-response curve.

The mathematical formula of such kind of model is as follow: $\Pr(\frac{ill}{d})=1-(1+\frac{d}{\beta})^{-\alpha}$ (1)

In the formula, d is the intake of microorganism; $\Pr(\frac{ill}{d})$ is the probability of having disease caused by microorganism in a certain concentration; α and β parameters have microorganism specificity, both of which have influence on the shape of curve.

The establishment of dose-response relationship between the number of morbigenous microorganism and human body is the key step in microorganism hazards characteristics description. However, the lack of microorganism-related data at present results in difficulty in establishing dose-response relationship.

Exposure assessment is the qualitative assessment or quantitative assessment on morbigenous microorganism exposed in human body through food intake or other relevant probable ways. Whiting and Buchanan (Tressou, 2008; Delhalle et al., 2012) in United States Department of Agriculture divided predictive microbiology model into first, second and third level, as shown in table 2.

Table 2. Classification of predictive microbiology model

First-level model	Linear model, Gompertz model, Logistic model, Baranyi model, Rosso model, Monod model
Second-level mode	Square root model, Arrhenius relationship, Response surface equation
Third-level model	Pathogen Modeling Program (PMP), Microbial Kineties Expert System), Food Micro-model (FM)

2.3. First-level model

1. Gompertz model includes effect of lag phase on microorganism growth. The equation of Gibsin and other Gompertz function growth models is: $N_t=N_0+a_1\times\frac{1}{e^{e^{\frac{1}{a_2}(\tau-\pi)}}}$ (2)

N_t is the Log Koc of bacteria count value after t (log10MPN/g) hours; N_0 is the asymptotic value of bacteria count value at the beginning of time t, i.e., initial bacteria count value (log10MPN/g); a_1 is the asymptotic value of bacteria growth amount when temperature t begins to increase, i.e., Log Koc of growth cycle (log10MPN/g); τ is the time length when growth rate is at absolute maximum; a_2 is the relative maximum of growth rate (log10MPN/g).

Maximum population density (MPD) refers to count result (log10MPN/g) at the end of bacteria growth, MPD= N_0+a_1.

Lag phase duration (LPD) refers to a period of time (hours) before bacteria growth is maintained at a fixed growth rate, LPD= $\tau-\frac{1}{a_2}$.

Logistic model can be represented as: $y=\frac{A}{1+e^{\frac{4\mu m(\lambda-t)}{A}+2}}$ (3)

y is the common Log Koc of relative bacterial count at time t, i.e., $\log \frac{N_t}{N_0}$; A is the relative maximum bacteria concentration, i.e., $\log \frac{N_{\max}}{N_0}$; μm is growth velocity and λ is lag period.

Baranyi model can be represented as:

$$N = N_{\min} + (N_0 - N_{\min}) \times e^{-k_{\max}[t - B(t)]}$$

$$B(t) = \int_0^t \left[\frac{r_n}{r_n} + s_n \right] ds \quad (4)$$

N is number of microorganism at time t; N_0 is number of microorganism at zero hour; $N_{\min}$ is the minimum number of microorganism; $k_{\max}$ is the maximum relative death rate; r and s are parameters. The model only considers one parameter in the growth of bacteria. The first formula describes change of microorganism along with the time and the second formula describes physiology stage of microorganism. On account of characteristics like convenient usage, wide application range and all parameters in the model have physiological significance, Baranyi model is widely applied. Besides, Baranyi model is also widely applied to prediction studies of microorganism in recent years due to its simple and practical usage.

2.4. Second-level model

1. Square root model represents growth velocity of microorganism as temperature. When a_w (water activity), temperature T and pH are substituted into the square root model, the formula can be extended as:

$$\sqrt{k} = b(T - T_{\min}) \sqrt{a_w - a_{w\min}} \times \sqrt{pH - pH_{\min}} \quad (6)$$

k is the maximum growth rate; a_w is water activity; T is temperature; $T_{\min}$ is the temperature when microorganism growth rate is assumed to be zero; $a_{w\min}$ is the water activity when microorganism growth rate is assumed to be zero; $pH_{\min}$ is the pH value when microorganism growth rate is assumed to be zero; b is regression coefficient to be estimated.

2. Arrhenius relationship model constructed by Davey that food temperature and water activity influences microorganism growth rate is:

$$\ln k = a_0 + \frac{a_1}{T} + \frac{a_2}{T^2} + a_3 a_w + a_4 a_w^2 \quad (5)$$

k is growth rate and $a_0 \sim a_4$ is parameters of model.

3. Response surface equation represents microorganism growth parameters as a polynomial equation, and the general form is:

$$y = a + b_1 x_1 + b_2 x_2 + \cdots + b_i x_i + b_n x_1 + b_1 x_1^2 + \cdots + b_t x_i^2 + \cdots + b_v x_1 x_2 + \cdots + b_m x_i x_j$$

a_1, $b_1 \sim b_m$ are regression coefficients; $x_1 \sim x_i$ is time, temperature, pH value, a_w and other influencing factors of microorganism.

2.5. Third-level model

Third-level model is also called expert system, which is the combination of above two models in computer software application. Users do not need to be skilled in engineering mathematics knowledge, and only need to input initial conditional values of food in computer software.

3. Results and discussions

Game theory analysis of enterprises, customers and supervision institutions of Qingdao catering enterprises in food market

3.1. Game theory analysis between enterprises and customers

Game theory mainly studies decisions and their balance problems when behaviors of participants have direct interaction (Hadjichrysanthou and Broom, 2012; Camerer, 2003). Generally speaking, game theory

considers anticipated behaviors and actual behaviors of participants in the "game" to study optimal strategies of each individual as well as the final balance results of "game". Game between enterprises and customers is the most fundamental and widest part in game activities related to food security. Detailed behavior hypotheses of game between enterprises and customers in competitive market are as follows:

Hypothesis 1: Suppose enterprises and customers are all rational-economic men and pursuit maximum self-interest based on personal rational perspective.

Hypothesis 2: Strategy selection of enterprises includes qualified products production and unqualified products production. Cost of qualified products production is C_1 and cost of unqualified products production is C_2, $C_1>C_2$. Information in market is asymmetric, thus the prices of qualified products and unqualified products are the same, which is P. However, enterprises that produce unqualified products need to pay C to bribe supervision institutions or deceive customers ($C\geq 0$). The relationship between C and supervision strength of government and society is in direct proportion.

Hypothesis 3: Customers can choose to buy food or not. If customers choose to not buy, the utility of income is zero; and if customers choose to buy, the utility of income is V_1; if food is unqualified, then utility of income is V_2; $V_1>P>V_2$. Information in market is asymmetric, thus purchase decisions of customers depend on their belief in product quality. If the probability of customers believing products are qualified is q, then the probability of customers believing products are unqualified is $1-q$.

According to behavior hypotheses, specific benefits of enterprises and customers can be divided as following four circumstances:

If enterprises produce qualified products and customers purchase them, then benefits of enterprises are $P-C_1$ and benefits of customers are V_1-P.

If enterprises produce qualified products but customers do not purchase them, then benefits of enterprises are $-C_1$ and benefits of customers are zero.

If enterprises produce unqualified products and customers purchase them, then benefits of enterprises are $P-C_2-C$ and benefits of customers are V_2-P (less than zero).

If enterprises produce unqualified products and customers do not purchase them, then benefits of enterprises are $-C_2-C$ and benefits of customers are zero.

If customers are not sure about safety level of products, the purchase decisions of customers are random, thus $0<q<1$. Under such circumstances, the expected revenue of enterprises is related to production decisions. If an enterprise produces qualified products, its expected revenue is:

$$E_1=q(P-C_1)+(1-q)(-C_1)=qP-C_1 \quad (7)$$

If the enterprise produces unqualified products, its expected revenue is:

$$E_2=q(P-C_2-C)+(1-q)(-C_2-C)=qP-C_2-C \quad (8)$$

If $C_1>C_2+C$, rent-seeking and other extra cost C is less than cost saving of producing unqualified products. If $E_1<E_2$, the optimal strategy of enterprises is to produce inferior products. Even if customers do not purchase these products, producing unqualified products is still a dominant strategy of enterprises because $-C_1<-C_2-C$.

3.2. Game theory analysis between enterprises and supervision institutions

Although market is the optimal method of resource allocation, problems in asymmetric information, public goods and externality can not be solved only by market, which is called

market failure. Thus, government institutions should have macro-regulatory and micro-regulation on market. In order to solve market failure problem in food catering industry, Qingdao city established supervision and management institutions aimed at all links of food industry, including Food and Drug Administration, General Administration of Quality Supervision, Administrative Bureau for Industry and Commerce, etc.

Supervision from food security related institutions is significantly important to food market order standardization and food security guarantee (Botelho, 2002). In order to completely discuss reasons of frequent occurrence of Qingdao food security problems, food security supervision is divided into market entry stage as well as production and processing stage, and game theory models of enterprises and supervision institutions are established respectively.

In market entry stage, food supervision institutions are responsible for qualification examination of new food enterprises, and main supervision institutions are Food and Drug Administration and Administrative Bureau for Industry and Commerce (Redmond and Griffith, 2003). Suppose the newly entered enterprise is unqualified, there are two circumstances. First, if supervision institutions perform their duties, the enterprise will be strictly penalized, i.e., its' entrance will be prohibited permanently. Second, if supervision institutions do not perform their duties, the enterprise will enter the market successfully and gain profits.

Hypothesis 1: Suppose enterprises and supervision institutions are all rational-economic men and pursuit maximum self-interest based on personal rational perspective.

Hypothesis 2: The prospective earnings of qualified enterprises is R_1 and the prospective earnings of unqualified enterprises is R_2. Because unqualified enterprises have cost advantages, usually $R_1<R_2$. In the meantime, qualified rate of new enterprises is q and unqualified rate is $1-q$.

Hypothesis 3: If examination cost of supervision institutions is C and the probability of examination is p, then the probability of not having examination is $1-q$.

Hypothesis 4: If unqualified enterprises enter market successfully, their dereliction of duty will result in expected utility loss W, including decapitation due to food security problems, etc.

Thus, the game matrix between enterprises and supervision institutions is as shown in table 3.

Table 3. Supervision game analysis in market entry stage

		Enterprises	
		Qualified	Unqualified
Supervision institutions	Supervision	(-C,R_1)	(-C,0)
	Nosupervision	(0,R_1)	(-W,R_2)

Table 3 shows that the game has no pure strategy Nash equilibrium. Therefore, U_s and U_f are used to represent supervision institutions and enterprises respectively to analyze whether the game contains mixed strategies Nash equilibrium or not.

$$U_f=q[R_1p+R_1(1-p)]+(1-q)[0*p+R_2(1-p)]$$
$$=qR_1+R_2(1-p)(1-q)$$
$$U_s=p[(-C)q+(-C)(1-q)]+(1-p)[0*q+(-W)(1-q)] \quad (9)$$

First order condition can be obtained form differential of utility functions:

$$U'_f=R_1-R_2(1-p) \qquad U'_s=-C+W(1-q) \quad (10)$$

Therefore, $p^*=1-R_1/R_2, q^*=1-C/W$ is the mixed strategy Nash equilibrium in this game, i.e., examination probability of supervision

institutions is $1-R_1/R_2$ and qualification probability of entering enterprises is $1-C/W$.

Above game analysis of enterprises and supervision institutions in market entry stage shows that reasons like high cost of examination will result in lack of examination from supervision institutions, thus some unqualified enterprises can get away from examination of supervision institutions and enter market successfully. Therefore, supervision institutions have to enforce supervision on enterprises in production and processing stage to ensure food security. Current institution in Qingdao city that is responsible for supervision of production and processing of food enterprises is General Administration of Quality Supervision, while judicial organizations are responsible for penalizing enterprises that produce unqualified products.

3.3. Solutions for improving food supervision system of Qingdao catering enterprises

Establishment of supervision system that is unified and has clear rights and liabilities

It is a development tendency of current society to establish an interactive system among government, enterprises, customers and industrial organizations. Improvement of food supervision system of Qingdao catering industry relies on active participation and hardworking of all social members. It is an active force of catering enterprises to actively maintain food security by using their reputation to keep effective operation of food security supervision system of catering industry (Egan et al., 2007; Mcmeekin *et al*, 2006). Supervision from government is merely external restraint and the core factor is the self-regulation of enterprises. Industrial organizations play a role of bridge and bond in communicating government, enterprises and market, which are social organizations that aim for self-regulation of industries, standardization of industrial behaviors and guarantee of fair competition (Wang et al., 2013). In order to stimulate enthusiasm of the whole society to maintain food security, it is significantly important to establish an interactive system among government, enterprises, customers and industrial organizations to reinforce understanding and seek solutions for key problems in food security through communication.

3.4. Accelerating establishment of supervision system

Most of current food security detection equipments in Qingdao are outdated, thus investment on food security detection equipments should be increased to guarantee food security. First, investment on equipments should be increased to replenish more advanced equipments and update outdated equipments. Second, more researches should be done on food security, such as food traceability and restriction, especially retention analysis technology and limited supervision technology, etc. At last, technicians should have equipment analysis, tests and other basic application technology training to improve their quality. Besides, technicians should have opportunities to learn to use advanced equipments in provided places.

4. Conclusions

Based on problems that occur in production and service management system of Qingdao hotel catering enterprises, this study carried out several investigations to analyze reasons and discuss solutions. Besides, according to game analysis of enterprises, customers and supervision institutions of Qingdao catering enterprises in food market, this study clears the relationship among them and fundamentally solves problems in food production and service supervision, thus provides solutions for Qingdao hotel catering enterprises and improves food supervision system.

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COMPUTER GRAPHIC IMAGE TECHNOLOGY IN THE DETECTION OF BACILLUS CEREUS IN FOOD

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ABSTRACT

As food poisoning incidents caused by food-borne pathogenic bacteria happen frequently, people in domestic and abroad have paid more and more attention on methods for detecting microorganism in food rapidly and strived to improve the current deficiencies of traditional detection methods, to meet the requirements of improving food quality and safety by detecting pathogenic bacteria in a quick and precise way. Bacillus cereus is one of the most common food-borne pathogenic bacteria inducing food poisoning. Based on developed microorganism rapid detection system, this study focuses on pretreatment methods used in detecting bacillus cereus in food and preliminarily explores microscopic image analysis and recognition in collected bacillus cereus specificity, in order to establish a set of quick method for detecting bacillus cereus in food.

1. Introduction

Bacillus cereus as a kind of bacillus with positive Gram stain is widely distributed in the nature, including nearly 50 species, such as zoonosis bacillus anthracis, bacillus cereus leading to food poisoning, non-pathogenic bacillus subtilis and bacillus thuringiensis (Curtis et al., 2008; Pollock et al., 2010). Research on rapid method for the detection of pathogenic bacteria in food is intensified as people focus on food safety issues. To date, there are plenty of researches on detection method of bacillus cereus in domestic and oversea, for instance, conventional detection methods on the basis of polymerase chain reaction (PCR) technology, immunological technique, rapid detection methods involving gene-based fundamental molecular biology, loop-mediated isothermal amplification (LAMP) technology, microbial automatic detector VITEK-AMS as well as viteck immune diagnosis system (VIDAS) (Zhang et al., 2013; Park et al., 2002; Collison et al., 2005; Qi et al., 2008; Horstkotte et al., 2002; Shuying,2014).

Automatic microorganism classification and recognition using computer technologies is able to reduce errors and provide more accurate and scientific detection results relative to artificial detection. Therefore, how to set up quick, accurate and sensitive food pathogenic bacteria detection method turns into one of the important and compelling topics in the field of micro-organism study.

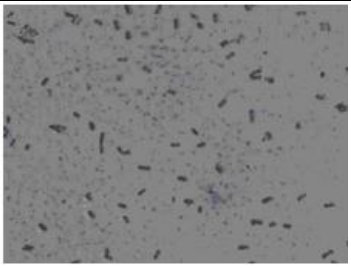
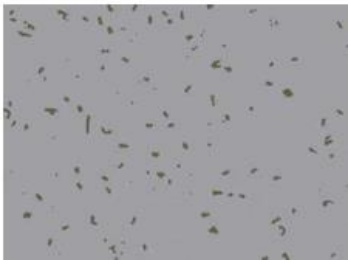
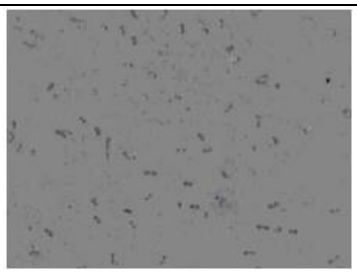
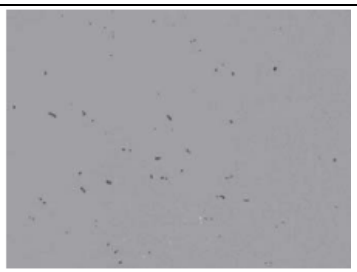
This study is designed to realize rapid detection of bacillus cereus in food by looking

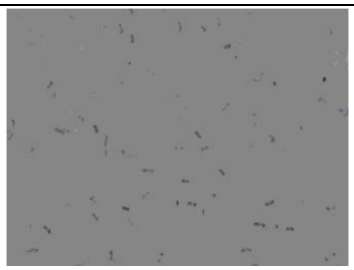
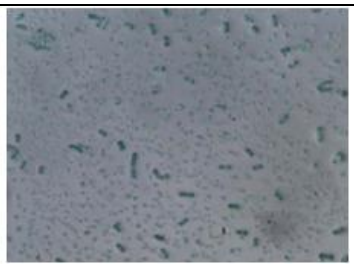
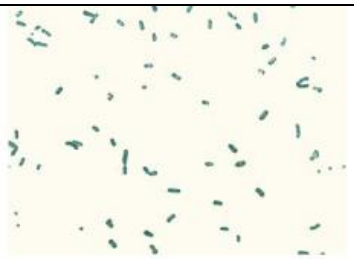
for effective methods preprocessing bacillus cereus as well as sensitive chromogenic substrate and combining computer vision technology. Through exploring specific enzyme substrate reaction of bacillus cereus and using image processing technology, this study establishes a set of image analysis system for quantitatively detecting bacillus cereus, and then optimizes required feature parameters during image analysis with the help of existing detection devices, and detects and analyzes data applying computer intelligence, so as to shorten detection period and improve the quality.

2. Materials and methods

A lot of noises including particle noises caused by impurities on the glass slide and camera lens and alternating current noises inside system circuit will be produced when shooting microscope images with camera, collecting and transiting images and preprocessing images, thereby decreasing the quality of images (Zhang et al., 2013). Known from the experience of using process of laboratory rapid detection system, median filtering algorithm in the application of image preprocessing is able to obtain clearer images suitable for post processing, which is a viable option for microbiological detection. Table 1 below shows 24-bit true color images after red (R), green (G) and blue (B) components and corresponding images after median filtering. Three components of R, G and B rebuild RGB color images after median filtering. Compared with before median filtering, it is obvious that a large portion of noises in the original image are filtered out after median filtering, and relatively clear images which can basically reflect effective information of original images are acquired.

Table 1. 24-bit true color images obtained after RGB components and corresponding images obtained after median filtering

	RGB component images	RGB component images after filtering
R		
G		

B		
	Original images	Coincident RGB images after filtering
		

3. Results and discussions

3.1. Analysis of image using RGB space

The color difference in the same image can show some characteristics of the target area because the polymorphism of bacterial cells and existence of impurity will affect the right segmentation of target bacteria. As color information is of important reference value, R, G and B components of the original color image (24-bit true color) are analyzed in this chapter, and the increase of color information can be considered to achieve the extraction and segmentation of target when segmenting image threshold. In the meantime, one of the bacteria is randomly taken as an example for analyzing RGB components of a single bacterium.

3.2. Analysis of image using hue, saturation and intensity (HSI) space

HSI space model expresses color with three basic features of hue, saturation and intensity. HSI space model is widely used in color image segmentation process as three components of HSI space model are able to separate information expressed with color (H and S components) and brightness (I component) and can be converted to a specific value. This color representation model is constructed based on I component unrelated to color information of image and H and S components closely correlated with the way of feeling color, so its effect is most obvious when processing each part with greater brightness changes in the cell image, thus helping computer vision technology better applying color information in the color image, which is applicable in detecting and analyzing characteristics of color images.

Color space alternation is required before analyzing images using HSI model, as images collected by the system are RGB color images. Conversion formulas (Zhao et al., 2013) are as follows:

$$H = \begin{cases} \theta & B \le G \\ 360 - \theta & B > G \end{cases} \quad (1)$$

$$\theta = \arccos\left\{\frac{\frac{1}{2}[(R-G)+(R-B)]}{[(R-G)^2+(R-G)(G-B)^{1/2}]}\right\} \quad (2)$$

Herein,

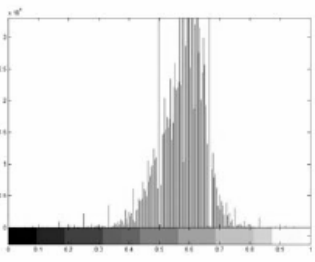
$$S = 1-\frac{3}{(R+G+B)}[\min\ (R,G,B)] \quad (3)$$

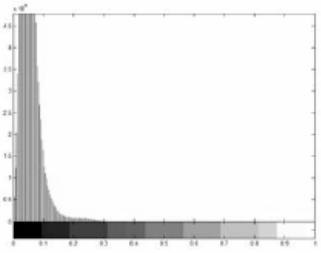
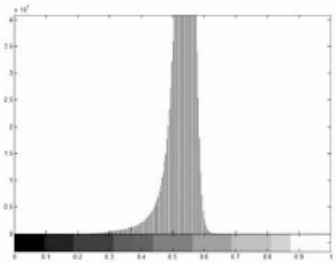
$$I = \frac{1}{3}(R+G+B) \quad (4)$$

Where H is used for distinguishing hues of different colors; S expresses saturation of a certain color; I refers to light and shade degree of color. Effect image of RGB original color image after HSI color space alternation is displayed in figure 1. HSI model is put forward based on the idea of separating color and brightness, so its effect image reflects the differences of color types, purity and brightness on the vision. Table 2 shows grey-scale map of figure 1 after extracting H, S and I components and corresponding grey level histogram.

Figure 1. Converted HSI model

Table 2. Grey-scale map obtained after extracting H, S and I components and corresponding grey level histogram

	HSI component images	HSI component grayscale histogram
H		

S		
I		

3.3. Extraction of feature parameters of bacteria images

3.3.1. Extraction of morphological characteristics

Chain code curve tracking method (Miyatake, Matsushima and Ejiri, 1996) is usually applied in extracting main parameters of target images when studying morphological characteristics of target images.

(1) Perimeter (L) referring to the length of contour line of measured objects is acquired by calculating the number of pixel on the edge area. Eight-chain code curve (Gao, 2004) is used in measuring the perimeter of target image, i.e., calculating the length of chain code. Length is denoted as $\sqrt{2}$ when chain code value is odd; otherwise, it is denoted as 1. Expression formula of target perimeter is:

$$L = N_1 + \sqrt{2}N_2 \quad (5)$$

Herein, N1 expresses the number of pixel when chain code is even; N2 is the number of pixel when chain code is odd.

(2) Area (S) refers to the number of pixel contained within the zone boundary of target image, that is to say, the number of concentrated pixel connecting pixel points in the binary image. The size of target image in bacteria somatic binary image f (x, y) is set as M×N using eight chain code (Ren and Hai-Tao, 2008). The area S is expressed below:

$$S = \sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y) \quad (6)$$

(3) Major axis (D) and minor axis (W) referring to long axis and short axis of the bacteria on the rod are obtained by calculating the longest and shortest line segments of target centroid. Taking ($\overline{X_0}, \overline{Y_0}$) as barycentric coordinates of target and f (x, y) as binary image of target, barycentric coordinates are expressed as follows:

$$\overline{X_0} = \frac{1}{S}\sum_{(i,j)\in R} xf(i,j) \quad (7)$$

$$\overline{Y_0} = \frac{1}{S}\sum_{(i,j)\in R} yf(i,j) \quad (8)$$

$$f(x,y) = \begin{cases} 1 & (x,\ y) \in R \\ 0 & \text{Others} \end{cases} \quad (9)$$

(4) Shape factor (R) is applied in reflecting the degree of deviation and irregularity of target image and round. Its computation expression is displayed below:

$$R = \frac{4\pi S}{L^2} \quad (10)$$

Rectangle degree (P) as a rectangle fitting parameter reflects the filled degree of target in

its bounding rectangle, and its expression is as follows:

$$P = \frac{S}{S_0} \quad (11)$$

Where S0 referring to the area of bounding rectangle can also be expressed with the product of long axis and short axis.

Elongation (F), another feature related to shape, is the ratio of width and length of bounding rectangle or the ratio of short axis and long axis of centroid. This feature is able to separate fine image from square or circular target image, and its expression is shown below:

$$F = \frac{W}{D} \quad (12)$$

3.3.2. Part of shape extracted

Morphological characteristics above have a certain influence on the detection results of cell and certain relations exist in above variables. To reduce computational time, some characteristic parameters can be selected to evaluate comprehensively, and results of part of shape extraction of some bacteria are in table 3.

Table 3. Part of bacteria morphological parameters extracted

Label	R	P	F	L	S	Signal
1	0.5634	0.8852	0.2598	105.743	490.71	0.9
2	0.6422	0.9873	0.3439	82.446	347.78	0.9
3	0.4463	0.8078	0.3785	108.535	418.48	0.9
4	0.5952	0.7913	0.3256	90.943	391.87	0.9
5	0.4521	0.8226	0.3105	122.527	540.27	0.9
6	0.5278	0.8455	0.2846	95.688	384.82	0.9
7	0.6638	0.7933	0.2691	80.378	341.38	0.9
8	0.4832	0.9877	0.3142	99.415	380.31	0.9
9	0.4763	0.7638	0.3908	88.024	497.38	0.9
10	0.5526	0.8693	0.4142	84.397	383.63	0.9
11	0.5249	0.8453	0.2191	89.916	396.38	0.9
12	0.4712	0.8462	0.3078	102.023	488.63	0.9
13	0.5576	0.9793	0.3334	102.723	293.75	0.9
14	0.5364	0.8312	0.4482	113.765	313.33	0.9
15	0.5621	0.9131	0.2702	96.314	337.82	0.9

3.3.3. Color feature extraction

Extraction of color feature

(1) Extraction of RGB color characteristics parameters

As images collected by system are RGB color images, the contribution value of each component in the whole image is calculated when R, G and B are analyzed (Hiremath, 2010), and two independent variables G and B are taken as parameters.

$$r = \frac{R}{R+G+B} \quad (13)$$

$$g = \frac{G}{R+G+B} \quad (14)$$

$$b = \frac{B}{R+G+B} \quad (15)$$

(2) Extraction of HSI color characteristics parameters

Three color characteristics parameters H, S and I are selected to analyze data, and the mean value is calculated.

$$h = \frac{1}{n}\sum_{i=1}^{n} H_i \quad (16)$$

$$h = \frac{1}{n}\sum_{i=1}^{n} H_i \quad (17)$$

$$i = \frac{1}{n}\sum_{i=1}^{n} I_i \quad (18)$$

Results of color feature extraction

(1) Extraction of RGB color characteristics parameters

This study is going to analyze the scope of three component values (R, G and B) of each single bacterium after removing the background. It can be known from table 4 which displays the contribution values of three components that RGB components have no significant difference in thallus and non-thallus, which may be caused by concentrated precipitation when target bacteria develop color, thereby forming color parameters same as bacteria. Therefore, other parameters are needed for recognition when extracting target bacteria.

Table 4. RGB parameters of some bacteria extracted

Serial number	R component	G component	B component	r	g	b	Signal
1	113.05	122.65	126.67	0.3121	0.3386	0.3496	0.9
2	116.74	135.26	142.87	0.2957	0.3425	0.3617	0.9
3	131.98	137.95	142.28	0.3201	0.3346	0.3451	0.9
4	127.28	139.24	141.98	0.3117	0.3408	0.3477	0.9
5	119.52	133.16	139.16	0.3051	0.3397	0.3551	0.9
6	118.86	128.92	134.92	0.3107	0.3368	0.3526	0.9
7	126.68	137.74	139.84	0.3135	0.3406	0.3458	0.9
8	129.82	142.88	145.71	0.3101	0.3416	0.3481	0.9
9	121.78	131.21	137.08	0.3121	0.3365	0.3516	0.9
10	125.96	134.17	137.61	0.3168	0.3372	0.3461	0.9
11	126.91	135.68	139.84	0.3153	0.3371	0.3476	0.9
12	122.87	131.07	135.11	0.3157	0.3368	0.3472	0.9
13	124.08	132.62	139.35	0.3134	0.3347	0.3517	0.9
14	128.13	135.84	139.82	0.3172	0.3363	0.3462	0.9
15	125.02	140.21	141.86	0.3071	0.3443	0.3486	0.9

(2) Extraction of HSI color characteristics parameters

Mean value of H, S and I components of target bacteria after removing the background is analyzed in table 5.

Table 5. Results of HSI parameter extraction of some bacteria

Serial number	h	s	i	Signal
1	0.5188	0.1305	0.5078	0.9
2	0.5642	0.0963	0.5497	0.9
3	0.5836	0.1174	0.5516	0.9
4	0.5723	0.0982	0.5345	0.9
5	0.5691	0.1173	0.5303	0.9
6	0.5822	0.1272	0.5182	0.9
7	0.5661	0.1085	0.5008	0.9
8	0.5507	0.1076	0.557	0.9
9	0.5793	0.1067	0.5383	0.9

10	0.5391	0.1148	0.5148	0.9
11	0.5849	0.1103	0.5573	0.9
12	0.5782	0.0987	0.5367	0.9
13	0.5901	0.1082	0.5599	0.9
14	0.5842	0.1196	0.5501	0.9
15	0.5708	0.0988	0.5333	0.9

3.4. Recognition classifier of bacteria images

3.4.1. Design of neural network

Back propagation (BP) algorithm of neural network, also called as error back-propagation neural network (BPNN), belonging to a kind of δ supervised learning algorithm, is widely applied in model recognition, functional approximation, data compression. The parameters of neural network should be designed first in the actual use of classification recognizer, involving the number of neurons and network layers, sample training as well as data input and output. Its main task is to confirm the number of network layers, the number of neurons in each layer, data transmission function between layers and learning rate, select expected error and train samples.

Through gaining service experience of the system and doing a large number of tests, parameters of neural network are set below:

The number of input and output neurons.

Both of them are confirmed by the number of selected feature parameter and the number of categories requiring output, so 8 input neurons and one output neuron are confirmed in this test. Neural network built-in function is used in quantizing and restoring input and output functions.

The number of neurons in the hidden layer

Single hidden layer is adopted in this system, and the number of neurons in the hidden layer can be known by calculation using the following formula, ranging from 4 to 13.

$$l = \sqrt{n+m} + a \tag{19}$$

Herein, m and n express the number of input and output neurons respectively; a is a constant between 1 and 10.

Activation function adopts hyperbolic tangent sigmoid function and uses alterable learning rate.

Expected error

The change of BP neural network will impact the convergence rate and accuracy as it is sensitive to the selection of initial weight value, so this test applies the expected error value 0.0001 obtained from experience and adjusts it through predicting error.

Evaluation index

The accuracy of sample recognition is used in evaluating the network, and its formula is as follows:

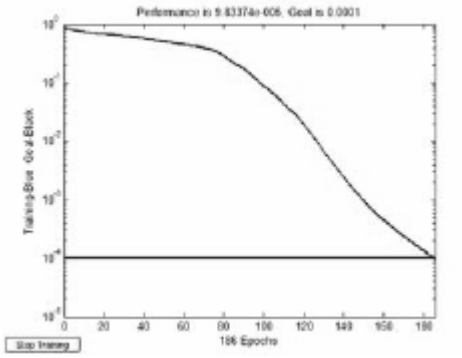
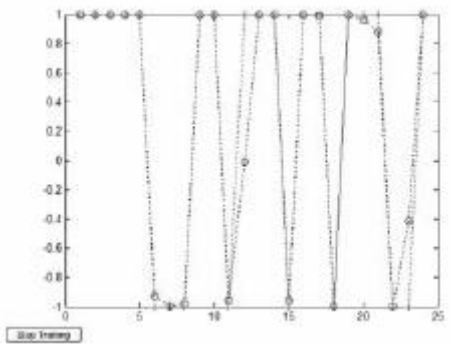
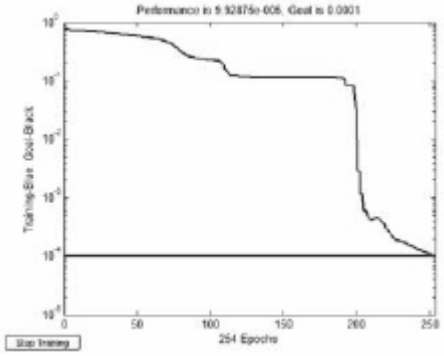
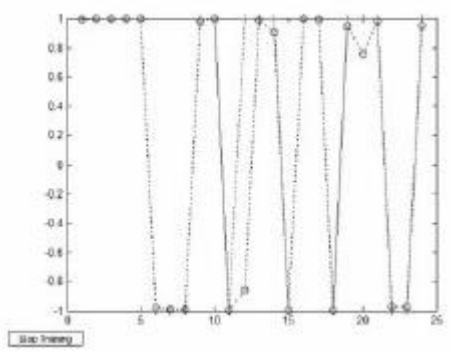
$$\text{Accuracy rate of sample recognition } (C) = \frac{\text{The number of correctly recognized samples}}{\text{Total number of samples}} \times 100\% \tag{20}$$

3.4.2. Training results of neural network

(1)Training results of network in the structure of 8-4-1 and 8-5-1

Training and test processes of network in the structure of 8-4-1 and 8-5-1 are displayed in table 6 when 0.0001 is considered as the expected error. It is observed that the network converges completely when Epochs is between 186 and 254, and error decreases to 9.71082e-005 from 9.83374e-005. Taking 24 samples as test samples, this study finds large error in two network structures when testing, as well as low recognition accuracy. Hence, increasing the number of training is taken into consideration to check the convergence results, but at the same time, training times and time are likely to increase and prolong, so repeated trainings and tests are required to select a optimal value.

Table 6. Training results of network in the structure of 8-4-1 and 8-5-1

	8-4-1 structure	8-5-1 structure
Training process		
Test results		

(1) Training results of network with better effect

Network in the structure of 8-6-1 chooses 0.0001 as the expected error (figure 2). It can be seen that the network converges and training stops when there are 6 nodes in the hidden layer, Epochs is 196 and error decreases to 9.98037e-005. Although a certain error exists in the test, output value is close to the expected output, and at this moment, the accuracy of sample recognition reaches up to 95%.

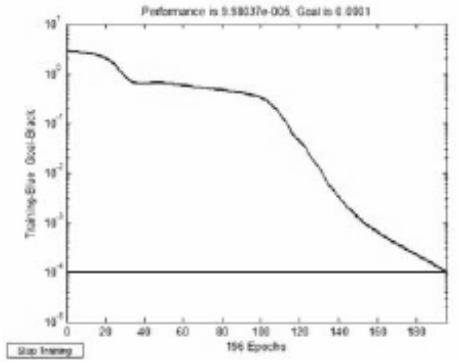


Figure 2. a. Training results of network with better effect. Training process of network in the structure of 8-6-1

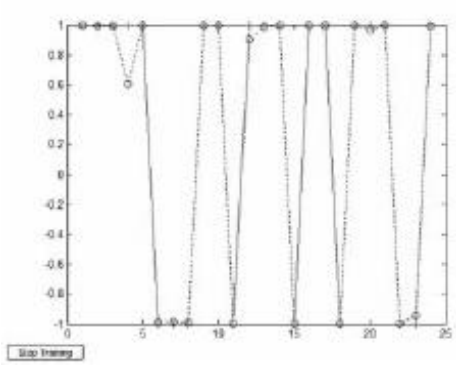


Figure 2. b. Training results of network with better effect. Test process of network in the structure of 8-6-1

4. Conclusions

Bacillus cereus, a common conditioned pathogen in food, is usually detected using traditional medium plate count method, so it is hard to meet the needs of real-time monitoring of food quality and safety. To look for quick detection methods, based on characteristics and specific chromogenic method of spore of bacillus cereus, this study introduces computer

vision technology into bacillus cereus rapid detection to preliminarily explore quick detection method of bacillus cereus in food, puts forward new thought for detecting bacillus cereus in food quickly and expands the application range of microorganism detection system, which provide theoretical and technical support for the perfection of microorganism rapid detection system.

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APPLICATION OF FOOD RISK INDEX ON FOOD SAFETY CONTROL OF SPORTS MEETING CATERINGS

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ABSTRACT

This study aims to build a risk-warning mechanism which is more suitable for sports meet food control based on the identification and evaluation of food safety risks of the catering industry, in order to improve the efficiency and effect of food safety control to achieve the purpose of ensuring food safety. Adopting the method of data review and contextual inquiry, a quantitative analysis on risk index data, time of regulation on catering enterprises and food safety risk factors is carried out. At the early stage of the sports meeting, the licensed catering enterprise accounts for 64.55% of the catering core area; unlicensed catering enterprise accounts for 35.45%; 10 large scale restaurants which account for 9.09%; 18 medium-sized restaurants which account for 16.36%; 28 small-sized restaurants which account for 25.45%; 64 snack bars, fast-food restaurants, drink shops, etc, which account for 58.18%; through quantitative classification, large scale restaurants are most likely to be ranked as A level, most of the medium-sized restaurants are ranked as B level while unlicensed restaurants are with a high proportion of C level. It has no statistical significance on quantitative classification result to analyze the food safety risk key projects, self-inspection records and tableware cleaning ($P>0.05$) while rest projects have statistical significance on quantitative classification result ($P<0.01$). Through the introduction of food risk index, measurement of risk degree of the overall intra-regional catering enterprises is realized; limited regulatory resources are reasonably distributed. Also, unlicensed food enterprises are included into risk management system, in order to reduce food safety risks and ensure food safety of catering industry under a controllable state.

1. Introduction

With the wide application of advanced food technologies, food safety incidents occur frequently, which caused huge financial losses and social influence. There are several malignant events emerged which affected food safety on a global scale (Van Boxstael et al., 2013; Pham et al., 2012). Catering industry as a traditional service industry in China recently has always maintained a strong momentum of development and has become an important force to pull China's rapid growth of consumer demand. Meanwhile, it is the final link in the food safety chain of food planting, production, circulation and catering services and so it has direct impact on people's life and health level (Qiang and Ki Chow, 2007; Gleeson, 2001). Therefore, it is the basis of food safety to timely identify and find out food safety problems existing in the catering industry and realize effective prevention and control of food poisoning and other foodborne diseases (Millman et al., 2015). Therefore, governments at all levels and the relevant regulatory

authorities are taking active measures to ensure the health and safety of food. In order to ensure the scientific nature and effectiveness of all kinds of measures and achieve a maximum use of existing food safety regulatory resources, it is an urgent need to establish a more practical and effective management mode.

Risk analysis is a new model to ensure food safety which appears internationally in recent years and it has been widely accepted in all developed countries (Davey, Chandrakash and B.K, 2013; Patil and Frey, 2004). Risk assessment, risk management and risk communication are three interrelated components of risk analysis. Food safety risk management is a process of making choices on food safety risk management policies and measures according to the results of risk assessment based on risk assessment on related food safety issues. Learnt from past experiences, applying risk management techniques in food security assurance in sports meetings and other important activities can effectively ensure food safety and achieve good results. This paper carries on the discussion and analysis on the application of food risk index in catering supervision, in order to provide the reference for the establishment of a safe, orderly and efficiently running long-term mechanism for the sports meeting food.

2. Materials and methods

2.1. Research Method

Look-up method refers to keyword searching for food safety risk assessment both at home and abroad, the application of food risk management and major events food regulatory and other documents through network searching tools such as Pub Med, CNKI and library electronic resources, etc. (Jorge et al., 2008). While brainstorming method invites 15 front-line food supervision personnel to review the food safety status of the core catering enterprises and evaluate restaurant food safety risk factors based on the quantitative form of evaluation of food hygiene risk (Ring and Ray, 2009). And expert consultation method invites 5 experts who have been long engaged in health management, epidemic disease, food hygiene, etc to make up a consultative expert group and make an in-depth analysis on food safety risk identification and evaluation of the catering enterprises in the study, clear and definite risk assessment methods, and put forward opinions and suggestions on the choice of the indicators (Spruijt et al., 2015). Field investigation method is to carry out the on-site supervision quantitative grading on the core catering enterprises based on the catering unit quantitative supervision and inspection table and calculate the daily risk index and four-color warning data according to the risk index model (Jamieson, 2004).

2.2. Object of Study

This paper takes the core area of sports meeting as the range of study, food risk index and food safety status as the object of study during the sports meeting (from April 15, 2014 to April 30, 2014). By the end of April 10, 2014, there are altogether 110 catering enterprises in the core area: 10 large scale catering enterprises; 18 moderate restaurants; 28 small catering enterprises; 25 snack bars; 39 unlicensed restaurants.

2.3. Quality Control

2.3.1. Establishment of Information System

Food and Drug Administration builds up the food supervision and management information system which is convenient for collecting and sorting out the regulatory information and therefore provides background information for research work. The information system collects information by the form of "one enterprise one file", and automatic reminders are set up to ensure that every enterprise is regulated during coverage checking thus to reduce the error between times and numbers of statistical supervision units.

2.3.2. Personnel Training

Personnel participated in the research have been engaged in the food safety supervision work for many years and accepted the standardization training on food safety regulatory knowledge.

2.3.3. Technical Route

The sports meeting is carried out according to the technical route in figure 1, so as to ensure the accuracy and scientificity of the research.

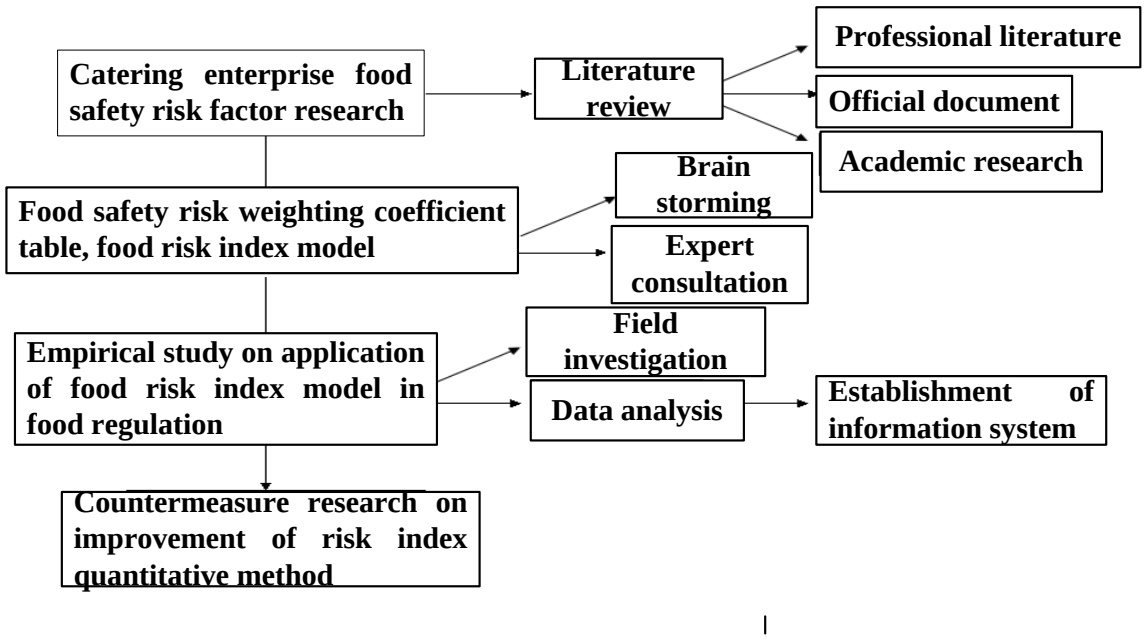

Figure 1. Technical route

2.4. Data Analysis

Collect the four-color warning data of risk index during the sports meeting, as well as the quantitative data of regulatory unit times and quantitative grading situation of the core catering enterprise before and during the sports meeting. The survey data are calculated through Excel Software and statistical analysis is made based on SPSS statistical analysis software.

3. Results and discussions

3.1. Catering Enterprise Food Safety Risk Factors

3.3.1. Basic Information of Catering Enterprise

By the end of April 10, 2014, there are altogether 110 catering enterprises in the core area of the sports meeting site.

And licensed enterprise accounts for 64.55%; unlicensed enterprise accounts for 35.45%; the situation of licensed enterprises is shown in table 1 based on business scope and classification. From table 1: there are 10 large scale restaurants which account for 9.09% in percentage; 18 medium-sized restaurants which account for 16.36%; 28 small-sized restaurants which account for 25.45%; 64 snack bars, fast-food restaurants, drink shops, etc, which account for 58.18.

Table 1. Licensed catering unit classification

Unit classification	Large scale unit	Medium-sized unit	Small-sized unit	Snack bars, fast-food restaurants,drink shops,etc	Total
Unit number(household)	10	18	28	64	110
Percentage (%)	9.09	16.36	25.45	58.18	100

The common area of unlicensed enterprises is under 150cm2 and the classification situation of 39 unlicensed enterprises according to business scope is shown in Table 2. From table 2: there are 7 restaurants which sell stir-fried dishes and cooked food, account for 17.95%; 13 restaurants which sell stir-fried dishes, account for 33.33%; 19 restaurants which sell steamed, boiled, fried simple meals, account for 48.72%.

Table 2. Classification of unlicensed catering enterprises

Unit classification	Stir-fried dishes and cooked food	Stir-fried dishes	Steamed, boiled and fried simple meals	Total
Number of units (household)	7	13	19	39
Percentage (%)	17.95	33.33	48.72	100

Through the fishing expedition on the unlicensed enterprises in the core area, the reason why these enterprises do not have certificates is shown in figure 2. From figure 2: there are 18 units which cannot have certificates because they don't have certificate of house property, account for 46.15%; 19 units which cannot have certificates due to the lack of environment assessment report, account for 48.72; 10units which cannot have certificates merely because their facilities do not meet the requirements, account for 25.64%; 2 units with other reasons, account for 5.13%.

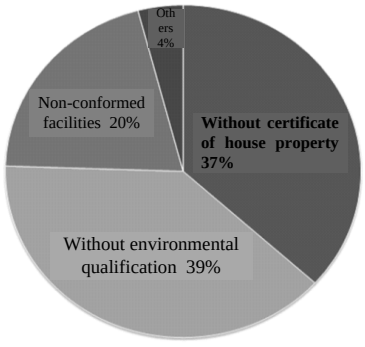

Figure 2. Reasons for unlicensed enterprises

3.3.2. Catering Enterprises Supervision and Quantitative Grading

At the early stage of the sports meeting, the catering enterprises in the core area are quantified and classified with full coverage and multi-frequency according to the catering unit quantitative supervision and inspection table, and there are altogether 1000 units which are included in this supervision and inspection. There are 435 A level (good) units; 352 B level (average) units; 213 C level (poor) units. The proportion of large scale restaurants which ranked as A level is high, with a percentage of 9.09%; and medium-sized units are with a highest percentage of B level; most of the

unlicensed units are ranked as C level; units which mainly sell simple meals are mostly ranked as C level, with a percentage of 48.72%; and the units which merely sells fried dish and which mainly sell fried dish are with a percentage of 33.33% and 17.95 respectively as ranked C level. Besides, whether the restaurants sell delicatessen and braised food has impact on the quantitative classification results. Especially for C level units, the restaurants which do not sell delicatessen and braised food are significantly less than those which sell delicatessen and braised food, and small restaurants occupies an percentage of 25.45%.

3.3.3. Environmental Health Condition of Catering Enterprises of Different Levels

The key project of catering enterprises' health management survey includes: inner-enterprise self-inspection; whether there exist the situation of expanding the scope of business and whether catering industry staff have health certificate; personal health status and clothing, etc. there are 205 units which do not have health certificate and the number is the most significant; besides, there are 174 units which cannot meet the personal hygiene condition and 193 units which don't manage self-inspection. Through the comparison of health management status, of catering enterprises of different levels, it can be found that business scope, health certificate and personal hygiene have statistical significance on quantitative classification ($P< 0.01$) and self-inspection record has no statistical significance on quantitative classification ($P> 0.01$), see (Table 3).

Table 3. Catering enterprises hygiene management situation analysis

Health management	A level		B level		C level		χ^2	p
	Total number of regula-tion	Number of unquail-fied	Total number of regulati on	Number of unqualifi-ed	Total number of regula-tion	Number of unqualifi-ed		
Self-inspectio n record	435	70	352	64	213	59	0.06	>0.05
Business scope	435	42	352	73	213	89	23.72	<0.01
With health certificate	435	35	352	77	213	93	704.64	<0.01
Personal hygiene	435	26	352	52	213	96	351.25	<0.01

Given that many times of supervision and guidance have been made on the catering enterprises in the core area at the early stage, the facilities and equipments of the enterprises are in good condition; there are 815 units which are not qualified on environmental health aspect and it has statistical significance on quantitative classification ($P< 0.01$), see (Table4)

Table 4. Catering enterprises environmental facilities situation analysis

Environmental facility	A level		B level		C level		χ^2	P
	Total number of regula-tion	Number of unquaili-fied	Total number of regula-tion	Number of unquail-fied	Total number of regula-tion	Number of unquaili-fied		
Drainage ground	435	7	352	46	213	108	739.72	<0.01
Facilities and equip-ments	435	0	352	0	213	0	-	-

3.2. Rapid Detection and Cause of Food Poisoning

A total number of 850 enterprises are given rapid detection with 84.47% percent of pass. ATP surface clearness and percent of pass of available chlorine in disinfectant fluid reached 82.59% and 86.73% respectively. And qualification rate of rapid detection of rest of the food and raw materials reached 100%. ATP surface clearness occupies a percentage of 79.06% of the total detection number. Also, cause of food poisoning of restaurant industry collective food poisoning occurred in the sports meeting from 2010f to 2014 is analyzed. There are altogether 9 collective food poisoning events, among which, 4 events were caused by food cross contamination and account for 45%; 2 events were caused by nitrite contained raw-food material and account for 22%; 1 event was caused by half-cooked food and unclean tableware and account for 11%.

3.3. Food Risk Index

According to the quantitative classification results and analysis of the potential food risk factors, catering enterprise food safety risk weighting factor questionnaire as well as formatted supervision and inspection table of sports meeting specific catering enterprises is established and food risk index is introduced. Based on the difference of category, scale and food provided by catering enterprises, the greater the scale, the more varieties of food, the bigger the risk of food safety, therefore weighting coefficient H is given. And according to the different number of customers as well as the processing number of food, large scale unit, medium sized unit, small sized unit and the snack bar are given weighting coefficient of 2, 1.5, 1 and 0.5 respectively, see (Table 5).

3.4. Classification and Configuration of Supervised Area and Four-Color Warning Distribution

According to the average principle of the amount, area and scale of catering enterprises, gridding method is applied to divide the core area of the sports meeting into 7 teams and 19 grids (one grid one team in the most core center and 6 team and 18 grids in the surrounding area). Apart from the most core area, the biggest number of enterprises is 67(team 4) and the smallest is 59 (team 1). Among which, team 2 has the biggest number of unlicensed enterprises, which is 39; and team 3 has 37 unlicensed enterprises; while team 5 has the smallest number of unlicensed enterprises, which is 21. Each grid supervision area produces 1 risk indicator daily; the core area produces 19 risk indicators daily. Based on relevant regulatory power of classification and configuration of the core grid area, the supervisors of the enterprises of the core area are divided into inspection, emergency and security groups.

Table 5. Weighting coefficient of catering enterprise

Enterprise classification	Large scale unit		Medium sized unit		Small sized unit		snack bar, fast food restaurant and drink shop	Unlicensed unit		
	Cooked food contained	No cooked food	Cooked food contained	No cooked food	Cooked food contained	No cooked food		Fried dish cooked food	Only fried dish	Steamed, boiled and fried food
Weighting coefficient H	2.5	2	2	1.5	1.5	1	0.5	2	1	0.5

During the 15 days of the sports meeting, there are altogether 96 times of four-color warning occurred in the 19 grids in the core area, with 50 times of green warning, which account for 52.08%; 20 times of yellow warning, which account for 20.83%; 18 times of orange warning, which account for 18.75%; 8 times of red warning, which account for 8.34%.

3.5. Correlation Analysis on Regulation Frequency and Risk Index

During the sports meeting, apart from the most core area, team 5 has the highest frequency of green warning among the 6 teams in the surrounding area, with a percentage of 71.92%; and the frequency of red warning is the lowest with a percentage of 2.92% among the 6 teams; while team 2 has the lowest frequency of green warning with a percentage of 34.61% while the frequency of red warning is highest with a percentage of 27.17%, see (Table 6). Analyze the risk indexes of the 6 teams of the surrounding area and the time of regulatory (since the frequency of red warning is 0 at some point, thus green warning is selected), the results of the 6 teams are $r= 0.835, 0.799, 0.869, 0.772, 0.780, 0.768$, $p< 0.01$, therefore there is positive correlation relationship.

Table 6. Percentage of red and green warning of 6 teams and times of regulatory during the sports meeting

group	Team 1	Team 2	Team 3	Team 4	Team 5	Team 6
Green （%）	62.85	34.61	47.26	58.73	71.92	73.25
red（%）	7.25	27.17	15.04	43.54	2.92	5.97
Time of regulatory	393	272	325	392	432	357

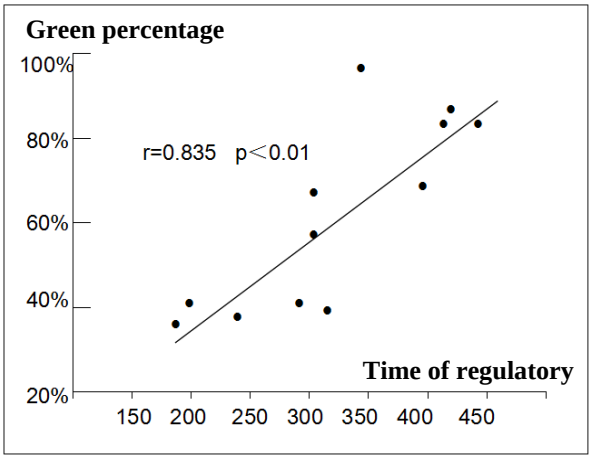

Figure 3. Correlation of green percentage and time of regulatory

3.6. Discussions

Risk management technology is applied to make the food risks under an acceptable range through effective management (Helland, 2008; Teymouri and Ashoori, 2011; Christine, 2001; Linfeng, 2015). And it is a powerful guarantee for food safety to establish an early warning system based on the determination of high risk units and high risk links.

During the sports meeting, the food safety of the core area is always under a controllable state. This study firstly determines the risk event, which is the food safety of the catering enterprises of the core area; secondly, risk identification is carried out and AHP (analytic hierarchy process) method is applied to analyze the potential risks of each food safety key items; by literature review, brain storming and expert consultation, risk evaluation is carried out and food risk index is set up.

Currently, unlicensed catering enterprises still exist to various degrees and it is a long-term accumulated social problem. And unlicensed food regulation has always been a difficulty in the catering services, which often involves the problem of employment, social security and rehabilitation mechanism and so on. In view of the influence of the sports meetings, this study includes the unlicensed catering units into the risk management system.

From the quantitative classification of the catering enterprises at the early stage of the sports meeting, it is found that the percentage of A level units in large scale restaurants is higher than that of small and medium sized units and percentage of C level units in large scale restaurants is the lowest among all restaurants, thus the overall food safety risk is low in large scale restaurants; among licensed units, small sized restaurants has the lowest percentage of A level units and highest percentage of C level, therefore its overall food safety risk is high; while unlicensed enterprises are mainly at C level. There is significant quantitative classification difference between catering enterprises of different scale and different business items also have impact on the results of quantitative classification. These results show that: with the increase of the operating scale, business operators pay more attention to food hygiene, thus food safety credibility is improved and food safety risk is reduced.

4. Conclusions

Through the application of food safety risk management techniques and introduction of food risk indicators to the catering enterprises in the sports meeting, this paper aims to focus the limited strength to the health supervision of the key link of catering units, so as to improve the effectiveness and level of the supervision and lower the food safety risk to a minimum level. By the discussion and analysis of application of food safety risk management techniques in the supervision of catering enterprises, it provides reference for the establishment of an orderly and efficiently running long-term mechanism for the food safety of sports meetings.

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CONSTRUCTION OF STARRED HOTEL'S CATERING QUALITY DETECTION MODEL AND EMPIRICAL STUDY

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ABSTRACT
Nowadays, Chinese catering become more and more prosperous. Hotel catering used to guide the development trend of catering and lead the market development direction; however, it became less competitive day by day. With the scale enlarge and class improvement of social catering, hotel catering loses a lot of customers and face a big challenge. Based on the above background, the study took the city's starred hotel as the sample and combined qualitative research and quantitative research to study the relationship between service quality, customer satisfaction and customer loyalty through literature survey method, sampling method and structural equation model analysis. In this way, we hope to encourage the hotel to complete and develop the catering services and promote the hotel service resources' development and utilization.

1. Introduction

In economy globalization times, with the international development of tourism and hotel industry and strong business competition, hotel service homogeneity is so serious, but the customers still have high expectation on hotel service quality. Service quality is the predisposing factor of customer satisfaction, which has been widely accepted in academia. Therefore, the improvement of the service quality is the base of customer loyalty and economic growth (Dong, 2004; Yan, 2014).

Gronroos divided service quality into technology quality and functional quality and put forward that service quality came from the customer's comparison on service expectation and the actual perception of services (Gronroos, 1997). General speaking, customers usually take service results for the granted, so service process is the most important factor that will influence the service quality (Gummesson, 1993). Chen, et al. (2005) studied the service quality problems of recreation hotel from technology quality and functional quality two aspects. Functional quality that customer can perceive refers to attitude, professional skill and behavior. Technology quality refers to the core product that customers have received during the service.

Wei, et al. scholars made analysis of hotel service quality management in similar way (Wei and Zhanming, 2008). From the angle of substantial study, Shen studied the effect of relation quality on customer loyalty of hotel. He made a conclusion that relation quality had a direct effect on customer attitude but no obvious direct effect on customer behavioral loyalty, customer's purchase usually depended on together work of many factors, which had an exploratory meaning to further discuss the internal mechanism of customer loyalty's forming (Shen, 2010). Combining with SERVQUAL model, Carrasco researched the evaluation system problem of hotel service

quality (Carrasco *et al.,* 2012). Based on the cause and effect diagram analysis of the effect of service quality on hotel, Gil put forward the concrete approach of hotel service quality improvement (Gil *et al.,* 2006).

The study took the city's starred hotel as the sample, studied the relationship between service quality, customer satisfaction and customer loyalty through literature survey method, sampling method and structural equation model analysis.

2. Materials and methods

2.1. Analysis steps of structural equation model

In general, it is necessary to evaluate the reliability and validity between observational variables and latent variables and the significant level of estimated parameters before the analysis operation of the model.

(1) Reliability appraisal: it refers to the results consistency or stability of the observed variable.

(2) Validity testing: the so-called validity is that the measurement tool can really measure the degree of what the researchers want to measure. The higher validity can more clearly reflects the characteristics of the testing results that researchers want to measure.

After assessing the reliability and validity of the observed variables and latent variables, data analysis using structural equation model generally can be divided into following steps.

(1) Model specification: analysts should build hypothetical initial theory model under the theories and previous research results, including make the definition for observational variables, latent variables and the relationship between them.

(2) Pattern recognition: confirmatory factor analysis model is generally divided into unrecognizable, recognizable and extra recognizable three types.

(3) Parameter estimation: on confirmatory factor analysis, Generalized Least Squares (GLS), Generalized Least Squares (ULS) and Maximum Likelihood (ML) are frequently-used parameter estimation methods.

(4) Model evaluation: after obtaining the results of parameter estimation, it is necessary to evaluate whether the model matches the data or not and make comparison with fitting index.

(5) Model modification: if the model can not fit with the hypothetical data well, it is necessary to modify the model and fit again.

2.2. Variable design and measurement

2.2.1. Service quality

SERVQUAL scale (Markovic and Raspor, 2012) defines the service quality around the 5 main dimensionalities, namely tangibility, reliability, responsiveness, assurance and solicitude. The study combined the reality of the hotel industry and defined the 5 quality dimensionalities as follows.

(1) Tangibility: it refers to hotel grade, location, surroundings, peripheral transportation and people dressing, etc.

(2) Reliability: it refers to the service ability that the hotel can execute accurately and reliably, such as food quality and security, food appearance, etc.

(3) Responsiveness: it refers to the spontaneity of hotel to help customers and provide convenient service and human-based management, etc.

(4) Assurance: it refers to the knowledge scope and polite attitude of the hotel staff and their attitudes toward the customers.

(5) Solicitude: it refers that the hotel shows caring for the customers and they can enjoy convenient reservation, polite service on the meal.

2.2.2. Customer satisfaction

IS0 9001 standards (2000) have made some pointed references to the eight quality management principles, such as customer focus, etc. and elaborated that customer satisfaction is customer's perception of the degree to which it is required. Whatever the definition of customer satisfaction evolved or changed, various kinds of researches divided

the basic characteristics of customer satisfaction index into hierarchy, relativity, subjectivity and periodicity.

2.2.3. Customer loyalty

Customer loyalty generally refers to the love that customers present on the company products or services, which mainly reflects from customers' emotional loyalty, behavior loyalty and awareness loyalty. The demarcation of the Customer loyalty should be analyzed case-by-case.

(1)Purchase motive: it will influence customers' brand loyalty. For those curious and affordable-concerned customers, they pay little attention on the brand. Therefore, they are easily to be influenced by the promotion strategy and have low brand loyalty.

(2)Promotion strategy: according to the purchasing involvement degree and the differences between the brands, customers' purchasing behaviors can be divided into 4 types: complex purchasing behaviors, disordered-reduced purchasing behaviors, brand-pursuit purchasing behaviors and regular purchasing behaviors.

(3)Customer economic condition: for customers, purchasing motivation is generally influenced by economic condition, social position and cultural environment, etc.

2.3. Build research hypothesis

2.3.1. The relational hypotheses of service quality and customer satisfaction

The study referred to a lot of suggestions from scholars, and set service quality as the influencing factor of the customer satisfaction. The study deduct that if customers perceive higher hotel service quality, they will be much more satisfied. The hypotheses are as follows.

H1: Service tangibility of hotel cantering has a positive effect on the customer satisfaction.

H2: Service reliability of hotel cantering has a positive effect on the customer satisfaction.

H3: Service responsiveness of hotel cantering has a positive effect on the customer satisfaction.

H4: Service assurance of hotel cantering has a positive effect on the customer satisfaction.

H5: Service solicitude of hotel cantering has a positive effect on the customer satisfaction.

2.3.2. The relational hypotheses of service quality and customer loyalty

Through the relevant researches, the study set service quality as the influencing factor of the customer loyalty and deducted that if the hotel had higher service quality, customers would be much more loyal to the hotel. The hypotheses are as follows.

H6: Service tangibility of hotel cantering has a positive effect on the customer loyalty.

H7: Service reliability of hotel cantering has a positive effect on the customer loyalty.

H8: Service responsiveness of hotel cantering has a positive effect on the customer loyalty.

H9: Service assurance of hotel cantering has a positive effect on the customer loyalty.

H10: Service solicitude of hotel cantering has a positive effect on the customer loyalty.

2.3.3. The relational hypotheses of customer satisfaction and customer loyalty

The study set customer satisfaction as the influencing factor of the customer loyalty and deducted that the more the customers satisfied with the starred hotel, the higher customer loyalty index would be. The hypothesis is as follows.

H10: Customer satisfaction has a positive effect on the customer loyalty.

2.4. Theoretical hypothesis model

According to the above-mentioned hypotheses, the study set service quality's tangibility, reliability, responsiveness, assurance and solicitude, customer satisfaction and customer loyalty as the latent variables.

And tangibility, reliability, responsiveness, assurance and solicitude are latent independent variables, and customer loyalty is latent dependent variable. On the one hand, when customer satisfaction is influenced by service quality, it is latent dependent variable. On the other hand, when customer satisfaction has an effect on service quality, it belongs to latent independent variable. Therefore, customer satisfaction is the intervening variable. The service quality management theoretical hypothesis model is shown in Figure 1.

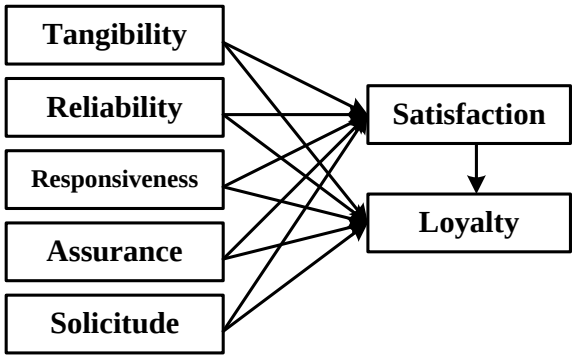

Figure 1. Service quality management theoretical hypothesis model

3. Results and discussions

3.1. Detection model empirical study of the starred hotel catering service quality

3.1.1. Respondents

In order to verify and complete the service quality management model in last chapter, the study selected the Lianyungang Dengtai Hotel and other starred hotels as the objects of empirical study. Several customers were randomly selected when they were settling accounts. And the study made questionnaires among them. On the base of questionnaires, the study applied the data to the quality management model to find more reference opinions and measures, which prompted the catering companies to make customer satisfaction plans and improved the service quality comprehensively to satisfied the increasing service needs of customers.

3.1.2. Variable measurement

(1) The measurement of service quality

Combined the facts of catering industry, the corresponding observation items are set up based on the five dimensions of SERVQUAL service quality table. The relevant contents are shown in Table 1.

Table 1. Service quality dimension and measurement

Quality dimension	Measurement items	Name of project variables
Tangibility	Hotel with high class	A1
	Great hotel location	A2
	Nice hotel surroundings	A3
	Convenient to get to the hotel	A4
Reliability	Food quality security	B1
	Good food appearance	B2
Responsiveness	Timely service	C1
	Human-based management	C2
Assurance	Polite waiters	D1
	Correct price measurement	D2
Solicitude	Convenient reservation	E1
	Be valued when wait for the seat	E2
	Be valued after check out	E3

The service quality measurement dimension model is shown in Figure 2.

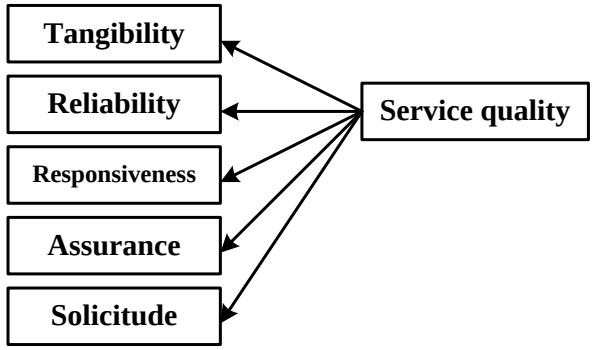

Figure 2. Service quality measurement dimension model (2) The measurement of customer satisfaction

The study has referred to literature (Lam *et al.*, 2004) satisfactory measuring index and combined with the facts of hotel industry in China and eventually set the corresponding observation items for the customer satisfaction dimension. The relevant contents are shown in Table 2.

Table 2. Customer satisfaction measurement

Dimension	Customer satisfaction		
Measurement items	Catering price satisfaction	Service attitude satisfaction	Professional skill satisfaction
Name of project variables	F1	F2	F3

The customer satisfaction measurement model is shown in (Figure 3).

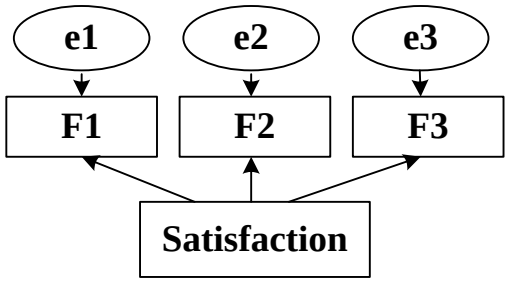

Figure 3. Customer satisfaction measurement model

(3)The measurement of customer loyalty

According to the Loyalty Scale that Dick and Bassou have studied in correlational researches, the study set the corresponding observation items for the customer loyalty dimension. The relevant contents are shown in Table 3.

Table 3. Customer loyalty measurement

Dimension	Customer loyalty		
Measurement items	To be a member	Recommend to others	As the first choice in the future
Name of project variables	G1	G2	G3

The customer loyalty measurement model is shown in Figure 4.

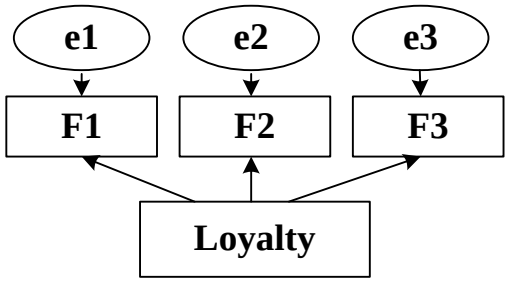

Figure 4. Customer loyalty measurement model

3.2. The test of questionnaire reliability and validity

3.2.1. Reliability test

Reliability is the degree of consistency or stability of the observed variables measurement results. If reliability is higher, the result can be more reliable. There are a lot of methods to test the reliability, such as splithalves method, retest method and Cronbach's Alpha coefficient method (Altman, 1997). Cronbach's Alpha coefficient method is a widely used calculation of homogeneity reliability.

Table 4. Comparison table of Cronbach's Alpha coefficient and reliability

Reliability	Unreliable	Barely unreliable	Reliable	Quite reliable*	Quite reliable*	Very reliable
Cronbach's Alpha coefficient value	<0.3	[0.3,0.4)	[0.4,0.5)	[0.5,0.7)	[0.7,0.9)	> 0.9

Note: ** refers to quite common, * refers to secondary common.

The study used the Cronbach's Alpha coefficient value to test the internal consistency of the variables. The specific results are shown in Table 5.

Table 5. Results of reliability test

Variable	Observational variable	Cronbach α	
Tangibility	A1	0.823	0.963
	A2		
	A3		
	A4		
Reliability	B1	0.863	
	B2		
Responsiveness	C1	0.805	
	C2		
Assurance	D1	0.792	
	D2		
Solicitude	E1	0.876	
	E2		
	E3		
Customer satisfaction	F1	0.906	
	F2		
	F3		
Customer loyalty	G1	0.915	
	G2		
	G3		

From the results of Table 5, it can be found that Cronbach's Alpha coefficient mean value of all latent variables is over 0.7. Therefore, the table is quite reliable.

3.2.2. Validity test

In this study, Validity construction used SPSS17.0 to make confirmatory factor analysis (XueJuan and Chen, 2010) and Average Variance Extracted (AVE) (Kisang *et al.*, 2012) to test construct validity. Before making factors analysis, the study used Kaiser-Meyer-Olkin (KMO) to measure whether it was suitable or not. KMO value that is more approach to 1 is more suitable for factor analysis. Kaiser (1974) thinks that if KMO value is greater than 0.9, it is fairly suitable to make factor analysis; KMO value ranged from 0.8 to 0.9, it is quite suitable to make factor analysis; KMO value ranged from 0.7 to 0.8 is suitable to make factor analysis; KMO value ranged from 0.6 to 0.7 is not so suitable to make factor analysis; KMO value ranged from 0.5 to 0.6 is quite difficult to make factor analysis; KMO value less than 0.5 is unsuitable to make factor analysis. Generally, KMO value over 0.5 can be regarded as the lowest standard.

Before extracting the factors, the sample should be examined sufficiently. Take tangibility factors analysis as the example, the results show that sample adequacy KMO value is 0.713, the sample distribution of the spherical Barteltt test chi-square value is 177.204, P is 0, which reflects that it's suitable to make factor analysis. At last, confirmatory factor analysis is performed on all variables and the results are shown in table 6.

Table 6. KMO and Barelett sphericity examination results

KMO examination		0.713
Barelett phericity examination	Approx. Chi-Square	177.204
	df	6
	Sig.	0.000

Table 7. Scale validity analysis

Validity	Observational variable	Factor loading	KMO	AVE
Tangibility	A1	0.801	0.713	0.524
	A2	0.778		
	A3	0.692		
	A4	0.602		
Reliability	B1	0.906	0.501	0.765
	B2	0.643		
Responsiveness	C1	0.718	0.501	0.476
	C2	0.662		
Assurance	D1	0.782	0.725	0.673
	D2	0.856		
Solicitude	E1	0.798	0.693	0.703
	E2	0.852		
	E3	0.864		
Customer satisfaction	F1	0.785	0.759	0.783
	F2	0.898		
	F3	0.961		
Customer loyalty	G1	0.895	0.775	0.775
	G2	0.864		
	G3	0.883		

From Table 7, it can be seen that factor loading of measurement observation items are ranged from 0.602 to 0.961, and all are greater than 0.5. Each factor KMO value is greater than or equal to 0.5. Except responsiveness value is 0.476, all variable values of AVE are ranged from 0.524 to 0.783, which are greater than 0.5 and reflects that latent variable can be much properly explained by target variable. Therefore, the scale has quite good construction validity.

3.3. Service quality detected structural model and goodness of fit evaluation

3.3.1. Service quality detected structural model

The Analysis of Moment Structures (AMOS) software (Jing, 2014) uses the maximum likelihood method to estimate and amend the structural equation model. AMOS is short for Analysis of Moment Structures, which is a easy-practical visualization module software. Using the image button of description toolbox can fast map SEM graphs, browse the estimation model and modifying the model diagram, evaluate the model adaptation and reference correction indexes, and output the best model. Building service quality management structural model under AMOS, it is required to set tangibility, reliability, responsiveness, assurance and solicitude as latent independent variables. Each of them has relevant relationship with the other. Therefore, these 5 latent variables establish pairwise correlation. Satisfaction and loyalty as dependent variables should be added with residual terms. The finished structural model is shown in (Figure 5).

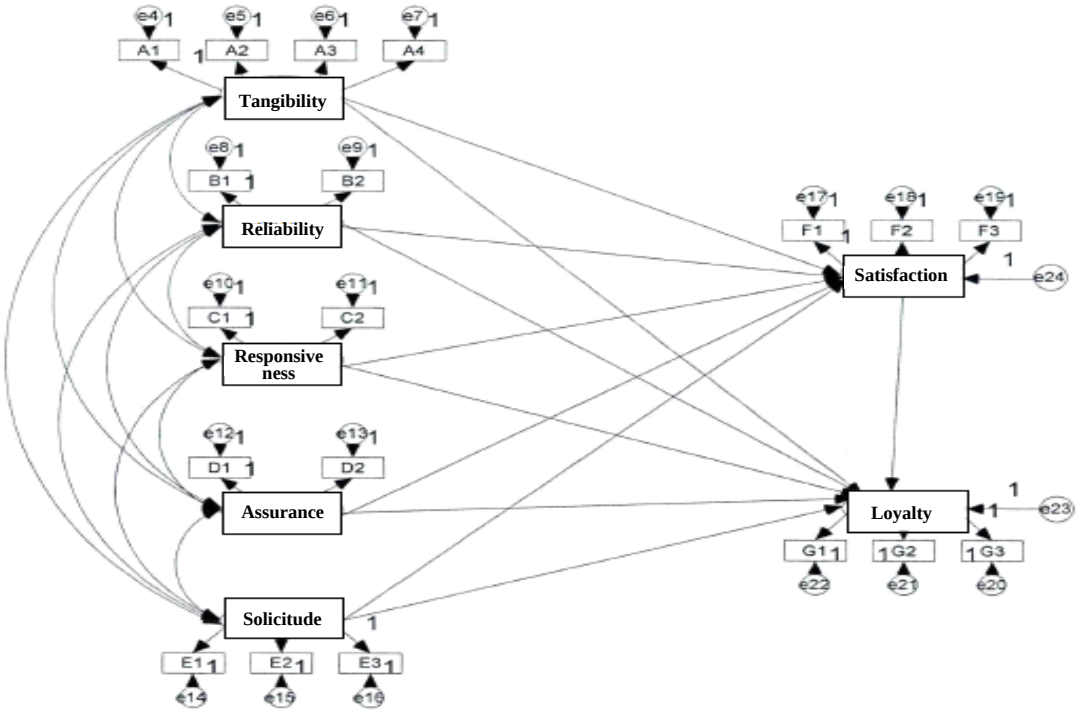

Figure 5. Service quality detected structural model

3.4. Service quality detected structural model and goodness of fit evaluation

The goodness of fit of the whole model is as follows.

Ratio of chi-square to degree of freedom is 1.955<3, RMR=0.031<0.05, GFI=0.941>0.9, RMSEA=0.064<0.08,NFI=0.901>0.9,CFI=0.932>0.9,RFI=0.879<0.9,TLI=0.910>0.9,IFI=0.934>0.9. It can be found that only RFI is smaller

than 0.9 but fairly close to 0.9. Therefore, the goodness of fit of the mode can be accepted.

Table 6 has given the structural equation model's standard path coefficient, Critical Ratio (CR) and significance level. The path coefficient of the model is estimated by using the CR value method. When P value of concomitant probability of CR statistics is less than 0.05, it is considered that two variables have path relationship, that is, path parameters is significant at the level of P<0.05.

Table 6. Path coefficient and P value of model in germination stage

Hypothesis	Standard path coefficient	C.R.	P
Customer satisfaction - tangibility	.11	2.832	***
Customer satisfaction - reliability	.21	3.501	0.0.13*
Customer satisfaction - responsiveness	.54	6.275	***
Customer satisfaction - assurance	-.13	-3.088	0.005**
Customer satisfaction - solicitude	.22	4.122	***
Customer loyalty - tangibility	.04	1.571	***
Customer loyalty - reliability	.03	0.613	***
Customer loyalty - responsiveness	.05	1.935	***
Customer loyalty - assurance	-.74	8.592	***
Customer loyalty - solicitude	-.46	5.536	0.006**
Customer loyalty - Customer satisfaction	.92	11.478	0.002**

Note: Significance level *P<0.05, **P<0.01, ***P<0.001

3.5. Hypothesis results

Table 7 provides the hypothesis path, path coefficient, P value and final examination results (support or nonsupport).

Table 7. Path coefficient and P value of model in germination stage

Hypothesis	Standard path coefficient	P	Results
Customer satisfaction - tangibility	.11	***	Support
Customer satisfaction - reliability	.21	0.0.13*	Support
Customer satisfaction - responsiveness	.54	***	Support
Customer satisfaction - assurance	-.13	0.005**	Nonsupport
Customer satisfaction - solicitude	.22	***	Support
Customer loyalty - tangibility	.04	***	Support
Customer loyalty - reliability	.03	***	Support
Customer loyalty - responsiveness	.05	***	Support
Customer loyalty - assurance	-.74	***	Nonsupport
Customer loyalty - solicitude	-.46	0.006**	Nonsupport
Customer loyalty - Customer satisfaction	.92	0.002**	Support

From the table 7, it can be seen that all the hypotheses have been verified except hypothesis H3, H9 and H10.

4. Conclusions

Empirical study has concluded that based on a part of starred hotels in Lianyungang, the 5 basic elements of service quality have different effects on customer satisfactory and customer

loyalty. Each latent variable influenced by observational variable in different degree. The study provides the empirical results for the whole catering service company leaders to urge local starred hotel managers to pay more attention to service quality management and supply more suggestions and measures to improve the service quality. In addition, the study hopes catering industry can make pointed references to make customer satisfaction plans and comprehensively improve service quality to satisfy the customers' increasing needs.

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EFFECT OF STARCH ENERGY GEL CONTAINED IN SPORTS FOOD ON RAPID ENERGY SUPPLY

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ABSTRACT

As the living level constantly improves, people require higher on health and then a sport storm rises. Under such a background pattern, sports food comes into sight. Sugar, fat and protein are the main energy source in sports food, which provide people nutrition needed during sports. Energy gel refers to the carbohydrates colloid made by choosing the Carbohydrates (sugar) as the main source of energy, at the same time adding all kinds of electrolytes and functional material. Using starch as the raw materials and all kinds of productions of amylase as the main source of energy, starch energy gel is a new sports nutritious food. At the same time, starch energy gel enjoys a large market and has a great development space due to the increasing demand of sport nutritious food. Based on the understanding of starch energy gel, this study explored the development and performance of starch energy gel and analyzed its rapid energy supply ability during sports. The quality of starch energy gel was improved by adding a little sodium citrate and electrolyte, on the premise of not affecting energy supply speed.

1. Introduction

Currently, with the appeal of extensive mass fitness programs, many body building exercises are carried out in China; however, many body builders have not obtained the optimal effect as expected. Some experts such as Szabó, S. A. and Chen Z find that, body builders only can create good sport performance by challenging their own body extremity, but at the same time, trauma is induced; therefore, body builders require a kind of sport nutritional food as a support during exercise to achieve extreme achievement (Szabó, 2004). As the functional food related to sports, Sports nutritious food is specially processed or modulated according to special formulation to meet the needs of physiology, metabolism and some specific nutrients of athletes, exercise groups and manual workers (Yao-Shan et al., 2013). The nutrition composition and content of this food, which has obvious difference between the ordinary food and health food, are collocated according to the physiological needs of sports population.

Based on the relationship of exercise physiology and nutrition, as well as the nutritional characteristics of various kinds of sports, Sports nutritious food is divided into four categories (Szabó, 2004): energy bars class, protein bars and protein powder, solid

electrolyte drinks and pedialyte and energy gel. Starch energy gel studied among this paper, as one kind gel of sports nutritious food, will be absorbed by human body quickly and used to metabolic after entering into the human body. Moreover, the edible can feel movement fatigue disappear soon because of its rapid energy providing. In addition to the energy source composition, starch energy gel itself contains scientific combination of multivitamins, electrolyte, etc., to make energy supply more reasonable. Starch energy gel as a representative of sport nutritional food draws attention from the world and more and more starch energy gel are sold (Shuqiong et al., 2000). Since Powet Bar Inc. released a special sports food called Pefoim, energy gel emerges in sport nutritional food. The product containing a large amount of energy is able to rapidly release energy if needed and meanwhile ensure absorption and utilization to the largest extent (Laure et al., 2013). Afterwards, more and more products come into the market (Ge et al., 2013): a bag of PR04 Gel produced by Pro4 Bodyfuel Company from Canada (45 g) contains 25 g of carbohydrate whose chain length is from 20 to 23, with electrolyte such as potassium, sodium, magnesium, calcium, phosphorus and caffeine inside, and it sells for 3 USD; a bag of CLIF SHOT produced by Vigorous Living Inc. (47 g) is composed of 23-24 g carbohydrate, 12 to 13 g oligosaccharide and various electrolyte, and it sells for 1.5 USD. Making use of the rapid supply ability of starch energy gel, this study discussed its development and performance and analyzed the effect of starch energy gel on sports.

2. Materials and methods

Overview of starch energy gel

2.1. Advantage of starch as the energy gel

In this paper, sugar was chosen to be the main power of energy gel and starch was used to be the main raw material of preparing starch gels. Choosing starch as the main raw material has the following advantages (Qin et al., 2004):

First is wide range of sources and low price. Starch is the naturally occurring carbohydrates and widely distributed in nature. Most of higher plants contain starch. The variety of starch is wide. At the same time, its price is low. Therefore, choosing the starch as the raw material for mass production will not only promote the processing and utilization of agro-food, but also provide a new way for the development of agro-food.

Compared to the protein and fat, starch as the material providing energy is more easily assimilated by human body to provide energy for human. The most important feature of energy gel is to provide energy rapidly. That's to say in a relatively short period of time, it can provide lots of energy, electrolyte that human needs. Therefore, starchy material has incomparable advantages in this aspect (Ruijing et al., 2015).

Green pollution-free, starchy material is not harmful to human body. Once entering the human body, starch will be fully hydrolyzed into monosaccharide or disaccharide. And finally, it will be out of the body in the form of CO_2 and water. Even if in the process of lacking of oxygen with high intensive exercise, it won't produce toxic substances, which meets the requirements of environmental protection in the body.

2.2. Energy supply advantage of starch energy gel

Sugar, fat and protein are called energy substance or biofuel as they can produce adenosine triphosphate (ATP) in human body. ATP is considered as direct energy supply substance in any form of movement of human body. Athletic ability can be remained by supplying ATP as soon as possible (Tracy et al., 2004). Starch energy gel with monosaccharide, oligosaccharide and polysaccharide as materials of energy supply has advantages of rapid energy supply and long-time effect. Sugar can provide energy in extreme conditions of sufficient supply or insufficient supply, and such performance is called energy supply by

sugar aerobic oxidation and energy supply by sugar anaerobic glycolysis, respectively, while fat and protein can only supply energy in condition of sufficient oxygen supply.

Sugar generates carbon dioxide and water after metabolism and decomposition and they will discharge from human body through breathing and perspiration, with little influence on internal environment. But fat and protein will produce ketone body and ammonia besides water and carbon dioxide, which will affect the homeostasis of body fluid.

Sugar shows a high utilization speed and rapid energy supply during sports. Energy can be released three times faster from sugar than fat.

Sugar is an indispensible energy substance during sports and also the most consumed substance; therefore, sugar supply is of great importance. As a high-quality fuel of cells, sugar consumes little oxygen while supplying energy. In the condition of same oxygen supply quantity, energy generation from sugar has a 4.5 % high efficiency than fat. When athletes are lack of oxygen, making use of sugar supply can be the decisive factor of an important competition.

Moreover, it has been suggested that, supplying sugar before sports can optimize carbohydrate storage in muscle and liver (Prahm et al., 2012), ensure rapid movement and sprint force at the end of long-term sports, keep concentration of sugar in blood, remain high sugar oxidation rate, save hepatic glycogen, reduce consumption of protein and significantly improve athletic ability (Baty et al., 2007; Kristin et al., 2010). Supplying sugar during sports can raise the concentration of blood glucose, increase the utilization of exogenous energy, save muscle glycogen, delay the emergence of fatigue and improve movement ability. Supplying sugar after sports can promote the resynthesis of glycogen, ease fatigue, promote the recovery of physical power, increase the storage of muscle glycogen and liver glycogen, thus to provide the largest guarantee for the continuous training and competition of athletes (John, 2011; van Hall, 2000).

3. Results and discussions

Development and performance of starch energy gel

3.1. Formula of starch energy gel

Table 1. Formula of starch energy gel

Starch energy	45 g/bag
Total energy	100 CAL
Complex carbohydrate	25g
Magnesium	4.5 mg
Sodium	40.5 mg
Chlorine	13.5mg
Fat	0 g
Protein	0 g

Preparation of starch energy gel is designed (Nancy, 2001) by referring to design schemes of various sport energy foods and combining with oversea products and sports nutrition requirements. Every bag of energy gel is confirmed as 45 g, which contains 25 g complex carbohydrate. Potato maltodextrin is added as carbohydrate source. Monosaccharide with little contained can rapidly provide energy and polysaccharide with large polymerization degree can remain energy supply for a long time. One bag each 30-45 min during sports can basically meet the demand of energy.

3.2. Performance of starch energy gel of sports food

Electrolyte is an important component of starch energy gel (Muffler and Ulber, 2008). According to the formula design of energy gel, sodium chloride, potassium chloride and anhydrous magnesium sulfate are added to investigate the effect of ion such as sodium, potassium and magnesium on rheological property and energy releasing speed.

Effect of electrolyte addition on rheological property

Starch energy gel is in colloidal state and its rheological property change plays an important effect on product performance. To explore the effect of electrolyte addition on product performance, product with and without electrolyte are analyzed. The relationship between viscosity and shearing rate is shown in figure 1.

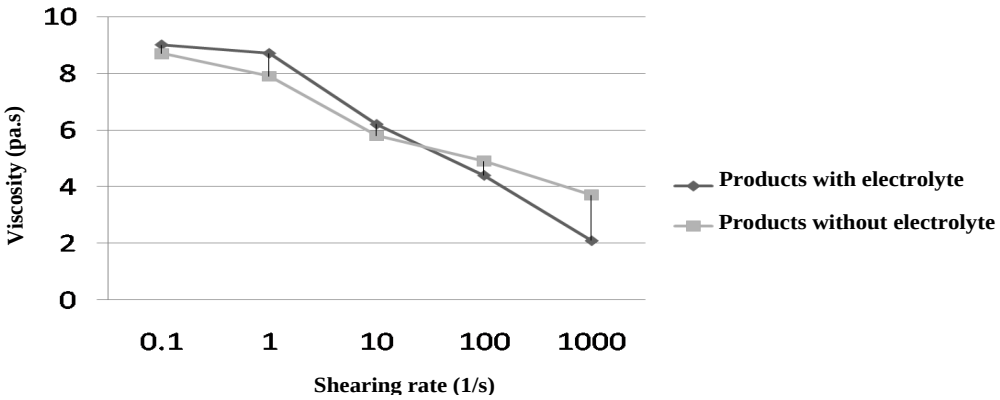

Figure 1. Effect of electrolyte on rheological property of product

Compared to products without electrolyte, a little electrolyte has almost no effect on rheological property of products, which is seen from the basically coincident curves. From the tendency of the curve, it is not hard to find that , rheological property of starch energy gel performs as thin shear, i.e., viscosity tends to be lower as shearing rate increases, which is the characteristic of pseudoplastic fluid.

Effect of electrolyte addition on energy releasing speed of products

To explore whether electrolyte has counteraction on digestion and absorption performance of energy gel products or not, this study tests the releasing speed of energy gel by in vitro digestion simulation experiment. Results are shown in figure 2. Products with electrolyte have a consistent digestion speed curve with those without electrolyte, suggesting they have the basically same digestion speed. It can be seen that, electrolyte addition has little influence on energy releasing speed of products. During hydrolysis reaction, reducing sugar releasing rate of products rises to a stable value after 40-minute reaction; at the moment, releasing speed of reducing sugar no longer changes and the energy released reaches the maximum. It is suggested that, energy gel can achieve a expected energy supply effect with a high speed; though the energy supply is slow at the beginning, energy increases over time; as enzymes gradually hydrolyzes, starch energy gel can completely provide part of the energy needed within 40 min.

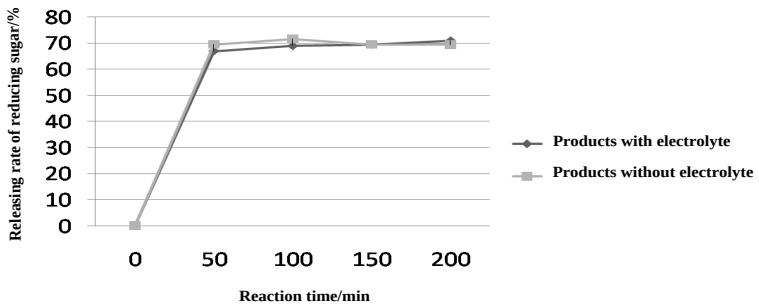

Figure 2. Effect of electrolyte addition on energy releasing speed

3.3. Energy releasing speed of starch energy gel

Energy gel as a digestible sports nutritional food can rapidly provide athletes with effective energy to remain their sports. Starch energy gel mainly provides energy necessary in strenuous exercise through monosaccharide which is the product of digested maltodextrin. Thus effect of energy gel is in a close correlation with digestion speed of energy. Digestion speed of starch energy gel was tested and then compared with ordinary potato starch and soluble starch. Figure 3 shows the content of reducing sugar of starch energy gel, potato starch and soluble starch under different reaction time.

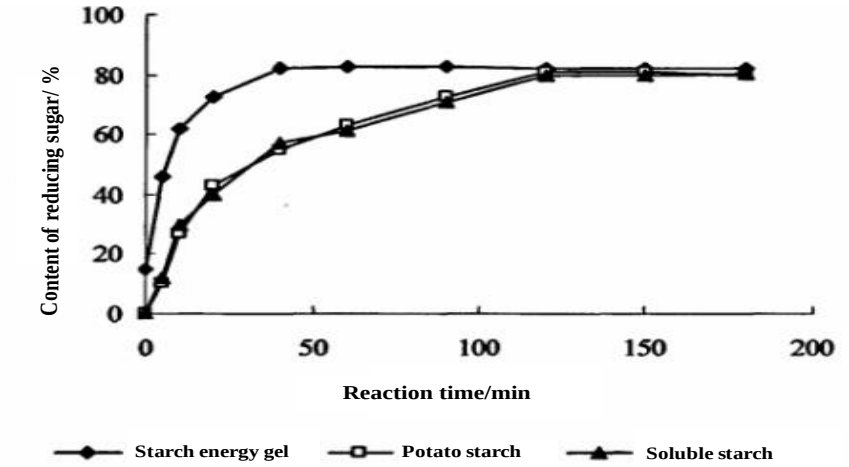

Figure 3. Comparison of digestion speed of starch energy gel, potato starch and soluble starch

Compared with native starch and soluble starch, starch energy gel is found with higher digestion speed. It can provide part of energy during sports for 40 min. Comparison experiment reveals that, starch energy gel supplies energy for athletes making use of high-speed energy supply speed.

3.4. Analysis of the effect of products on sports food through experiments

From the products in vitro digestion experiment, it can be found that the speed of energy releasing in energy gel war faster, which achieved expected results. However, due to the difference between the external digestion and internal digestion, it can't be entirely sure whether it will achieve expected results that effect of production on athletic ability after

being consumed by human body. So, in order to verify the effect of energy gel, in this paper, loading swimming time of laboratory rats that ingest products was used to be the index for inspecting. The results were shown as Table 2.

Table 2. Experimental results of the rats loading swimming

Laboratory rat number	blanking		Energy gel		Soluble starch	
	Weight	Exhaustive time	Weight	Exhaustive time	Weight	Exhaustive time
1	215	876	236	1005	194	889
2	235	798	220	967	206	953
3	234	867	184	953	211	904
4	189	901	245	963	187	917
5	226	934	213	892	228	921
6	204	890	193	922	237	967
The average swimming time	/	877.7	/	950.3	/	925.2

It can be seen from the Table 3-1 that the weight of rat is different in each group for this experiment adopted random allocation. But the average weight is between 180g to 250g. Meanwhile, ensure that loading weight of each rat is 5% of its own weight to reduce the experiment error by controlling the weight. The experimental results show that there is no necessary association between the weight of rat and its loading weight swimming time. For rats with light weight, the swimming time might be longer than those with heavy weight. Therefore, the experiment results influenced little by the rat's weight.

Comparing experimental results of three groups, it was found that the average swimming exhaustive time in both of energy gel and soluble starch is better than the blank group. For rats ingesting energy gel, their average swimming exhaustive time increased by 8.3%, and for those ingesting soluble starch, the time increased by 5.4%. That is to say the athletic ability improved obviously by feeding rats to provide the energy for movement with a certain amount of carbohydrates before doing exercise. From the aspect of index, energy gel group was better than the soluble starch group, which shown that effect of energy gel for improving athletic ability is obviously better than the soluble starch. The experimental results show that the starch energy gel developed in this paper performs well in quickly providing and improving sports ability and achieves the desired results.

4. Conclusions

Sodium citrate experiment demonstrates that sodium citrate is positive in improving product quality and enhancing storage stability of product, without affecting energy supply speed of energy gel. Comparison of native starch and soluble starch suggests that, sports food with starch energy gel can supply energy rapidly for almost 40 minutes and has a faster digestion speed than other sports food in same level; it can make athletes achieve the expected sports effect making use of fast energy releasing speed without harm to body.

Moreover, the research results demonstrate that, sodium, potassium and magnesium will not affect rheological property of energy gel and energy supply speed. To sum up, rapid energy supply ability of starch energy gel plays an important function in body building exercises, with no side effects.

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EFFECTS OF WAXY WHEAT FLOUR ON SKIN AND QUALITY OF QUICK-FROZEN DUMPLING

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ABSTRACT
This study was designed to explore effects of waxy wheat flour on skin and quality of quick-frozen dumpling. How different quantity of waxy wheat flour influenced cooking characteristics, texture properties and sensory characteristic were measured. Finally, we found cooking characteristics of quick-frozen dumpling skin was obviously improved, toughness of raw dumpling skin was also improved and moreover crackling rate of frozen dumpling had a remarkable decline. Analysis of sensory evaluation suggested that, quick-frozen dumpling which was added with waxy wheat flour turned to have higher score on stickiness and refinement, improved boiling resistance, but poor color and gloss. Adding 20% waxy wheat flour could achieve best improvement on dumpling skin, cooking characteristics, texture property, crackling rate and sensory characteristic. Waxy wheat flour has better gelatinization property, water holding capacity and freeze-thaw stability and adding a proper quantity of waxy wheat flour can effectively lower crackling rate of quick-frozen dumpling and improve cooking quality.

1. Introduction

Wheat distributing widely worldwide (Li et al., 2013) accounts for 32% of global crop planting area. Wheat grain is composed of starch, protein, water, little lipid and coarse fiber (Nadaud et al., 2010). Generally, wheat starch is made of 20% ~ 30% amylase and 70% ~ 80% amylopectin. Waxy wheat refers to wheat starch without amylase or with only a small quantity of amylase (<1%) (Chakraborty et al., 2004). Starch in waxy wheat contains 90% over amylopectin which is different from amylase in aspects of gelatinization, gel, swelling and crystal. No obvious differences are found in in structure, branch number and degree of polymerization of amylopectin, but amylopectin in waxy wheat is observed with no long branch but a dense structure. (Graybosch et al., 2003; Delwiche and Graybosch, 2002; Cai and Shi, 2010). Compared to ordinary wheat flour, waxy wheat flour has relatively low gelatinization temperature and resuscitation value but high peak value and breakdown value. That means waxy wheat flour can be gelatinized under a low temperature and it ages slowly after gelatinization; therefore, waxy wheat flour is suitable to be added in wheat flour to improve quality of bread and steamed bun (Guan et al., 2009). Though waxy wheat flour has high content of protein and gluten, short stability time, small farinograph quality number and poor protein lead to bad elasticity, restraining operation.

Waxy wheat flour possesses special physicochemical properties, such as strong water holding capacity and expansion ability, good freeze-thaw stability, small resuscitation

value and large coagulation resistance. Waxy wheat flour is supposed to be able to improve quality of product of wheat flour. It is widely applied in food processing and development of new product and is suitable to be used in refrigerated food and quick-frozen food (Fujita et al., 2012). Good coagulation resistance and freeze-thaw stability are beneficial for quality of frozen starch based products. Yi et al (Yi et al., 2009) once studied the effect of waxy wheat flour in frozen dough and found addition of waxy wheat flour could improve stickness of frozen dough and reduce damage on structure caused by crystal during long-time refrigeration, thereby maintaining elasticity and ductility.

In quick-freezing process, properties of dough turn to be deteriorative, resulting in poor quality. Thus it is necessary add proper quantity of food additives into dough to prevent quality deterioration in different processes. Recently, ameliorant used in quick-frozen dumpling made of wheat flour is studied more and more, but research on compound is still in a small number (Peng, Cheng and Chuan, 2007). This study explored variation of cooking characteristic, texture properties and sensory characteristics of quick-frozen dumpling added with different quantity of waxy wheat flour as well as effects of waxy wheat flour on freeze-thaw stability of starch gel, aiming to provide a new approach to avoid fracture of quick-frozen dumpling and expand the application of waxy wheat in food.

2. Materials and method

2.1. Materials and instruments

Materials used included wheat flour (special dumpling flour or high gluten flour). Manufacturing procedures of dumping included knead dough, fermentation, skin making, dumpling making, quick-freeze, test and refrigeration.

Main instruments included EL204-IC electronic scale, HH-4 digital displayed thermostat water bath, DFY-600 oscillating high-speed pulverizer, K9481 gerhardt kjeldahl determination device, low-speed and large-capacity multi-tube centrifuge, Kitchen Aid dough maker, JMTD 168/140 test noodle maker, MDF-U5412 cryogenic refrigerator, freezer dryer, UV-2800 ultraviolet and visible spectrophotometer, CR-400 color difference meter, Super-3 rapid viscosity analyser, Farinograph-E farinograph; D8 Advance x-ray diffractometer; S-4800 field emission scanning electron microscope.

2.2. Detection of cooking characteristics of quick-frozen dumpling skin

2.2.1. Optimal cooking time

First, 800 mL distilled water was poured into a beaker. After the water boiled, 10 dumpling skins were put into the water. Count from the second boiling of distilled water. Dumpling skins were taken out from the water every 30 s and cut apart on glass pan to observe whether the skin was totally well-done. If it was, then that time point was the best cooking time for dumpling skin (Szymczak and D02browski, 2015). Cooking time for quick-frozen dumpling was set as two minutes more than the best cooking time of dumpling skin.

2.2.2. Rate of cooking loss

Five pieces of quick-frozen dumpling skins were weighed by an electric scale and then cooked in 400 mL boiling distilled water. Afterwards, the dumpling skins were put on filter screen and washed by 50 mL distilled water. 30 s later, the water was moved into the beaker along with the dumpling skins. When the mixture cooking on electric stove was condensed to 200 mL, it was taken out and dried in 105 °C baking oven. Finally, the dumpling skins were weighed and the rate of cooking loss of dumpling skin was calculated as follows.

$$\text{Rate of cooking loss (\%)} = \frac{m_2 - m_1}{m_0} \times 100 \quad (1)$$

Where m0 refers to weight of dumpling skin (g); m1 refers to original weigh of beaker (g) and m2 refers to weight of beaker and dried substance (g).

2.2.3. Detection of toughness of raw dumpling skin

Dumpling skin which has been thawed was placed on test board and moved to the place below HDP/TPB probe of texture analyzer. Test mode was set as Distance, distance was set as 80 mm; speed before, during and after test was set as 1.0 mm/s, 2.0mm/s and 5.0 mm/s respectively. Induction force was set as Auto 10.0 g. Every sample was tested thrice (Uwabe, Akiyama and Nishinari, 2004).

2.2.4. Texture profile analysis (TPA)

The function of mixed type of food package can be simply summarized by a simplex text type. Sometimes, the text of mixed type has both the feature of informative and operative text, while express the information of food it has operative function. It has the function of advertising product and warning the consumer, such as trade mark, caution (sensitinogen etc,), reminder etc. Sometimes, it is neither informative text nor operative text but advocating ideas etc.

2.2.5. Detection of cracking ratio of quick-frozen dumpling

Forty dumplings were frozen at -40 °C. 30 min later, they were taken out and observed under natural light.

$$\text{Cracking ratio (\%)} = \frac{\text{number of frost-cracked dumplings}}{\text{total number of dumplings}} \times 100 \quad (2)$$

2.2.6. Sensory evaluation on quick-frozen dumpling

Quality of quick-frozen dumplings was scored using evaluation method in Dumpling Quality Scoring Criteria SB/T10138-1993 (Hallenstvedt et al., 2012; Armentia-Alvarez and Garcia-Moreno, 1994). A group consisting 10 people was set up. Everyone evaluated 10 dumplings once. The average value of scores was taken as the final result. Sensory evaluation criteria for quick-frozen dumpling are demonstrated in table 1.

Table 1. Sensory evaluation criteria for quick-frozen dumpling

Index		Evaluation criteria
Outlook30	Color 10	White, ivory, cream yellow (6-10); yellow or abnormal color (0~5)
	Glossiness 10	Bright (7-10); general (4-6); dim (0~3)
	Transparency 10	Transparent (7-10); semitransparent (4-6); non-transparent (0~3)
Taste 40	Stickness 15	Unsticky (11-15); slightly sticky (6-10); sticky (0-5)
	Toughness 15	Chewy (11-15); general (6-10); excessively cooked (0-5)
	Tenderness 10	Refine (7-10); relatively refine (4-6); rough (0-3)
Boiling resistance 15		Complete dumpling skin (11-15); damaged dumpling skin (6-10); Cracked dumpli ng skin (0-3)
Dumpling soup 15		Clear (11-15); clear and with little sediment (6-10); obvious sediment (0-5)

2.2.7. Statistical method

Diagram was plot with Excel and GraphPad Prism 5. Variance was analyzed by SPSS 17.0 software. Duncan test was also used. Data were statistically analyzed at the significant level of $P<0.05$; and correlation of data was analyzed at the significant level of $P<0.05$ and $P<0.01$.

3. Results and discussions

3.1. Effects of waxy wheat flour on the best cooking time and rate of cooling loss of quick-frozen dumpling

Cooking time is considered as an important index for reflecting cooking characteristics of product. Reducing cooking time is of great important for improving efficiency. Rate of cooking loss, another important index for reflecting cooking quality of dumpling skin, can reflect the content of starch dissolved in dumpling soup. Soup becomes turbid when irreversibly expanded starch particles are separated out from dumplings due to damaged hydrogen bond while cooking.

Table 2. The best cooking time of quick-frozen dumpling skin

Additive proportion	0	10	20	30
The best cooking time(min)	11.15 ± 0.03^{a}	9.99 ± 0.01^{b}	8.48 ± 0.02^{c}	7.52 ± 0.11^{c}

Table 2 demonstrates that, adding 10% or 20% waxy wheat flour could obviously shorten the best cooking time of quick-frozen dumpling skin ($P<0.05$), and more additive proportion could result in more reduction in cooking time. As waxy wheat flour with low gelatinization temperature needs little energy during cooking, it is easy to be gelatinized after absorbing water.

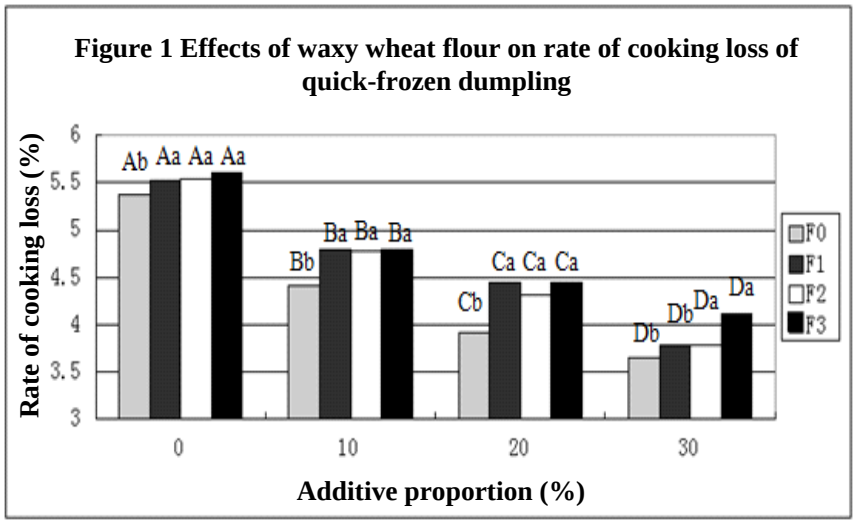

Figure 1. Effects of waxy wheat flour on rate of cooking loss of quick-frozen dumpling

It can be seen from figure 1 that, rate of cooling loss remarkably decreased as adding content of waxy wheat flour became larger, under the same freezing and thawing cycle ($P<0.05$); rate of cooking loss of dumpling skin which was made of mixed powder containing 20% lower waxy wheat flour had a significant difference with unfrozen dumplings, but when the additive proportion turned to be 30%, the difference was not obvious ($P<0.05$). It has

been found that, flour used for making quick-frozen dumplings should have high thermoviscosity, thus reducing loss of flour on the surface of dumpling skin. Gelatinized waxy wheat flour with high stickness prevents falling of starch effectively; moreover, amylopectin with good water binding capacity lowers content of congealable water and restrains growth of ice crystal in freeze-thaw process, thus reducing the damage of ice crystal on network structure of protein (Zheng, Zhang and Ren, 2013). On this account, starch is not easy to dissolve into dumpling soup during cooking, reducing the loss.

3.2. Effects of waxy wheat flour on toughness of raw dumpling skin

Toughness of raw dumpling skin reflects the evenness and anti-tensile strength of dumpling skin. Toughess of dumpling skin is not only correlated to the property of starch but also can be impacted by the manufacturing technique of dumpling skin. Dumpling skin made with reasonable manufacturing technique is smooth and elastic.

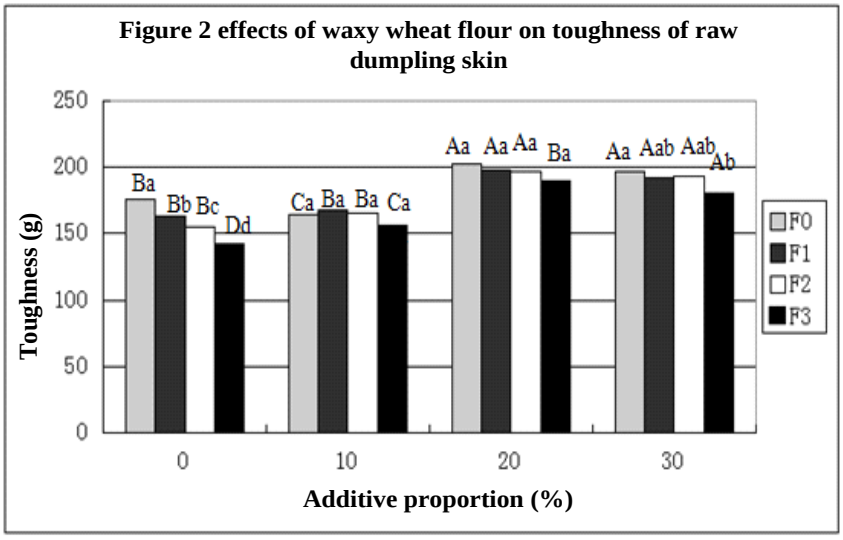

Figure 2. Effects of waxy wheat flour on toughness of raw dumpling skin

Figure 2 suggests that, adding 20% over waxy wheat flour could improve the toughness of raw dumpling skin; as freeze thawing performed over and over, dumpling skins without waxy wheat flour tended to be less tough ($P<0.05$), while those which was added with 10% or 20% waxy wheat flour had no obvious changes of toughness, showing a sound stability. It might be correlated with ice crystal formed in dumpling skin. Repeated freeze thawing can promote formation of large ice crystal in starch, resulting in damage on structure of protein in dumpling skin, expelling water out of skin and thus inducing cracking of dumpling skin (Nyman et al.,2006). Thus waxy wheat flour with good water-retaining property was found to be effective in enhancing stability of toughness of dumpling skin during freezing and thawing cycle.

3.3. Effects of waxy wheat flour on TPA of quick-frozen dumpling skin after cooking

Texture profile of food is widely applied to represent texture, taste and feeling of food. TPA is a quantitative evaluation method for evaluating hardness, springiness, adhesiveness and chewiness of foods based on analysis of chewing curve. Property of food can be known by simulating chewing action of teeth. Hardness refers to changes of resistance felt in the process of biting food, which can represent the aging degree of the tested sample.

Springiness refers to the ability of specimen recovering to original size and form after being condensed. Dumpling with large springiness would be chewy. Cohesiveness refers to size of internal bonding strength required by formation of shape, which reflects the size of bonding effect between internal molecules or structural elements. Gumminess is usually used to describe semi-solid samples. Chewiness refers to energy needed by chewing solid samples, which can be used for reflecting the resistance capability of samples to chewing. Resilience reflects the resilience capability of samples after being condensed. High resilience indicates dumpling skin has strong rebound ability.

Table 3. TPA property of quick-frozen dumpling skin after cooking

Additive proportion	Feezing and thawing cycle	Hardness (g)	Elasticity	Gumminess	Chewiness
0 (%)	F0	5954.2310±9.483^{a}	0.9870±0.005^{a}	5965.458±30.389^{a}	4003.456±106.887^{c}
	F1	5352.995±6.284^{b}	0.985±0.002^{ab}	5800.189±23.214^{b}	5718.774±18.443^{a}
	F2	5354.102±11.266^{bc}	0.984±0.026^{bc}	5410.332±7.457^{c}	5346.552±37.224^{b}
	F3	5212.567±17.667^{c}	0.922±0.101^{d}	4365.789±48.181^{d}	5885.321±37.483^{a}
10 (%)	F0	4986.478±31.255^{a}	0.973±0.029^{a}	3732.441±41.615^{a}	3487.921±10.975^{a}
	F1	4838.754±27.416^{bc}	0.950±0.099^{a}	3722.455±16.015^{a}	3510.228±17.885^{a}
	F2	4893.541±35.226^{bc}	0.959±0.104^{b}	3666.778±19.474^{b}	3200.818±21.784^{b}
	F3	4458.874±22.151^{d}	0.948±0.117^{c}	3580.369±24.727^{c}	2561.852±11.567^{c}
20 (%)	F0	4320.777±29.725^{a}	0.984±0.119^{a}	3451.787±25.715^{a}	3363.448±8.124^{b}
	F1	4300.220±34.705^{a}	0.970±0.027^{b}	3452.414±1.385^{a}	3551.663±3.969^{a}
	F2	3996.039±1.754^{b}	0.962±0.007^{c}	3152.812±3.484^{b}	3521.411±11.879^{a}
	F3	3730.365±3.447^{c}	0.964±0.126^{bc}	2621.246±0.757^{c}	3066.332±19.587^{c}
30 (%)	F0	3923.411±33.215^{a}	0.977±0.099^{a}	3450.898±15.415^{a}	3210.485±23.989^{a}
	F1	3799.231±3.124^{b}	0.976±0.119^{a}	2999.445±11.664^{b}	2893.854±7.104^{b}
	F2	3503.022±4.987^{c}	0.966±0.034^{b}	2352.387±11.567^{c}	2722.621±13.777^{c}
	F3	2999.401±4.051^{d}	0.968±0.004^{b}	2002.100±2.331^{d}	2000.348±13.071^{d}

It can be known from table 3 that, quick-frozen dumpling skin showed up remarkable changes in hardness, springiness and gumminess as additive proportion of waxy wheat flour and cycle time of freeze-thaw increased ($P<0.05$). From F0 to F3, hardness and adhesiveness of dumpling skin gradually decreased. Addition of waxy wheat flour can also lower the hardness of dumpling skin, but the variation tendency became less obvious when 20% waxy wheat flour was added. Quick-frozen dumpling skin added with 20% or 30% waxy wheat flour presented good elasticity and changed little during freeze-thaw cycle. It might be correlated to good freeze-thaw stability of waxy wheat flour.

3.4. Effects of waxy wheat flour on cracking rate of quick-frozen dumpling

Cracking rate is also an important index for evaluating quality of quick-frozen dumpling. In the process of quick-freezing, dumpling first becomes hard and gradually loses elasticity, then gluten matrix is damaged and finally cracks appear. Figure 3 shows that, cracking rate of quick-frozen dumpling significantly decreased as additive proportion of waxy wheat flour became more; and cracking rate rose slowly as cycle time of freeze-thaw increased. Change of cracking rate was the smallest when 20% waxy wheat flour was added. Two factors contribute to the cracking of quick-frozen dumpling. One is the high content of amylopectin. Amylopectin with a good water-binding capacity inhibits loss of water, thereby reducing the possibility of cracking. The other reason is that, amylopectin can restrain formation of ice crystal in the process of freezing, reducing the damage of ice crystal on network structure of dumpling skin.

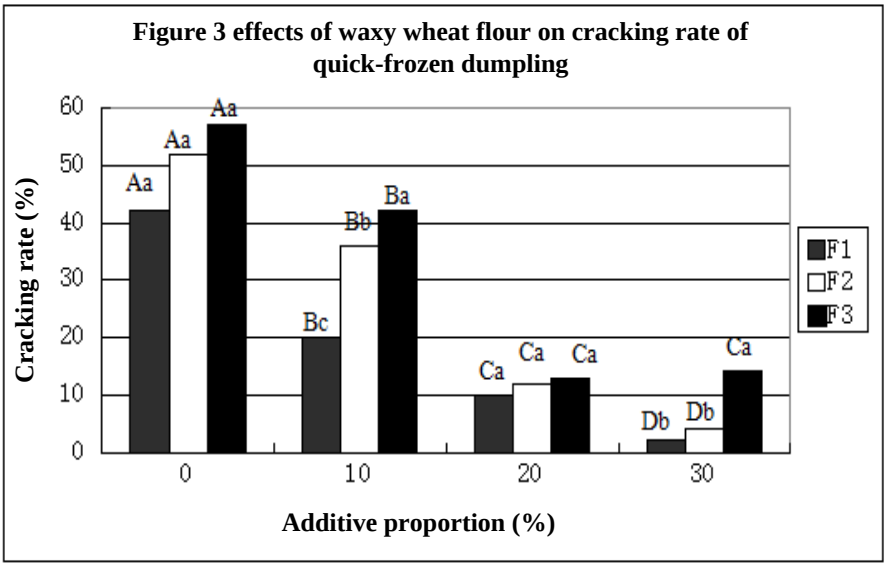

Figure 3. Effects of waxy wheat flour on sensory evaluation of quick-frozen dumpling

Table 4. Table of sensory evaluation on quick-frozen dumpling

Additive proportion	Freezing and thawing cycle	Outlook			Taste			Boiling resis-tance	Dum-pling soup	Total
		Color	Glo-ssine ss	Trans-parency	Stick-ness	Tough-ness	Tender-ness			
0 (%)	F0	8.2	7.1	7.1	9.9	9.8	6.1	12.1	11.7	72
	F1	8	6.3	6.4	9.3	8.7	6.0	10	8.7	63.4
	F2	7.5	7.0	6.9	10.2	8.6	6.0	7.7	11.6	65.5

	F3	7.2	6.9	7.2	9.8	9.7	6.1	9.1	6.1	62.1
10 (%)	F0	8.1	7.6	6.1	10.1	10.2	6.3	12.2	13.2	73.8
	F1	7.6	6.4	5.4	9.7	10.2	6.5	11.8	12.5	70.1
	F2	7.7	7.3	6.7	9.3	9.7	6.4	10.7	8.5	66.3
	F3	7	7.4	7.4	10.1	9.7	6.5	11.2	12	71.3
20 (%)	F0	7.4	7.3	6.2	10.9	11.1	7.4	12.4	12.6	75.3
	F1	7.2	7.1	6.8	9.9	10.7	7.4	11.8	11.4	72.3
	F2	6.8	6.7	6.1	10.3	9.7	6.9	11.2	11.5	69.2
	F3	7.2	7.2	6.9	9.9	9.5	6.2	11.1	10.8	68.8
30 (%)	F0	7.4	7.1	7.1	10.6	10.6	7.3	11.6	12.3	74
	F1	7.1	7.0	6	9.5	10.3	7.3	11.5	11.6	70.3
	F2	7.2	6.6	6.5	9.2	10.8	7.2	9.5	11.2	68.2
	F3	6.9	7.1	6.7	9.3	9.2	6.7	11.2	11	68.1

Table 4 suggests that, total score of quick-frozen dumpling was lower than unfrozen dumplings; quick-frozen dumpling added with waxy wheat flour showed improved taste (stickness, roughness and tenderness), boiling resistance and soup but poor color and glossiness. Overall sensory score of quick-frozen dumpling tended to rise and then decrease as additive proportion of waxy wheat flour increased and the overall score was the highest when additive proportion was 20%.

3.5. Analysis of correlation between mixed flour and quality of quick-frozen dumpling

To explore factors influencing quality of quick-frozen dumpling, we made a correlation analysis on the property of mixed flour and quality of quick-frozen dumplings. Results are shown in table 5.

Table 5. Correlation between property of mixed flour

	Water absorption	Stable time	Formation time	Peak stickness	Retrogradation value	Gelatinization temperature	Enthalpy value	Gel hardness
Rate of cooking loss	-0.973*	-0.545	0.938	-0.958*	0.937	0.953*	0.971*	0.985*
Roughness of raw dumpling skin	0.785	0.825	-0.812	0.937	-0.801	-0.788	-0.831	-0.930
TPA hardness	-0.911	-0.715	0.952*	-0.998**	0.950	0.953*	0.925	0.995**
Chewiness	-0.982*	-0.214	0.794	-0.800	0.793	0.911	0.965*	0.881
Cracking rate	-0.986*	-0.510	0.912	-0.946	0.912	0.973*	0.985*	0.985*
Color after cooking	-0.968*	-0.579	-0.877	-0.958*	0.875	0.930	0.981*	0.995**
Boiling resistance	0.890	-0.042	-0.502	0.574	-0.499	-0.683	0.882	-0.717
Dumpling soup	0.831	-0.211	-0.470	0.470	-0.475	-0.623	-0.799	-0.938
Sensory score	0.928	0.166	-0.577	0.693	-0.574	-0.729	-0.936	-0.815

Through analyzing the results shown in table 5, we found that, gelatinization temperature and gel hardness of mixed flour was positively correlated to rate of cooking loss ($P<0.05$), while water absorption rate and peak stickness were negatively correlated to rate of cooking loss; roughness and sensory score of dumpling skin was in a positive correlation with water absorption rate, stable time and peak stickness and in a negative correlation with other indexes. Among TPA indexes, hardness after cooking and formation time of dough were in a positive correlation with gelatinization temperature ($P<0.05$), in a significant positive correlation with gel hardness ($P<0.01$) and in a significant negative correlation with peak stickness. Moreover, chewiness, cracking rate and color after cooking were all in a significant positive correlation with enthalpy value of gelatinization and in a negative correlation with water absorption rate. Cracking rate was in a remarkable correlation with gelatinization temperature and gel hardness. Therefore, the above indexes can be used to evaluate quality of dumplings.

4. Conclusions

Based on the analysis of cooking, texture and sensory properties of dumpling, we conclude that, property of flour changes significantly if waxy wheat flour is added; indexes such as absorption rate, peak stickness and gelatinization temperature are all closely correlated to quality of quick-frozen dumplings. Thus waxy wheat flour has obvious effect on quality of quick-frozen dumpling, especially when additive amount is 20%. Adding 20% waxy wheat flour can improving cooking and texture properties of product, improving sensory feeling and increase editable value. It has been reported that (Hung et al., 2007; Ruijing and Yuhong, 2015), adding waxy wheat flour is ineffective in lowering cracking rate of dumpling, but, in turn, increases cracking rate. That may be associated to category and property of waxy wheat flour; the poor gluten strength affects the quality of quick-frozen dumpling. But the waxy wheat flour used in this experiment has proper gluten strength; therefore, it is effective in improving quality of dumpling.

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RESEARCH ON THE URBAN ARCHITECTURAL HERITAGE FOOD COMPOUND METHOD BASED ON RSM – TAKING THE ANCIENT CITY OF QUANZHOU AS AN EXAMPLE

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ABSTRACT

Recently, information technology (IT) and digital media have been widely applied as a new era rises, and RSM playing a more and more important role in many scientific fields has become a medium presenting design concept and operating mode. Taking the food distribution method of the ancient city of Quanzhou as an example. On the basis of two factors of two compound bacterium suppression experiments, this paper aims to firstly extract the purple potato anthocyanins by the assistance of Response Surface Analysis(RSA) and the Optimization of Ultrasonic. Then to purify the purple potato anthocyanins using the AB-8 macroporous resin and the thin layer chromatography(TLC). It helps to shorten extracting time and to improve the extraction rate. In the meanwhile, this paper also explores the influence on bacteriostatic action on purple potato anthocyanins with the External conditions of PH, temperature and ultraviolet light. Taking the extraction and purification of anthocyanins as natural antimicrobial substances and distributing with the preservative sodium benzoate and potassium sorbate to explore the bacteriostatic action towards *Staphylococcus aureus*, *Escherichia coli*, *Bacillus subtilis*, white mildew and *Candida albicans*. Among them, we are able to choose optimal antibacterial compound the bacteria dispensing. It is approved that the purple potato anthocyanins is not only a kind of natural colorants, but also is of the bacteriostasis function.

1. Introduction

To date, China develops faster and faster, and disordered demolition and construction phenomena can be seen everywhere, thereby a large number of ancient architectural heritages are abandoned, or even damaged, which lead to unwanted results. A variety of heritage protection workers want to protect and reuse industrial heritages depending on advanced modern technologies with the advent of high-speed development of information era today. In recent years, research on Quanzhou urban architectural heritage food compound method based on RSM has drawn more and more attention (Oikonomopoulou et al., 2014; Saioa et al., 2010; Si-Kyung et al., 2013). With the continuous improvement of people's food safety consciousness, calls for a reduction of food preservatives usage become stronger and stronger (Mowafy et al., 2007; Fanyu et al., 2015). According to the researches at home and abroad, compound use of several natural preservatives with different sources or combination of a natural preservative with

other chemical preservatives can not only reduce the dosage of chemical preservatives in food, at the same time it can also make food bactericidal or bacteriostatic conditions more moderate, so as to achieve synergy or complementary role. Moreover, since most natural active substances have certain physiological activity, so they have good health care function on human body health (Xianqing et al., 2015).

Quanzhou, famous for history and culture in China with plenty of cultural relics in the historic area and unique urban geographical characteristics, is the place with most centralized ancient architecture relics in Quanzhou city. The protection and update of historic city Quanzhou have made great achievements over the years, but unfortunately, ancient architectural heritages in historic area are still in the fate of demolition and food compound method also gradually declines (Lanbo et al., 2015). Sodium benzoate and potassium sorbate are two of the most commonly used chemical preservatives in food. They have very good antibacterial effect on bacteria, mold and yeast, etc. (António et al., 2003; Zengin et al., 2010; Harry et al., 2000). Purple potato anthocyanins is not only a good colorant, it also has certain antibacterial function against bacteria and fungi. As a natural active substance, purple potato anthocyanins also has the physiological function to lower blood pressure and fat, as well as anti-oxidation and anti-tumor effect. Therefore, it has certain practical significance to make a deep step discussion on purple potato anthocyanins as a kind of antibacterial substance(Jin-Ge et al., 2013; Hwa et al., 2011). Currently, optimization on compound conditions of preservatives mostly adopts orthogonal design method (Wenyin et al., 2008; Qing et al., 2014). The application of response surface in food mainly reflects in extraction technological conditions of optimization of natural active substances, and its application on preservative compounding has not been reported so far. This paper applies the method of response surface analysis designed by Box-Behnken to realize the optimization of optimal bacteriostatic ratio of sodium benzoate, potassium sorbate and purple potato anthocyanins, so as to determine the optimal antibacterial compound with bacteriostatic agent and make the result more accurate and reliable.

2. Materials and methods

2.1. Experiment Reagent and Instrument

The main raw material and reagent used in this study are: purple potato anthocyanins, which can be obtained through extraction and purification method; beef extract, AGAR, peptone; sodium chloride as biochemical reagents, is provided by Beijing Arbor star Bio-technology limited; sodium benzoate and potassium sorbate, provided by Mindong Ruicai food additive co., LTD(food grade); *Staphylococcus aureus*, *Escherichia coli*, *Bacillus subtilis*, white mildew, *Candida albicans*, preserved by the state key laboratory of food science and technology.

Main instruments and equipment: YXQ-SG46-280A High-Pressure Steam Sterilization Pot (Shanghai silver technology instrument co., LTD.); VD-650 small ultra clean workbench (suzhou purification co., LTD.); DNP-9052 constant temperature incubator (Shanghai Sanfa technology instrument factory), etc.

2.2. Bacteriostasis of Pairwise Compounding

When food additives with the same function (colorant with same color, preservative and antioxidant) are mixed up, sum of proportion of dosage of each kind accounting for the largest dosage should not be larger than 1. We carried out bacteriostasis experiment by compounding sodium benzoate, potassium sorbate and purple sweet potato anthocyanin in ratio of 1:9, 2:8, 3:7, 4:6, 5:5, 6:4, 7:3, 8:2 and 9:1. Then the optimal proportion portfolio was confirmed based on comparison of average bacterial inhibition

diameter. Afterwards, MIC of every optimal proportion portfolio was detected as per the following method.

Purified purple sweet potato anthocyanin was made into solution in different concentration with double dilution method. Then 2 ml solution was taken and transferred into culture dish. Afterwards, every dish was added with 15 – 20 mL dissolved solid medium and mixed up. After the mixture was cooled and solidified, every dish was smeared with 0.2 mL suspension containing bacteria. The bacteria were cultured at 37℃ for 12 h and fungi were cultured at 20 ℃ for 24 h. Concentration which would not grow bacteria was taken as MIC.

2.3. Statistical Method

Data were compared between groups using Analysis of Variance in SPSS11.0 software. Difference was considered to be statistically significant if $P<0.05$.

3. Results and discussions

3.1. Bacteriostasis of Compound of Sodium Benzoate and Potassium Sorbate

It can be known from table 1 that, compound of sodium benzoate and potassium sorbate had the best bacteriostasis to *Staphylococcus aureus* when their ratio was 7:3 and bacterial inhibition diameter was 22.8 mm; and it showed the best bacteriostasis to *Escherichia coli*, *Bacillus subtilis*, white mould and *Candida albicans* when compounding ratio and bacterial inhibition diameter was 2:8 and 17.0 mm, 4:6 and 17.2 mm, 8:2 and 17.9 mm, 5:5 and 22.4 mm.

Table 1. The results of bacteriostasis of redistribution of benzoic acid uranium and potassium sorbate(mm)

Antimicrobial	Proportion of Benzoic acid uranium and potassium sorbate									Best Collaboration
	1:9	2:8	3:7	4:6	5:5	6:4	7:3	8:2	9:1	
Staphylococcus aureus	18.5	19.4	19.7	20.5	21.0	22.1	22.8	22.5	21.9	7:3
Escherichia coli	16.7	17.0	16.0	15.7	14.9	15.1	15.5	13.1	12.1	2:8
Eacillus subtilis	14.9	16.5	17.1	17.2	16.9	18.6	17.5	16.8	15.4	4:6
Pepsins	10.1	11.0	12.0	13.7	14.7	15.2	16.8	17.9	17.3	8:2
Candida albicans	19.5	22.1	20.4	21.9	22.4	18.7	17.4	16.5	16.8	5:5

3.2.The results of bacteriostasis of redistribution of sodium benzoate and purple potato anthocyanins

From the analysis of the results in table 2, we are able to know the best proportion of sodium benzoate and purple potato anthocyanins towards *Staphylococcus aureus* is 4:6 and the acteriostatic diameter is 22.0 mm; the best proportion of sodium benzoate and purple potato anthocyanins towards *Escherichia coli* is 6:4 and the bacteriostatic diameter is 15.9mm; the best proportion of sodium benzoate and purple potato anthocyanins towards *Bacillus subtilis* is 3:7 and the bacteriostatic diameter is 16.4mm; the best proportion of sodium benzoate and purple potato anthocyanins towards pepsins is 5:5 and the bacteriostatic diameter is 18.1mm; the best

proportion of sodium benzoate and purple potato anthocyanins towards *Candida albicans* is 7:3 and bacteriostatic diameter is 23.9mm.

Table 2. The results of bacteriostasis of redistribution of sodium benzoate and purple potato anthocyanins

Antimicrobial	Proportion of sodium benzoate and purple potato anthocyanins									Best Collaboration
	1:9	2:8	3:7	4:6	5:5	6:4	7:3	8:2	9:1	
Staphylococcus aureus	21.7	20.4	21.3	22.0	21.9	22.1	17.6	18.1	15.9	4:6
Escherichia coli	10.5	12.5	14.5	15.7	14.8	15.9	14.8	12.6	9.8	6:4
Bacillus subtilis	8.9	9.5	16.4	17.2	15.9	18.6	12.9	10.1	11.4	3:7
Pepsins	10.1	11.4	12.5	13.7	18.1	15.2	16.5	14.5	13.8	5:5
Candida albicans	16.5	16.3	17.4	21.9	19.8	18.7	23.9	22.5	23.1	7:3

3.3. The results of bacteriostasis of redistribution of potassium sorbate and purple potato anthocyanins

From the analysis of the results in table 3, we are able to know the best proportion of potassium sorbate and purple potato anthocyanins towards *Staphylococcus aureus* is 7:3 and the acteriostatic diameter is 21.4 mm; the best proportion of potassium sorbate and purple potato anthocyanins towards *Escherichia coli* is 5:5 and the bacteriostatic diameter is 16.5mm; the best proportion of potassium sorbate and purple potato anthocyanins towards *Bacillus subtilis* is 9:1 and the bacteriostatic diameter is 17.0mm; the best proportion of potassium sorbate and purple potato anthocyanins towards pepsins is 2:8 and the bacteriostatic diameter is 17.6mm; the best proportion of potassium sorbate and purple potato anthocyanins towards *Candida albicans* is 4:6 and bacteriostatic diameter is 22.0mm.

Table 3. The results of bacteriostasis of redistribution of potassium sorbate and purple potato anthocyanins

Antimicrobial	Proportion of potassium sorbate and purple potato anthocyanins									Best Collaboration
	1:9	2:8	3:7	4:6	5:5	6:4	7:3	8:2	9:1	
Staphylococcus aureus	16.5	16.9	17.8	18.6	19.1	20.3	21.4	21.1	19.4	7:3
Escherichia coli	14.8	15.8	13.5	16.7	16.5	16.4	14.8	13.6	12.8	5:5
Bacillus subtilis	10.5	13.5	12.7	13.8	15.1	14.9	15.4	16.9	17.0	9:1
Pepsins	17.5	17.6	16.8	15.4	13.5	14.7	12.5	10.8	9.1	2:8
Candida albicans	17.5	18.7	19.4	22.0	22.4	22.5	20.9	19.5	18.1	4:6

By comparing the table 1,2 and 3, the bacteriostatic diameter of the best proportion of the results of bacteriostasis with *Staphylococcus aureus*, *Escherichia coli*, *Bacillus subtilis*, Pepsins and *Candida albicans*, we are able to know the best results of bacteriostasis towards *Staphylococcus aureus* is the redistribution of sodium benzoate and purple potato anthocyanins , the proportion is 4:6;the best results of bacteriostasis towards *Escherichia coli* is the redistribution of Benzoic acid uranium and potassium sorbate, the proportion is 2:8; the best results of bacteriostasis towards *Bacillus subtilis* is redistribution of potassium sorbate and benzoic acid uranium, the proportion is 4:6; the best results of bacteriostasis towards Pepsins is the redistribution of sodium benzoate and purple potato anthocyanins, the proportion is 5:5; the best results of bacteriostasis towards *Candida albicans* is the redistribution of sodium benzoate and purple potato anthocyanins, the proportion is 7:3.

3.4. The best mixture of bacteriostasis of all the antimicrobial and MIC value

Measuare the MIC value of above mixture with the best results of bacteriostasis, the results are as shown in table 4.

Table 4. The best mixture of bacteriostasis of all the antimicrobial and MIC value

Antimicrobial	The choosed mixture	MIC(mg/mL)
Staphylococcus aureus	sodium benzoate and purple potato anthocyanins (4:6)	0.060
Escherichia coli	benzoic acid uranium and potassium sorbate (2:8)	0.250
Bacillus subtilis	Potassium sorbate and benzoic acid uranium (4:6)	0.130
Pepsins	sodium benzoate and purple potato anthocyanins (5:5)	0.500
Candida albicans	sodium benzoate and purple potato anthocyanins (7:3)	0.060

3.5. Bacteriostasis of all the mixtures with the best proportion

Figures of bacteriostasis of all the mixtures with the best proportion are as shown in figure 1-5.

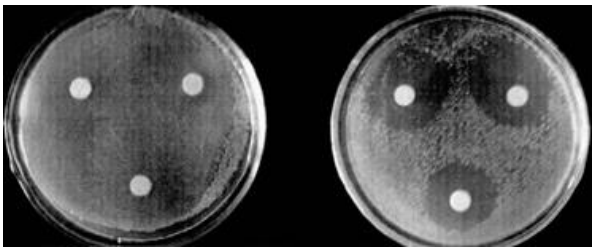

Figure 1. Bacteriostasis of the best mixture towards *Staphylococcus aureus*

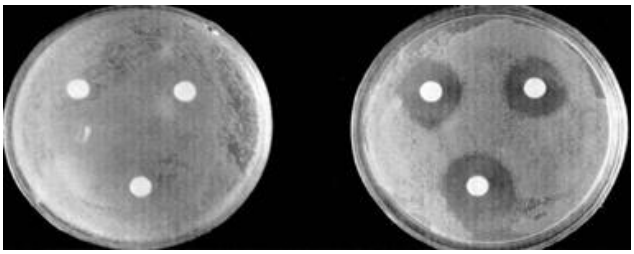

Figure 2. Bacteriostasis of the best mixture towards *Escherichia coli*

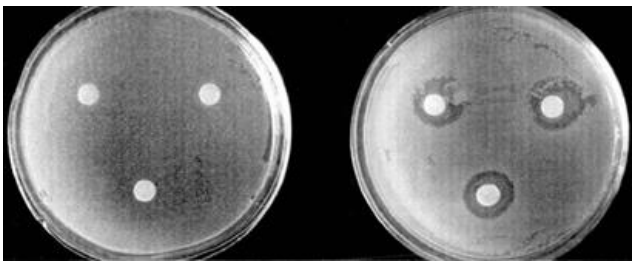

Figure 3. Bacteriostasis of the best mixture towards *Bacillus subtilis*

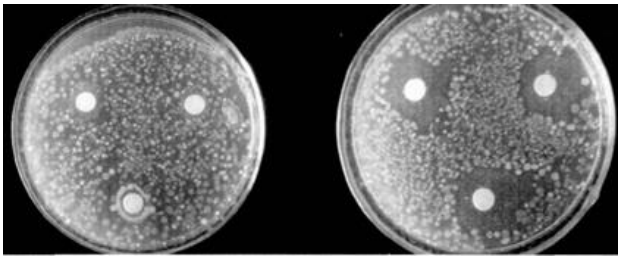

Figure 4. Bacteriostasis of the best mixture towards pepsins

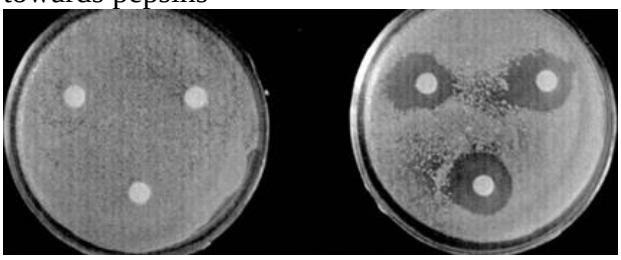

Figure 5. Bacteriostasis of the best mixture towards *Candida albicans*

4.Conclusions

The purple potato anthocyanins is a color charming purple potato colorant, eggs, milk tea and cake. After joining the purple potato pigment, it will give a person with romantic and special taste. In the meantime, it is proved that Purple potato anthocyanins has good bacteriostatic action and this is also the important research result of the paper. In addition, there was a scholar who had study (Ahmed et al., 2010) and found through the purple potato anthocyanins bacteriostatic experiment research that pigment of anthocyanin has good bacteriostasis towards *Staphylococcus aureus* and *Escherichia coli*, and the bacteriostasis is positively correlated with the concentration of anthocyanins. With the method of the projection electron microscope to study the antibacterial mechanism of anthocyanins and we are able to know by mapping *Escherichia coli* growth curve that the antibacterial mechanism of anthocyanins is probably can enhance the permeability of the cell so as to make the normal growth of cells abnormal and thus in the logarithmic phase of cell division is subdued so that the whole cell of qualitative changes thin. Eventually it leads to the disintegration of cells and achieve the effect of bacteriostasis.

The experiment of the paper firstly finds out the best anti-bacterial combination in all parts, then determines various bacteria optimal antibacterial compound dispensing by comparing each part of the best combination of MIC. At the same time, it studies the role of anthocyanins in purple potato distribution. Compounding separately sodium benzoate and potassium sorbate, sodium benzoate - purple potato anthocyanins and potassium sorbate - purple potato anthocyanins in two distribution with 1:9, 2:8,3:7,4:6, 5:5,6:4,7:3, 8:2,9:1, then this paper do bacteriostasis experiment. The best proportion of combination of each bacterium can be get by comparing the average size of bacteriostatic diameter,among which the best mixed preparations of *Staphylococcus aureus* is 4:6 sodium benzoate - purple potato anthocyanins with MIC 0.060mg/mL; the best mixed preparations of *Escherichia coli* is 2:8 sodium benzoate, sorbic acid sodium with MIC 0.250 mg/mL; the best mixed preparations of *Bacillus subtilis* is 4:6 potassium sorbate, sodium benzoate with MIC 0.130 mg/mL; the best mixed preparations of white mould is 5:5 sodium benzoate - purple potato anthocyanins with MIC 0.500 mg/mL; the best mixed preparations of *Candida albicans* is 7:3 sodium benzoate - design and color of purple potato with MIC 0.060mg/mL. By comparing the MIC, the MIC of two elements dispensing was much lower than that of single element, which reflected that synergistic effect between the mixture could improve the bacteriostasis. According to different bacterium, the solanum

tuberdsm anthocyanin had the different interaction with sodium benzoate and potassium sorbate, and also had different antibacterial effect during the compound. After compounding the *Staphylococcus aureus*, *Escherichia coli*, white mildew and adding the olanum tuberdsm anthocyanin, the synergistic effect among them made MIC be lower than MIC of sodium benzoate-potassium sorbate mixture, which showed that solanum tuberdsm anthocyanin could have interaction with sodium benzoate and potassium sorbate much better to enhance the bacteriostat effect. As for *Bacillus subtilis*, its optimal proportion dispensing was sodium benzoate:potassium sorbate=6:4, which reflected that the antibacterial effect of solanum tuberdsm anthocyanin with sodium benzoate and potassium sorbate was better than that with sodium benzoate and potassium sorbate. For *Candida albicans*, its optimal proportion dispensing was sodium benzoate: solanum tuberdsm anthocyanin=7:3, which reflected that olanum tuberdsm anthocyanin had the strong interaction with sodium benzoate.

To sum up, anthocyanin of purple sweet potatoes have high activity in acidic conditions; it also has bacteriostatic actions which will not be influenced under short-time high temperature. However, long-time high temperature can reduce the bacteriostatic actions to some extent. Instant high temperature has no effect on bacteriostatic actions of above five bacteria; bacteriostatic actions of anthocyanin of purple sweet potatoes are not affected under ultraviolet rays. Besides, interactions between anthocyanin of purple sweet potatoes and sodium benzoate and potassium sorbate can improve the bacteriostatic actions.

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EFFECT OF ALLICIN ON PERIPHERAL BLOOD CELL DNA DAMAGE IN HUMAN BODY AFTER EXHAUSTIVE EXERCISE

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ABSTRACT

This study was designed to observe the effect of allicin tonic on peripheral blood cell DNA damage as well as superoxide dismutase (SOD), glutathione (GSH) and methane dicarboxylic aldehyde (MDA) activities in serum after exhaustive exercise, and explore the mechanism of allicin in anti-DNA oxidative damage. Totally 16 healthy male athletes were randomly divided into control group and experimental group, with 8 athletes in each group. Each group was treated with oral administration of placebo and garlicin capsules fourteen days before exercise; then all subjects took part in Bruce exhaustive exercise scheme after tonic, and blood was sampled for anticoagulation before and after tonic and immediately after exercise respectively. Peripheral blood cell DNA damage in human body was detected with single cell gel electrophoresis (SCGE), and SOD activity, content of GSH and MDA were measured in plasma. Results showed that levels of DNA damage and oxidative stress in two groups had no significant difference before and after tonic ($P>0.05$); furthermore, athletes' peripheral blood cell DNA damage detected immediately after exercise in experimental group was obviously lower than that after exhaustive exercise in control group, and its MDA level, SOD and GSH content decreased significantly compared with exhaustive control group ($P<0.001$, $P<0.05$, $P<0.05$). However, SOD, GSH and MDA level detected immediately after exercise in control group increased notably in comparison with those before exercise, and DNA damage intensified apparently ($P<0.001$). Thus, it can be concluded that exhaustive exercise is able to induce the increase of peripheral blood cell DNA damage in human body as well as MDA level of lipid peroxidative product, and mediate the over expression of SOD and GSH antioxidant enzyme activities. In addition, allicin is believed to be capable of improving antioxidant ability of body, reducing free radical level, also relieving and preventing DNA damage caused by oxidative stress in exercise.

1. Introduction

Garlic, one of the vegetables for food and medicine use, is also an important seasoning in daily diet. Allicin is a kind of effective ingredient extracted from garlic, with main component of Diallyl Disulfide (CH_2=CH-CH_2-S-S-S-CH_2-CH=CH_2), which has very high nutritional and medicinal values, especially in reducing blood fat and blood pressure, protecting vessels, regulating immune function, resisting fatigue, radiation, tumor and pathogenic bacteria, scavenging free radical, resisting lipid peroxidation and relieving body oxidative damage caused by reactive oxygen species (ROS) (Macpherson et al., 2005; Oommen et al., 2004; Park et al., 2005; Lang et al., 2004). Intensive endurance exercise produces excessive free radical and oxidative

stress in body, meanwhile DNA damage of skeletal muscle cell resulted from exhaustive exercise is closely related to the level of oxidative stress. Studies have indicated that exhaustive exercise causes lymphocyte DNA oxidative damage, and also promotes lymphocyte apoptosis (Tauler et al., 2005; Hwang et al., 2007; Lancaster et al., 2004).

This study applies single cell gel electrophoresis (SCGE) to detect DNA damage of peripheral blood cell in human body after exhaustive exercise, observe the protective and antioxidant effect of allicin tonic on human peripheral blood cell DNA damage and discuss its mechanism, which provides a new way for preventing and eliminating sports fatigue and offers an experimental and theoretical foundation for developing health-care food with antioxidant activity.

2. Materials and methods

2.1. Research objects

Totally 16 male athletes majored in sports in Liaoning Normal University were randomly divided into experimental group (T group, supplemented with garlicin capsules) and control group (C group, supplemented with starch placebo capsules), with 8 athletes in each group. All athletes who had no smoking history and were in good health participated in the experiment voluntarily and abided by a regular and rational diet during the experiment.

2.2. Research methods

2.2.1. Exercise scheme

Subjects exercised exhaustively in Lode Valiant medical electric treadmill applying Bruce scheme (Kaminski et al., 2000) based on three exhaustion standards. 1) Subjects could not keep the exercise intensity after repeated encouragement; 2) heart rate reached over 180 times/min during exercise; 3) RPE value reached 19 or 20.

2.2.2. Blood specimen collection and tonic taking methods

Two weeks before exercise, subjects in control and experimental group orally took 80 mg placebo and 80mg garlicin capsules respectively every day at the same time (Abdel-Daim et al., 2015). In the first day of experiment, stature, weight and body composition of all subjects were measured; and then 1ml peripheral venous blood collected from subjects before tonic, in the 14th and 15th day of tonic and immediately after exercise was put into anticoagulation tube containing 0.1 mg heparin. After that, 10-15 μL anticoagulant was taken for measuring SCGE, and the rest of anticoagulant was used for testing the level of antioxidant enzyme and lipid peroxidation immediately after refrigerated centrifugation.

2.2.3. Detection for DNA damage of blood cell

Film was improved slightly referring to Hartmann method (Hartmann et al., 2003). Prepared glass slide was put into horizontal electrophoresis chamber, and newly configured alkaline electrophoresis buffer also poured into it by covering about 0.25 cm rubber surface. Then, it was unwound for 20 min to untwist DNA into single strand and make the DNA fragments migrate in the electrophoresis field easily. After untwisting, it was electrophoresed for 30 min under 25 V and 250 mA, and the slide was carefully taken into neutral buffer for 15 min after electrophoresis. Afterwards, the slide was taken out, and 30~50 μL ethidium bromide (EB) dye liquor with the concentration of 5 μg/mL was dropped on the surface of colloid, then the cover glass was covered and observed under fluorescence microscope after dyeing for 15~20 min.

2.2.4. Measurement for level of antioxidant enzyme and lipid peroxidation

Superoxide dismutase (SOD), methane dicarboxylic aldehyde (MDA) and glutathione (GSH) were measured with Xanthine Oxidase method, glucosinolates barbituric acid colorimetric method and quantitative colorimetry, orderly.

2.3. Main instrument and reagents

Instruments and reagents included DYY-6C type three-constant electrophoresis apparatus and DYZC -248 type electrophoresis chamber (Liu Yi Instrument Factory, Beijing, China); BX-51 type fluorescence microscope and E-330 type digital camera (OLYMPUS); visible spectrophotometer; ECOM-F6124 type semiautomatic biochemistry analyzer. Heparin anticoagulant, low metling agarose (LMA), normal melting agarosegel (NMA), sodium sarcosinate, Triton X-100 dimethyl sulfoxide (DMSO) and EB (Amresco Company, America); garlicin capsules (Zhengda Qingjiang Pharmaceutical Co., LTD, Jiangsu, China) (H32025683), and other reagents were all guaranteed analytical pure.

2.4. Statistical analysis

Each smear was observed with 515-560 nm exciting light under 200 times fluorescence microscope from 5 different views, with more than 5 cells per view and 6 slides in a group. Indexes, such as comet length, tail length, percentage of tail DNA, comet distribution moment, tail inertia, Olive tail moment were measured with IMI1.0 comet analysis software (Liangzheng Software Development Co., LTD, Shenzhen, China). Moreover, data performed Normality Test (1-Sample K-S) and one-way ANOVA using EXCELL and SPSS software, and results were expressed with mean ± SD. The difference between groups was considered to be significant if $P < 0.05$.

3. Results and discussions

3.1. General information of subjects' body shape index

According to subjects' basic information in table 1, physical characteristics in two groups were basically identical, embodied in without significant differences of body shape indexes (stature, weight, BMI value and percentage of body fat). After allicin was supplemented in control and experimental group respectively, exhaustive time in experimental group was remarkably longer than that in control group ($P < 0.01$).

Table 1. List of basic information of subjects

Groups	Age	Stature (cm)	Weight (kg)	BMI	Body fat %	Exhaustive time (min)
Control group	21.35±1.04	172.3±1.67	64.87±2.09	21.80±1.0	13.98±2.43	15.89±1.10
Experimental group	20.76±1.02	172.24±1.84	65.37±1.79	21.69±0.51	13.97±2.44	16.88±0.81**

Note: **P<0.01 compared with control group.

3.2. Morphological observation of DNA damage of human peripheral blood cells before and after taking allicin

Under fluorescence microscope, from dyed smear, the vast majority of peripheral blood cells of athletes in a resting state in two groups before tonic were found with a round fluorophore (comet head) with uniform fluorescence intensity, smooth edge and no significant tailing phenomenon (figure A1 and A2); and so did the most of peripheral blood cells of athletes in a resting state in two groups after 14 days of continuous tonic (figure B1and B2). Fluorescence intensity of peripheral blood cell tail of athletes in two groups strengthened after Bruce exhaustive exercise, and only part of cells in experimental group occurred "comet tail" without significantly prolonged "comet

tail" length (figure C1), while it got longer and larger in control group, the diameter of the comet head decreased as tail lengthened, and comet-like cells occurred more frequently (figure C2).

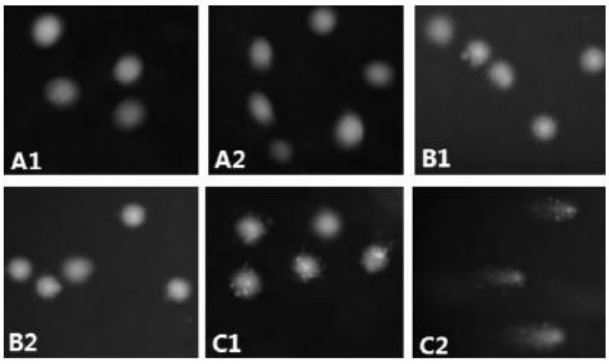

Figure 1. DNA comet pictures of peripheral blood cell of athletes after taking allicin (×100)

3.3. Changes of SCGE testing indexes of DNA damage of human peripheral blood cell after taking allicin

Table 2 shows the results of comet image analysis by using comet analysis software and selecting international universal indexes of tail length, tail distribution moment and Olive tail moment. Comet detection indexes, such as tail length, tail distribution moment and Olive tail moment of peripheral blood cells of athletes in a resting state in two groups before tonic had no obvious difference (P >0.05); after 14 days of continuous tonic, those indexes in allicin tonic group before exercise had a tendency to decrease in comparison with control group, but there was no statistical significance (P>0.05). Compared with before exercise, those indexes in control group detected immediately after exercise rose notably (P<0.001), while they were significantly lower in allicin tonic group than in control group (P<0.01), which explained that allicin markedly lowered peripheral blood cell DNA damage induced by exhaustive exercise.

Table 2. Influence of allicin on peripheral blood cell DNA damage index

Groups	N	Tail length	Olive tail moment	Tail distribution moment
Group C before tonic	8	35.11±10.11	14.55±3.27	78.93±24.79
Group T before tonic	8	35.94±8.60	14.62±4.98	79.37±17.66
Group C after tonic	8	34.90±10.06	14.47±4.76	77.59±18.40
Group T after tonic	8	34.14±7.25	14.40±3.75	75.18±21.46
Group C after exercise	8	62.91±12.59***	21.46±4.60***	95.01±27.55***
Group T after exercise	8	42.59±11.31▲▲	15.82±3.81*▲▲	83.17±19.72▲▲

Note: *P<0.05, **P<0.01, ***P<0.001 compared with group C before tonic; ▲▲P<0.01, ▲▲▲ <0.001 compared with group C after exercise.

3.4. Changes of SOD enzyme activity, GSH and MDA content in serum of athletes' body after taking allicin

It could be known from table 3 that resting athletes' SOD enzyme activity, GSH and MDA content in serum in two groups had no obvious significance before and after tonic (P>0.05). However, those three indexes in control group improved markedly after exhaustive exercise compared with resting state before tonic (P<0.05, P<0.05, P<0.001); in the meantime, those indexes in experimental group after exhaustive exercise significantly reduced in different degrees in comparison with control group after exercise (P<0. 05, P<0. 05, P<0.001), and there was no obvious difference in two groups in a resting state before tonic (P>0.05), which suggested that allicin was effective in reducing lipid peroxidative product.

Table 3. Changes of SOD, GSH and MDA content in serum after allicin intervention

Groups	N	SOD (U/ml)	GSH (mg/L)	MDA (nmol/ml)
Group C before tonic	7	90.38±13.65	103.77±14.19	4.35±0.93
Group T before tonic	7	88.64±14.12	105.40±16.44	4.57±1.04
Group C after tonic	7	98.26±12.11	107.11±18.07	4.30±0.92
Group T after tonic	7	99.35±17.61	100.76±14.28	4.17±1.06
Group C after exercise		122.61±15.10*	127.14±19.57*	7.75±1.10***
Group T after exercise		102.12±11.90▲	106.39±24.65▲	5.41±1.05▲▲▲

Note: compared with group C before tonic, *P<0.05, ***P<0.001; and compared with group C after exercise, ▲P<0.05, ▲▲▲P<0.001.

3.5. Discussions

In recent years, researches have shown that allicin is capable of resisting aging, tumor, pathogenic bacteria and infection, scavenging free radical, and preventing cardiovascular and cerebrovascular diseases, etc. (Macpherson et al., 2005; Oommen et al., 2004; Park et al., 2005; Lang et al., 2004). Besides, clinical studies also have confirmed that allicin can effectively reduce MDA level of rat with diabetes and relieve the degree of oxidative stress damage (Osman et al., 2012). Vigorous exercise produces ROS in vivo and increases lipid peroxidation, for example, MDA level, thus decreasing exercise capacity and triggering sports fatigue. One of the mechanisms is that, because of the increase of respiratory rate in the process of exercise, air pollutants including NO_2 and O_3 increase with the increased intake during breathing. Those free radicals enhance the probability of oxidative damage exactly through respiratory tract. However, cells in the body have a complex working mechanism to resist the generation of ROS free radical, thereby protecting macromolecular substances from infringement. This working is usually completed by antioxidant substances, such as SOD, GSH, AA and VE, and the intake of antioxidant substances is also an important way (Flavia and Mihaela, 2009). As DNA is a key target molecule that ROS free radical attacks, free radical redox reaction can induce a variety of consequences, for instance, DNA molecular base modified or chain breaking, and cause a

series of physiological dysfunctions and histopathological alterations, even canceration. Moreover, the degree of DNA damage is closely related to the severity of disease (Aitken and Roman, 2008). By using SCGE detection technology, this research discovered that the level of peripheral blood cell DNA damage of athletes supplemented with allicin after exhaustive exercise was significantly lower than that after exhaustive exercise in control group. Therefore, allicin had a distinct protective effect on DNA damage resulted from exhaustive exercise.

The content of SOD and GSH, the main antioxidant biomarkers in antioxidant system, and MDA as the end product of lipid peroxidation triggered by polyunsaturated fatty acid can reflect the lipid peroxidation strength of tissue cells in the body as well as the metabolism of free radicals in vivo (Best and Benjamin, 2009; Niki, 2010). Based on results acquired from this experiment, it was found that MDA level in control group after exhaustive exercise rose notably; SOD and GSH antioxidant enzyme activities also increased in a significantly compensatory way, and DNA damage presented an obviously increased trend as well compared with control group before exercise. It indicated that exhaustive exercise increasing MDA level deepened the degree of DNA oxidative damage; at the same time, overexpressed SOD and GSH in body tissues improved the antioxidant ability of body, eliminated light base, reduced peroxide pressure and decreased a large amount of toxic ROS induced by strenuous exercise. However, comparing tonic group with control group after exhaustive exercise, SOD enzymatic activity, GSH and MDA content in serum decreased in different degrees, so did DNA damage level, which explained that allicin tonic directly involved in eliminating free radicals produced in exercise and decreasing the degree of lipid peroxidation in the body remarkably, thus reducing DNA damage in human peripheral blood cell. The experimental results were in line with other research conclusions that allicin was more likely to effectively lower oxidative stress level of the body than other antioxidants. However, the effect of allicin complementary amount remains to be further researched.

4. Conclusions

Doing exhaustive exercise in treadmill is quite effective in increasing human peripheral blood cell DNA damage as well as MDA level of lipid peroxidative products and mediating the over expression of SOD and GSH autioxidant enzyme activities in body tissues. In addition, allicine can improve antioxidant ability of the body, stabilize cell membrane structure, reduce the level of free radicals, relieve and prevent DNA damage from oxidative stress in exercise, which is believed to have good nutritional and health-care efficacies in preventing and treating sports fatigue.

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ANALYSIS ON NUTRIENTS EVALUATION OF HOTEL CATERING DISHES AND MARKETING MANAGEMENT

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ABSTRACT

The traditional evaluation on catering dishes mainly rests on color, fragrance, flavor, appearance and meaning without analyzing on nutrition. This paper made an attempt to introduce nutrition to the evaluation process and chose energy, protein, fat, carbohydrates, vitamins, inorganic salt (including microelement) and dietary fiber as the evaluated factors; at the same time, relative nutritional evaluation method was adopted as the standard; on this basis, we discussed the combination mode of nominal nutrition evaluation and catering marketing management, with the websites and information system of enterprises involved. Especially, the connection with hotel catering information system not only took full advantage of the convenience, accuracy and efficiency of information technology, but also solved the contradiction of lacking in professional nutritionists to some extent. Application of the whole system was beneficial for the enterprises to carry out market segmentation and positioning and to provide customized services for different customers in order to exceed customers' expectations and earn a better reputation. Combination with hotel restaurant information system contributed to the management and optimization of customer relations; furthermore, it assisted enterprises to implement differentiation and market-leading strategy, at the same time, it contributed to brand moulding and image promotion.

1. Introduction

Introduction With the rapid improvement in people's living standards, people expect higher nutrition value of the dishes, which makes it crucial to introduce nutritional factors into evaluation process (Prejbeanu et al., 2012). For the increasingly competitive hotel catering industry, new breakthrough point is in urgent need, therefore, assessment information of nutritional value is provided for the customers as guidance so as to promote the competitive advantage and customers' experience. There were relevant theoretical and practical explorations on the informatization of hotel catering nutrition evaluation both in China and other countries, however, the explorations mostly aimed at information engineering level or catering concept level in stead of researching on the combination of the two levels. In China, there were fewer researches on the application of introducing nutritional assessment into hotel catering industry, and informatization was not popularized in hotel catering, so the combination of nutritional evaluation and catering information system was not mentioned yet. On the basis of the previous researches on catering, this study made an attempt to embody nominal nutrition in the menu and utilize the information system, so that customers' appeals of catering nutrition were combined with

advanced information technology, providing the foundation for related applications. Compared to Chinese consumers, foreigners paid attention to nutritional value of dishes earlier. With people's demands for dietary nutrition growing, overseas scholars began to research on labeling nutritional evaluation factors on hotel menus (Zimmet et al., 2006). Lisa J. Hamaek (Hamaek, 2006) also noticed the evident differences between nutrition information that customers expected and the information provided by restaurants; Margo G (Margo et al., 2006) researched on nutrition information of the food in a noshery.

In foreign countries, informationization in hotel enterprises was relatively mature, while the development in this aspect was relatively backward in China due to various limitations and environmental constraints. Based on this problem, many scholars and experts did researches mostly on the exploration of the concept and prediction of the developing trend. With the rapid development of domestic economy and the gradual maturity of related concepts, more and more enterprises (especially large-scale and chain enterprises) gradually introduced the restaurant information system and achieved ideal economic and social effects (Ren and Lv, 2014). Domestic scholars have launched some researches on the implementation of engineering background informatization and related application cases. Feng Weixing and Wang Kejun put forward a set of small-scale cable network formed by six hosts to show the advantages and rudiment of catering industry informatization. Hua Qing first introduced the concept of Enterprise Resource Planning (ERP) into the informationization process of the catering industry. Throughout the existing literature in China, application researches on the combination of nutritional evaluation and restaurant information management system as well as marketing campaigns were not common. On the basis of the current research situations in China and foreign countries, this study put more emphasis on the interdisciplinary crossover research in stead of being confined to the research on a single subject, and served as a reference for the promotion of enterprise competitiveness.

2. Materials and methods

The application foundation of nominal nutrition evaluation in hotel catering marketing

2.1. Index selection of nutrition nominal

In general, the nutrients that human body needs can be simplified into six categories: protein, fat, carbohydrates, vitamin, inorganic salt (including microelement) and water. Some scholars also define dietary fiber as the seventh major nutrient (Atwal and Preetpal, 2007).The inorganic salt that accounts for 0.01% of the human body weight is named macroelement, and the inorganic salt that accounts for less than 0.01% is microelement. Carbohydrates, fats and protein are referred to as heat-yielding nutrients for producing a certain amount of heat energy to meet the human body's need after oxygenolysis in the body. In addition, energy is also the common nutritional index. Multiply the contents of energy supply nutrients (protein, fat, carbohydrates and etc.) by the corresponding conversion coefficients and through summation, the energy value is obtained. The specific energy conversion coefficients are shown in table 1. Kilojoules (KJ) and kilocalorie (kcal) are the units of energy (1 calorie is equivalent to 4.184 joules).

Table 1. The conversion coefficients of energy in food

Nutrients	KJ/g (kcal/g)	Nutrients	KJ/g (kcal/g)
Protein	17 (4)	Alcohol	29 (7)
Fat	37 (9)	Organic acid	13 (3)
Carbohydrate	17 (4)	Dietary fiber	8 (2)

2.2.Contents and methods of nutritional survey

Integrated nutrition survey includes dietary survey, physical examination on nutriture and laboratory examination. This study focused on dietary survey and evaluation which is the basis of nutrition survey. Dietary survey gave us a comprehensive understanding of dietary pattern and dietary nutrition. According to the survey, calculate the quantity and quality of the diner's daily consumption of energy and various nutrients; then, in contrast with the daily supply standard, find out the advantages and disadvantages in the diner's dietary nutrition and put forward feasible improvement measures (Bridget and Michael, 2009). In dietary survey, the common methods are weighing method, audit method and inquiry method (Yanping et al., 2006).

2.3.Nominal nutrition evaluation method

(1) Direct calculation of nutrients content

According to the quick-view table 2 of energy supply quantity for different people (Table 2), the requisite amount of energy for different people can be looked up directly.

Table 2. Quick-view table of energy supply quantity for different people

Diners	Daily energy(kcal)	Energy for breakfast(kcal)	Energy for lunch(kcal)	Energy for supper(kcal)
Preschoolers	1300	390	520	390
Students from Grade 1 to Grade 3	1800	540	720	540
Students from Grade 4 to Grade 6	2100	630	840	630
Junior school students	2400	720	960	720
High school students	2800	840	1120	840
Mental workers	2400	720	960	720
Medium manual workers	2600	780	1040	780
Heavy manual workers	>3000	>900	>1200	>9900

Note: the energy supply quantity in the table is the average quantity

Data source: Beijing sports science research institute Energy coefficients of the three kinds of energy-yielding nutrients can be obtained by the following conversion formula: energy(kcal) = 4×protein(g) + 4×available carbohydrates(g) + 9×fat(g) + 3×organic acid(g)+7×ethanol(g) + 2×dietary fiber(g). With the daily nutrients intake determined, the reasonable nutrients distribution in three meals should be in accord with the energy distribution (30% for breakfast, 40% for lunch and 30% for dinner).

(2) Index of food nutrition quality

Index of Nutrition Quality (INQ) refers to the proportion of the nutrient content and heat energy content with regard to the supply quantity for human body. The relative relations can be referred to as nutrient density and heat energy density. Here is computation formula: nutrient content of the dish/ standard supply quantity of the nutrient heat energy of the dish/ standard supply quantity of heat energy. According to the formula above, we can get the INQ values of various nutrients of each dish. For example, if INQ of a nutrient in the dish is 1, it means the supply quantity of the nutrient and heat energy is balanced with the standard nutritional requirements; if INQ is more or less than 1, it means the diet is not scientific. When it comes to comprehensive evaluation of dishes for a group of people, the amount of the people should be converted to standard amount according to Table 3. For example, when the table is set for 10 people (including four old people, four middle-aged people and two children), by converting, the standard amount of the people is 8.7. According to the nutritional requirements of rational diet, heat energy supply for dinner should account for 30% of the daily heat energy supply, so the supply quantities of total heat energy and major nutrients for 8.7 standard people are

respectively presented as follows: heat 6786 kcal, protein 208.89, fat 188.49, sugar 1.0 kg, VA 2088 μg, VB2 3.39 mg, calcium 2088 mg, sodium 5.74 mg, iron 3.32 mg, dietary fiber 52.2 g, cholesterol < 780 mg. According to the standardized menu, we can make nutritional evaluation and corresponding adjustments on the dishes.

Table 3. Conversion coefficients of nutrients requirements for different people

Under age			Adult			Old people		
Age	Gender	Coefficient	Labor intensity	Gender	Coefficient	Age	Gender	Coefficient
<3 years old	/	0.46	Very low	Male	0.85	60-70 years old	/	0.8
<5 years old	/	0.5		Female	0.75			
<7 years old	/	0.55	Low	Male	0.95			
<10 years old	/	0.71		Female	0.85	70-80 years old	/	0.7
<13 years old	/	0.82	Medium	Male	1.1			
<16 years old	Male	0.92		Female	1.0			
	Female	0.85	Intense	Male	1.2	>80 years old	/	0.61
<18 years old	Male	1.2		Female	1.15			
	Female	1.0	Very Intense	Male	1.5			

2.4.Implementation of nominal nutrition evaluation in hotel catering management

2.4.1.Implementation in menu design

In the process of practical application, nutrition labeling (including nutrient content, taste, the appropriate or inappropriate crowds) on each dish is necessary for the customers to choose what they need. The standardization of dishes is the premise of nutrition evaluation and the key of the combination with the information system. It's also important to add nutritive value on traditional menu (with only dish names and prices on) and offer specific recommendations and suggestions according to customers' needs.

There are intuitive ways to implement nominal nutrition evaluation, such as the use of graphs, proportion, color labeling, tabular statement. Circle graphs or radar maps are also applicable in reflecting the specific values of heat, protein, fat, vitamin and etc. in regard to the standard intake; if the graph is close to a circle, it means the diet is balanced and scientific. For example, the percentages of related index system contents of dish A and B with regard to the standard reference intake are shown in Table 4.

Table 4. Nutrient contents of dish A and B

	Dish A	Dish B
Protein	0.56	0.45
Fat	0.80	0.31
Carbohydrate	0.44	0.16
Vitamin	0.25	0.72
Inorganic salt	0.35	0.82
Dietary fiber	0.36	0.73
Energy	0.77	0.54

The radar map below can reflect the nutritional evaluation on menu. In radar map, either separate evaluation of each dish or comparative evaluation between different dishes is applicable.

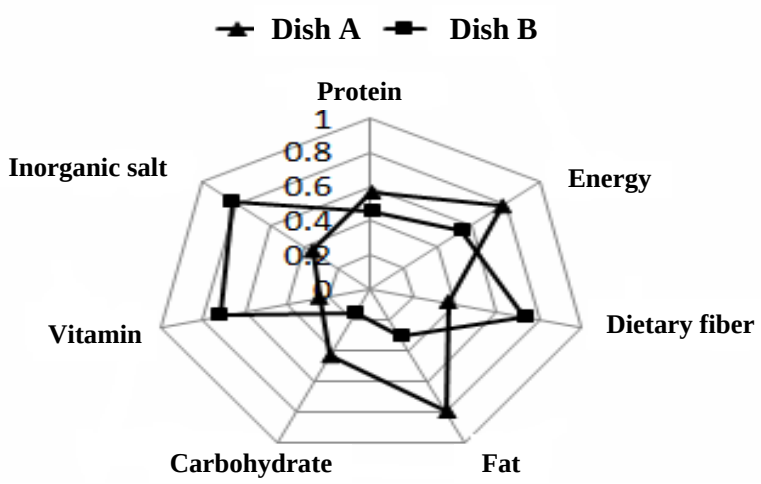

Figure 1. Radar map of dish evaluation

2.4.2.Implementation in corporate websites

Network marketing is the inevitable requirement of individuation, customization and more rational consumption (Campbell et al., 2014). According to the field survey, the majority of large-scale hotels and catering enterprises have built their specialized websites; considering the limitation of paper menu and the interactivity advantages of Internet, enterprises can integrate nutrition evaluation data in their official websites, which not only publicizes the enterprise, but also conforms to the self-service consumption trend. Network marketing management is characterized with low cost, less marketing process, larger information content, wider-range marketing and around the clock. Therefore, hotel enterprises need to convert the original management idea of two-dimensional structure (yield and quality) into four-dimensional structure (production, quality, personality and time).

2.4.3.Implementation in information management system of hotel catering

The nominal nutritional evaluation involved in this paper is mainly applied in daily marketing process of hotel enterprises, so the key point is to make corresponding adjustments and suggestions according to customers' personalized demands instead of precise testing and comparison. In this study, the relevant analysis and evaluation were automatically completed by computer information system, with the advantage of avoiding reliance on dietitians and promoting the application of nominal nutrition evaluation in the daily marketing campaigns of hotel catering industry.

(1) The advantage of information management system in hotel catering

Catering informatization and network management have been the display windows of the economic development of modern cities and the key factors to improve the efficiency and market competitiveness of hotel enterprises. Informatization management construction of hotel enterprises refers to the integration of all the procedures by means of informatization and comprehensive computerized management of booking, reception, ordering, dish serving, cashier and manager query and etc. Informatization management plays an important role in transformation process, strengthening management, reducing cost and containment throttling; in addition, it promotes the competitiveness of hotel enterprises by saving manpower, cost control, improving efficiency and service and promoting management level. Table 5 gives a clear analysis on the advantages of hotel catering information management.

Table 5. Advantages of information management system in hotel enterprises

		Traditional manual management	Catering information system management
Cost management	Paper	It's difficult to achieve quantifying control	Printing paper is rarely used.
	Raw material	Experience management of stock is needed.	The system automatically detects and performs early warning for top and bottom limits
Efficiency	Manpower	One waiter can only serve 2 to 4 tables.	The system can serve at least 6 tables.
	Information stream	Leakage occurs easily.	The information stream is accurate.
	Accounting	The heavy workload makes it difficult to make statistics and budgets.	Daily accounting, real-time inquiry and statistical prediction are available.
Quality	Service image	Busy	Specialized and elegant
	Accuracy	There are skippers.	Accurate
	Management of client relations	None	Customers' information can be saved accurately to achieve personalized service.

(2) Model of typical hotel catering information management system

The typical hotel catering information management system includes ten parts: reservation management system, reception management system, handheld order system, submenu printing system (in kitchen), bar code system, temporary dish and beverage system, cashier system, member management system, meal preparation system and inventory management system. The specific system framework is shown in figure 2.

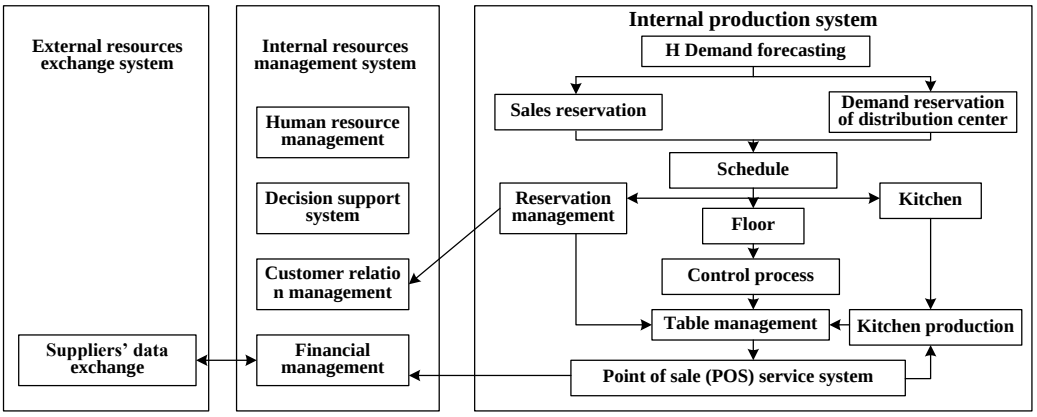

Figure 2. Framework of typical hotel catering information system

(3) Approach to connecting nominal nutrition evaluation with hotel catering information system

On the basis of standardized menu, we can select a single dish or a whole banquet to analyze on and make a trophic analysis according to pre-recorded database; then, carry out targeted evaluation based on different types of work, population characteristics, special groups or even the seasonal characteristics; what's more, make corresponding suggestions and achieve optimization according to the predefined process; at last, display the results on visual device for customers as reference, as is shown in figure 3.

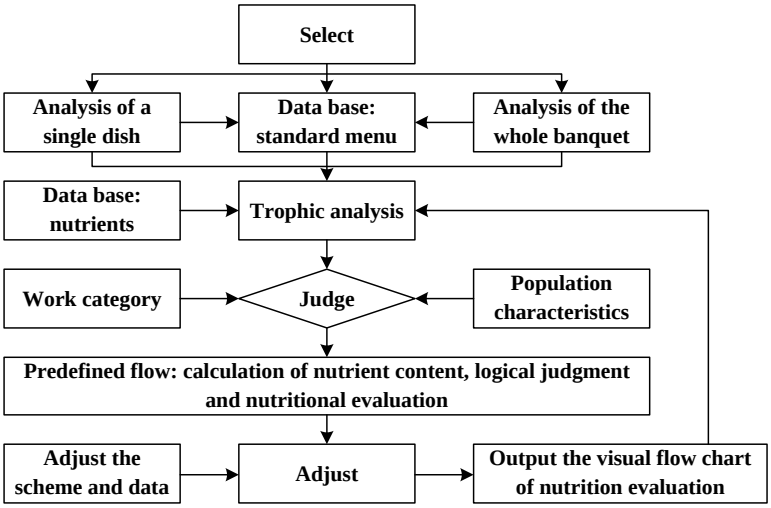

Figure 3. Flow chart of the subsystem module

3. Results and discussions

3.1.Nominal nutrition evaluation and market segmentation and positioning

With the economic development and income improvement, consumption capacity gives consumers several new mental characteristics (Nan et al., 2010): they are ready to follow the fashion and put more emphasis on healthy, individuality and superior quality. Therefore, introduction of nominal nutrition in hotel catering marketing not only meets consumers' consumption psychology, but also plays an important role in market segmentation and positioning of enterprises. Traditional hotel enterprises barely consider the characteristics of consumers in market segmentation and positioning; in general, there is only the concept of top-grade, middle-grade and low-grade consumption. By introducing catering nominal system, enterprises can offer personalized services for consumers based on their physical characteristics and consumption habits; in addition, there are different service products and marketing mix strategy for different market segments to highlight the leading and characteristic localization (Yan, 2014).

3.2.Nominal nutrition evaluation and market strategy

Choice of strategy is the key factor for the development and success of an enterprise (Fogel and Zapalska, 2001). Application of nominal nutrition system makes it convenient for the enterprise to adopt the strategy of differentiation and market leading. What's more, the enterprise has established a perfect evaluation system and determined its dominant position before the majority of companies realize the importance of nutritional problems. By introducing nutrition nominal system, the enterprise can provide customers with distinguished products and services and form irreplaceable advantages to some degree; at the same time, the enterprise can defeat its competitors and gain more profits. The purpose of market-leading strategy is to earn customers' loyalty to the company, so that the customers will be less sensitive to price changes (Delgado et al., 2011).

3.3.Construction of nominal nutrition evaluation and marketing pattern

(1) Service marketing

In addition to high-quality catering services, the offer of nutritional information and suggestions is part of close-to-customer services (Fańgpei, 2011). Large-scale material input is unnecessary; instead, enterprises can create their own core competitiveness by

making appropriate modifications on the original flow path and realizing differentiation.

By communicating with customers in one-to-one marketing, enterprises can learn the clients' specific requirements and adjust the products and services; furthermore, they can save customers' consumption characteristics in related database and form customers' files so that personalized products and services will be provided for the customers when they eat in the same restaurants again. During implementation, enterprises can make use of the Customer Relationship Management (CRM) module of catering information system and refer to the ABC analysis method to classify customers and focus on the marketing with key customers. The basic idea of ABC method is to divide the objects into A item (key point), B item (ordinary) and C item (minor) according to influence factors, property, proportion (or the cumulative proportion) and so on (Jiang and Yuan, 2008). There are no strict rules for the division standards of A item, B item and C item. In general, the factor whose cumulative percentage of main characteristic value is within 0-80% is mentioned as A item (in need of focal management); the factor whose cumulative percentage is within 80-90% is mentioned as B item (in need of general management); the factor whose cumulative percentage is within 90-100% is mentioned as C item (in need of minor management).

As a relatively smaller group, A-class customers contribute a lot to the gross turnover of enterprises, and form a steady relation with the enterprises, therefore, in addition to necessary preferential promotion, the hotel enterprises need to communicate with the customers heartfully, learn their opinions and suggestions, and strive to earn their loyalty to the enterprises; as for B-class customers, enterprises need to communicate with them patiently and try to improve their satisfaction and trust degree with the purpose of leading them to become A-class customers; C-class customers account for the majority in population while their contribution to corporate profits is much less than the other customers, however, they also need to be paid attention to because they might help promote the enterprises and bring more loyal customers.

(2) Network marketing

According to a supplementary survey on nine well-known hotel enterprises, we can learn that most enterprises have gradually adopted mature information management system, but the back-stage management system is still the weak point, which reveals the shortage of thorough utilization of information system in enterprises.

Table 6. Network marketing

Information system	Amount of enterprises
Font office management system	9
Finance management system	8
Association organization information communication platform	7
Brochures or books for enterprise promotion	8
Back-stage management system	6
Chain management system	9
Amount of enterprise websites	9

4. Conclusions

In this study, we made an attempt to introduce multidisciplinary cross application in the daily marketing campaigns of hotel catering; by taking advantage of nominal nutrition evaluation and integrated application of multiple subjects such as nutriology, information system theory and marketing management, this study made a contribution to hotel enterprises in search of new competitive advantages in the white-hot competition situation. Considering the usability of application, we chose energy, protein, fat, carbohydrates, vitamins, inorganic salt

(including microelement) and dietary fiber as the evaluation contents; at the same time, by comparing several typical calculation methods, we chose the relative nutritional evaluation method as the standard, so that nutrition calculation is more compact, intuitive and applicable; on this basis, we discussed the combination mode of nominal nutrition evaluation and catering marketing, and connected the mode with electronic sites and information management system. The application of the whole system helps enterprises to carry out market segmentation and positioning in the marketing level and provide customized services according to different customers so as to obtain a wider range of customers' satisfaction; furthermore, along with hotel catering information system, the whole system can realize the management and optimization of customer relations; eventually, it assists enterprises to achieve differentiation and market-leading strategy; in addition, it benefits brand moulding and image promotion.

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THE NUTRITION IMPROVEMENT EFFECTS OF FRUCUS CANNABIS PROTEIN POWDER ON ATHLETE DURING WEIGHT CONTROL PROCESS

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ABSTRACT

The study discussed the nutrition improvement effects of frucus cannabis protein powder on athlete who took part in the weight restriction sports during the weight control process and aimed to solve the nutrition lacking problem of them during the process. Besides, the study provided a new approach for athlete weight control nutrition research field to introduce traditional Chinese medicine sport nutrition and hoped to broaden the channels of sport nutrition and make sport nutrition diversified to further improve the competition results of athlete. Adding the fructus cannabis protein powder to the common food, the athletes in experimental group ate food 1 g per kilogram weight in the morning and evening each day. But the athletes in contrast group ate the common food with no drug. The athletes in two groups respectively did blood test before 1 day of the experiment and the 21 day of the experiment (the last day of experiment). Biochemical items of blood test include: serum albumin, hemoglobin, prealbumin, blood lactic acid, blood urea and blood ammonia. The value of hemoglobin, serum protein and prealbumin of athletes in experimental group all rise obviously, which shows frucus cannabis protein powder can improve the nutritional ingredient of weight restriction sports athletes. But the value of hemoglobin, serum protein and prealbumin of weight restriction sports athletes in contrast group have no change at all, which reflects that the athletes who do not eat frucus cannabis protein powder have change of nutritional ingredient after the experiment. Since the value of hemoglobin, serum albumin and prealbumin in experimental group is higher than those in contrast group obviously after the experiment, it shows that frucus cannabis protein powder has a remarkable effect on the nutrition improvement of weight restriction sports. Frucus cannabis protein powder effectively improves the nutrition targeted value of weight restriction sports athletes, such as hemoglobin, serum protein and prealbumin.

1. Introduction

In recent years, since winning the champion on the sports competition being regarded as face-saving project of the country (Andersen and Aagaard, 2010), many countries increase the investment to competitive sports. Due to the attention from various of parts, competitive sports develop rapidly and comprehensively and the grades of athletes have improved a lot, some of them even challenge the extremity of human, such as sprint, high jump, hurdles and so on (Liguo, 2015). When athletes get the great grade, a part of sports science researchers also make a lot of excellent achievements on

competitive sports, especially on sport nutrition products, which makes a great contribution to the good grades of athletes.

The research of athlete nutraceuticals is flourishing in the world. Foreign scientists studied the athlete nutraceuticals in early time and formed a rounded system in theoretical research and experimental research (Jiechun, 2015). There are some researches of fructus cannabis both at home and abroad, and it is sweet, flat, Guipi and stomach channel in aspect of pharmacology (Zhao, Hong-Liang and Zhang, 2011). Fructus cannabis contains multiple chemical components, such as glutamic acid that 17 essential amino acid people needed, including metallic elements of iron, calcium, zinc, selenium, etc (Jun-Qiang et al., 2011). Fructus cannabis can increase anoxia tolerance capability, improve anemia, defy aging and lower lipid. All these chemical components and effects have been approved by fructus cannabis researchers (Wan et al., 2013). As nutraceutical, fructus cannabis has been used at home, but it is hardly reported that fructus cannabis is used in physical exercise flied (Wan et al., 2013), especially for weight restriction sports athletes. Therefore, applying the fructus cannabis to exercise field and making new attempt and discussion can find a new way for athletes to supply nutrition and stay in shape at the same time. The athletes can also have more chooses of domestic nutritional products.

2. Materials and methods

2.1. Ordinary material

Eighty weight restriction athletes are extracted from physical training center.

Inclusion criteria: weight restriction sports athletes between the ages of 20 and 28; have meal by oneself; understand the research purpose; join of one's own accord; sign the informed consent.

Exclusion criteria: weight non-restriction sports athletes, people who have known be allergic to researched food ingredient; people who do not take fructus cannabis according to designed usage and dosage; take part in other health food experiments before 30 days; heart, liver and kidney be abnormal during the research process.

2.2. Compliance

Compliance of researched food: record the practical intake of researched food every day and make assessment from the first, second, third cure week. When researched food intake reaches the 80% of calculated amount or more, it is defined as compliance; otherwise, it is noncompliance.

Compliance of diet: record the intake of diet every day and make assessment from the first, second, third cure week. When diet intake reaches 80%-120% of calculated amount, it is defined as compliance; otherwise, it is noncompliance.

2.3. Research technique

Eighty study objects are randomly divided into experimental group and contrast group. Random allocation adopts automatic random number table envelope method. Experimental group add the frucus cannabis protein powder based on common food, each athlete has 1g/kg.d in the morning and afternoon. Contrast group add nothing to common food. Both group regard 21 days as a course of treatment (there is no research about it in foreign countries, and we can just take course of treatment of bean protein powder as the reference). Experimental period is a course of treatment in both groups.

2.4. Experiment test index

1) Hemoglobin, serum protein and prealbumin (nutritional evaluation index);

2) Blood urea, blood lactic acid, blood ammonia (training amount and training intensity index)

The athletes of two groups should have fasting blood at 7 a.m. one day before the experiment starts and one day after the experiment ends respectively. Detective indexes are all measured by A-6 self-motion biochemical analyzer and test paper is

produced by Chinese Academy of Sciences Beijing biology institution.

2.5. Symptom observation

Making survey of symptom that athlete may occur in experimental group, such as energy recovery, sleep condition, muscle growth, endurance, weight index, skin allergy and gastrointestinal discomfort, etc.

2.6. Statistical method

The data is collected based on designed table, data statistics adopts SPSS 19.0 statistics software to analyze. If comparative data in the group be in normal or approximately normal distribution, it is tested by pair t; otherwise, it is tested by Wilcoxon pair. When comparing the change value between experimental group and contrast group, if variance of two groups is homogeneous, it adopts bunching variance test; otherwise, rank sum test is used.

3. Results and discussions

3.1. Statistics condition of general data

The research randomly divides 90 objects of study into experimental group and contrast group, and each group has 45 objects. Ninety objects are consisted of 25 judokas (15 males, 10 females), 24 wrestlers (10 male freestyle wrestlers, 6 female freestyle wrestlers, 8 male Graeco-Roman wrestlers), 28 taekwondo athletes (14 males, 14 females), 13 boxers (all are males). The general conditions of two sets study objects are shown in Table 1. Through the t test, the age, height, weight and sports life of two sets o study objects have no statistics difference.

Table 1. General condition of study objects

Group	Number	Age	Height(cm)	Weight(kg)	Sports life(year)
Experimental group	45	24.35±1.85	169.34±6.34	65.38±7.24	8.64±3.21
Contrast group	45	25.06±1.38	166.56±7.26	66.62±7.28	8.68±3.67

3.2. The comparison of laboratory detection index of athletes in two groups before the experiment

As shown in table 2, comparing the laboratory index of athletes in contrast group to experimental group, there is no statistics difference between them, and P>0.05.

Table 2. The comparison of laboratory detection index of athletes in two groups before the experiment

Laboratory index	Contrast group	Experimental group
Blood urea (mmol/l)	7.69±0.58	7.92±0.75
Hemoglobin (g/l)	13.87±1.14	13.92±1.56
Blood lactic acid (mmol/l)	2.08±0.83	2.15±0.66
Blood ammonia (umol)	43.11±4.26	42.61±4.19
Serum albumin (g/l)	41.11±2.08	41.59±3.88
Prealbumin (mmol/l)	200.35±15.28	201.74±15.03

Note: adopting T test method, comparison of the two groups of study objects indexes P>0.05

3.3. The comparison of laboratory index of experimental group before and after the experiment

As shown in table 3, the hemoglobin, serum protein and prealbumin index of athlete in experimental group after the experiment is obviously different from those before the experiment in statistics, P<0.01. But there is no obviously statistics difference of blood urea, blood lactic acid and blood ammonia index after the experiment, P>0.05

Table 3. The comparison of laboratory index of experimental group before and after the experiment

Laboratory index	Contrast group	Experimental group
Blood urea (mmol/l)	7.92±0.75	7.95±0.66*
Hemoglobin (g/l)	13.92±1.56	14.86±1.01**
Blood lactic acid (mmol/l)	2.15±0.66	2.14±0.55*
Blood ammonia (umol)	42.61±4.19	43.56±3.43*
Serum albumin (g/l)	41.59±3.88	54.28±4.21**
Prealbumin (mmol/l)	201.74±15.03	213.16±16.36**

Note: adopting T test method, *P>0.05, **P<0.05 compared with the index before the experiment.

3.4. The comparison of laboratory index of contrast group before and after the experiment

As shown in table 4, the laboratory indexes of athletes in contrast group have no obvious statistics difference after the experiment, P>0.05.

Table 4. The comparison of laboratory index of contrast group before and after the experiment

Laboratory index	Contrast group	Experimental group
Blood urea (mmol/l)	7.69±0.58	7.98±0.81
Hemoglobin (g/l)	13.87±1.14	13.72±0.99
Blood lactic acid (mmol/l)	2.08±0.83	2.08±0.32
Blood ammonia (umol)	43.11±4.26	43.57±3.16
Serum albumin (g/l)	41.11±2.08	42.26±3.17
Prealbumin (mmol/l)	200.35±15.28	200.86±15.24

Table 5. Laboratory index comparison of athletes in experimental group and contrast group after the experiment

Laboratory index	Contrast group	Experimental group
Blood urea (mmol/l)	7.95±0.66*	7.98±0.81
Hemoglobin (g/l)	14.86±1.01**	13.72±0.99
Blood lactic acid (mmol/l)	2.14±0.55*	2.08±0.32
Blood ammonia (umol)	43.56±3.43*	43.57±3.16
Serum albumin (g/l)	54.28±4.21**	42.26±3.17
Prealbumin (mmol/l)	213.16±16.36**	200.86±15.24

Note: adopting T test method, compare with pre-experiment *P>0.05, **P<0.05.

3.5. The comparison of laboratory index of two groups of athlete after the experiment

As shown in table 5, compared with pre-experiment, hemoglobin, serum protein and prealbumin index of athletes in two groups after the experiment appears obvious statistics differences, P<0.01, which reflects that hemoglobin, serum protein and prealbumin value of athletes in experimental group increases obviously. Compared with blood urea, blood lactic and acid blood ammonia of athletes in two groups after the experiment, it can be found the differences has no statistical significance, P>0.05, which reflects that the training amount and training intensity of athletes in two groups has not changed during the experiment.

3.6. Symptom observed result of experimental group

There are some symptoms that 45 athletes in experimental group appear during the experiment. 38 athletes recover their energies faster, which accounts for 84.4%; 43 athletes enhance the endurance obviously, which accounts for 95.6%; 29 athletes feel muscles be thickening, which accounts for 64.4%; 40 athletes improve the sleeping, which accounts for 88.9%; 27 athletes feel their weight be in downtrend, which accounts for 60%; 2 athletes feel gastrointestinal discomfort, which accounts for 4.4%; none has skin allergy.

3.7. Discussions

3.7.1. Chemical component and effect of frucus cannabis protein

Frucus cannabis protein is made up of edestin and edestan albumin. Edestin accounts for 65% and edestan albumin accounts for 35%. Edestin can promote the digestion of small intestine, which contains no phosphorus relatively and be the material of DNA skeleton. Edestan albumin contains the amino acid that people need; therefore, frucus cannabis protein is a kind of excellent plant protein (Malomo and Aluko, 2015). Compared with the chemical components of other seed protein, frucus cannabis protein has much more amino acid content. Fructus cannabis contains 21 kinds of amino acid, 17 of which is essential to human body, amino acid content is highest and reaches to 34.8 mg/g; aspartic acid and arginine contains 19.8mg/g and 18.8 mg/g respectively (Docimo et al., 2014). Fructus cannabis protein also has high-content arginine, cystine, methionine and histidine, which play important roles in body growth and development. Arginine does good to vascular disease, and frucus cannabis protein contains vitriol creatine and cysteine, which all belong to the amino acid that synthetase needs. In addition, frucus cannabis protein contains a lot of branched chain amino acid, which has important effects on the restore of weight restriction athletes' gene.

Clinical experiments have proved that (Wu et al., 2009; Luo, Yin and He-Zhen, 2003) frucus cannabis protein can promote the capacity of hypoxia tolerance, improve the anemia and linseed oil can relax the bowels. Frucus cannabis protein powder contains zero soybean oligosaccharide and sensitization factors, which will not cause gasteremphraxis, stomachache and other anaphylaxis. Therefore, frucus cannabis protein powder bot only contains abundant nutritional ingredients, but also has the effect of relaxing bowel, which is so useful for weight restriction sports athletes to supply nutrition.

3.7.2. The result analysis of athletes in experimental group during the experiment

During the experiment, athletes feel muscle be thickening because human muscle is consisted of protein, water and carbohydrate, and frucus cannabis protein powder contains abundant protein, which is easily assimilated by small intestine. In this way, athletes have more materials of muscle synthesis, which quickens the growth of muscular tissue. Therefore, after having the frucus cannabis protein powder, athletes (weight restriction sports) have more materials of muscle synthesis to increase muscles. Some athletes feel that their endurance has improved and their weight be in downtrend obviously. But it is mutual contradiction. It is difficult for weight restriction sports athletes to keep good endurance and strength and control the weight under dietary restriction at the same time. However, frucus cannabis protein powder contains abundant amino acid, vitamins and microelement, which enhances nutritional ingredients and oxidation resistance capacity of human body. Frucus cannabis protein powder also contains 17 essential amino acids, which is beneficial for athletes to supply nutritional ingredient. In addition, frucus cannabis protein powder doesn't contain the fat ingredient that will increase the weight. Therefore, taking frucus cannabis protein powder can solve the contradiction of diet and weight of athlete.

Some athletes have improved the sleeping because fructus cannabis has the function of analgesia, hypnosis, and prolong sleep time. Linseed oil contains rare r-linolenic acid, which is benefit to repair nerve cell and cure insomnia (Ying, Xin and Wen-cong, 2013).

Frucus cannabis protein powder is easily assimilated by small intestine; fructus cannabis contains vitamin which has high antioxidant ability and microelement; linseed oil can facilitate lipid metabolism, promote blood circulation and accelerate metabolite (blood lactic acid, etc.) to allay tiredness and quicken the physical recovery of athletes (Zhou et al., 2013).

3.7.3. Discussion of laboratory detection index change

Since the indexes (hemoglobin, serum protein and prealbumin) tested in the experiment can be influenced by protein supply, athlete training amount and training intensity, it is necessary to fix dietary nutrition supply of each athlete during the experiment. In other words, the diet should make fixed match with meat, protide or the food can influence the intake of protein. The experiment should do under the same training amount and training intensity. The study have found that the indexes of weight restriction sports athletes in the experimental group have obvious statistics difference ($P<0.01$) after the experiment; but indexes (hemoglobin, serum protein and prealbumin) of athletes in contrast group have no obvious statistics difference ($P>0.05$) after the experiment, which explains that frucus cannabis protein powder can be assimilated easily and provide abundant materials for the composition of hemoglobin, serum protein and prealbumin to increase the rise of them.

Through statistic analysis, we can find that the indexes (blood urea, hemoglobin, blood lactic acid, blood ammonia, serum albumin and prealbumin) of athletes in two groups and indexes (blood urea, hemoglobin, blood lactic acid, blood ammonia, serum albumin and prealbumin) of athletes in contrast group all have no obvious difference ($P>0.05$) after the experiment, which reflects that dietary recipe, training amount and training intensity of athlete are on the same standard during the experiment. Because the index (blood urea, hemoglobin, blood lactic acid, blood ammonia, serum albumin and prealbumin) of experiment detection will change with the alteration of training amount and training intensify. When training amount and training intensify of athletes increase, the energy they need also increases. Most energy of the body is gained from anaerobic metabolism, and seldom from aerobic metabolism. Therefore, hemoglobin, serum albumin and prealbumin be consumed much more because of the increasing training amount and training intensity, blood urea, blood lactic acid and blood ammonia also changes at the same time. When athlete has same training amount, training intensity and protein of diet, the value of blood urea, hemoglobin, blood lactic acid, blood ammonia, serum albumin and prealbumin is relative equal.

4. Conclusions

We found that, 2 athletes had gastrointestinal discomfort and mild diarrhea during experiment, accounting for 4.4%. Frucus cannabis containing toxic carnitine and choline can cause poisoning symptoms such as emesis, nausea and diarrhea if being applied for a long time; and in severe cases, it can result in blood pressure decrease, dysphoria, limbs anesthesia, dance, coma and opisthotonos (Luo, 2003). People should be closely monitored while taking frucus cannabis and stop taking drugs once poisoning symptoms occur. Two out of 45 athletes who took frucus cannabis protein powder were found with symptom of laxativeness, and the reason is thought to be associated to linseed oil contained by frucus cannabis. Linseed oil can promote excretion by moisturizing pathogenic dryness, loosening the bowel and accelerating gastrointestinal motility (Jamaluddin, Redzwan and Chua, 2014). But the reason might also be related to digestive

tract disease and individual difference between athletes.

Thus we believe that, frucus cannabis protein powder can effectively restrain nutritional indexes (hemoglobin, serum protein and prealbumin) of athletes who engage in weight restriction sports. To further improve the nutriture of athletes and help athletes achieve excellent performance, frucus cannabis protein powder is recommended for those athletes.

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EFFECT OF CARBOHYDRATE-PROTEIN DRINKS ON ANDROGEN METABOLISM OF ATHLETES ENGAGING IN STRENGTH-NEEDED SPORTS AFTER ACUTE RESISTANT EXERCISES

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ABSTRACT

This study aims to explore the effect of carbohydrate-protein drinks on androgen metabolism of athletes engaging in strength-needed sports items after acute resistant exercises. We chose 63 male athletes who engaging in strength-needed sports items and divided them randomly into three groups, carbohydrate-high protein group (HP group, CHO:PRO=3:1), carbohydrate-low protein group (LP group, CHO:PRO=6:1) and carbohydrate group (C group). Total intake of drinks was 15 ml·kg-1 and concentration of carbohydrate (CHO) was 8%. Drink intakes in 30 min before exercise, during exercise and 30 min after exercise were 6 ml·kg-1, 3 ml·kg-1 and 6 ml·kg-1, respectively. Resistant exercises were divided into deep squats and bench presses, and the load was 70% 1RM. Every athlete had four groups of resistant exercises and each group was repeated for eight times. Athletes could have 60 s rest between each group of exercise and 90 s rest after completion of four groups. After that, the load was changed to 50% 1RM, but rest time between each group of exercise remained the same. Bench presses were carried on after 150 s rest after deep squats, and the exercise load was the same as deep squats. Venous blood samples and urine samples of rest time, immediately after exercise, 3 h recovery time and next day morning after exercise were collected to test androgen levels in blood and urine as well as other exercise monitoring indexes

1. Introduction

Fatigue can be generated in body due to certain intensity of exercise and it occurs in all links from nervous centralis to outside muscle contraction. An important expression of fatigue is its effect on neuroendocrine system (Linfeng, 2015). Central inhibition of fatigue can directly result in decrease of testosterone secretion through hypothalamus- hypophysis-gonad axis (Suzuki et al., 2007). Under many circumstances, change of testosterone level is ahead of change of athletic ability, thus observation of testosterone level change has important significance on monitoring exercise as well as nutritional recovery. As the standard of monitoring sports functions of athletes, observing fatigue state of athletes and recovery of fatigue, testosterone is now widely accepted and adopted (Richard et al., 2015). During pre-competition training, in order to obtain testosterone values of athletes, venous blood of athletes should be collected frequently for a long time, especially those who have high intensity of training, which can cause adverse influence on athletes' health.

As molecular biology develops, researches about effect of resistance exercises on human body has improved to a molecular level, in

which scholars can explain influence of resistance exercises on macroscopic and microcosmic change of human body gradually; meanwhile, during exercise training and rehabilitation practices, physical training specialists can immediately use these research results for references to improve athletic ability of athletes as well as delay or correct attenuation tendency of athletes with decreased muscle force (Kicman and Gower, 2003). Researches about effect of exercises on androgen metabolism of body combine theories of sports training, theoretical knowledge of sports biochemistry with androgen detection methods of human biological samples, thus to explore the effect of exercises on androgen metabolism of body (Sinha-Hikim et al., 2003). With the development of clinical detection, analytical chemistry as well as chromatographic apparatus (Kicman, 2008), androgen detection technologies are also developing rapidly. Main biological samples of androgen detection are urine and blood, and detection of effect of exercise training on these biological samples is an important method in sports monitoring field, which is to collect blood and urine samples of athletes during daily training, as well as to match up pre-designed nutritional intervention methods and adopt methods that are most similar to training practice to study the effect of exercise and nutritional intervention on androgen metabolism; meanwhile, the research results can also be used to guide exercise recovery.

2. Materials and methods

2.1. General Materials

We selected 63 male athletes who engaging in strength-needed sports items from Beijing Sport University and divided them randomly and equally into three groups, which are carbohydrate-high protein group (HP group), carbohydrate-low protein group (LP group) and carbohydrate group (C group). Athletes had physical tests before selection, and all selected athletes had no splanchnic diseases or bad habits. Strenuous exercises were forbidden the day before tests (including 1 repetition maximum (1 RM test) as well as the period after tests and before the sampling in next morning. All athletes signed informed consent, and general information of selected athletes is as shown in table 1.

Table 1. General information of athletes engaging in resistance exercises

Item	C group	HP group	LP group
Age	21.23±0.47	21.36±0.52	21.39±0.48
Height (cm)	177.9±2.31	180.13±2.62	178.58±1.95
Weight (kg)	82.35±4.39	80.26±4.59	81.84±3.95
Percentage of body fat (%)	15.16±2.62	12.86±2.68	12.08±3.55
Lean body mass (kg)	65.55±1.72	69.19±1.88	66.38±1.85
Bench presses 1RM (kg)	102.35±4.51	89.16±4.25	89.96±4.68
Deep squats 1RM (kg)	131.29±4.26	130.08±5.69	128.68±6.56

2.2. Diet Control

Selected athletes were required not to smoke, drink, drink coffee or take medicines. Normal sleep, regular diet and sufficient water supply should be guaranteed. Besides, any other nutritional supplements were forbidden. All athletes had prepared sports drinks before resistance exercises and during exercises. Breakfast bread and yoghourt were also supplied after exercises. Besides, lunch and dinner were standard diet, and nutrient proportion was CHO: PRO: Fat=55-65:20:15-25.

2.3. Scheme of Nutritional Intervention

Nutritional intervention was to mix oligosaccharide with protein powder to make into drinks, in which carbohydrate (CHO)

concentration was 8% and water supplement was 15 ml·kg-1. Supplements of carbohydrate-protein of each group were as follows:

HP group: CHO (g) =W (kg) ×15 g·kg-1 ×8%; PRO (g) =CHO (g)/3;

LP group: CHO (g) =W (kg) ×15 g·kg-1 ×8%; PRO (g) =CHO (g)/6;

C group: CHO (g) =W (kg) ×15 g·kg-1 ×8%;

W is weight of tested athletes.

Intakes of drinks 30 min before exercises, during exercises and 30 min after exercises were 6 ml·kg-1, 3 ml·kg-1 and 6 ml·kg-1 respectively (Rodriguez et al., 2009).

2.4. Tests of Athletic Ability

Test contents were bench presses and 1RM deep squats. Barbells designed for competition that were accepted by International Weightlifting Federation were adopted. First, athletes used 40-60% of known maximum strength to lift a barbell and repeated for 5-10 times as warm-up. Then athletes could have 1 min rest and also had stretch during the rest. Next, athletes used 60-80% of known maximum strength to lift a barbell and repeated for 3-5 times, and then repeated 3-4 time to complete maximum strength test until athletes were unable to complete the exercise. Athletes were required to move joints fully during exercise and movement speed was 2:0:2 (2 s eccentric contraction, 2 s concentric contraction).

2.5. Scheme of Resistance Exercises

Resistance exercises were carried through in three days, 21 tested athletes per day and each intervention groups had seven tested athletes. Strength test equipments were three deep squat racks (NO.1, NO.2 and NO.3) and barbells as well as three bench press racks (NO.1, NO.2 and NO.3) and barbells. Exercises were divided into seven turns. For example, deep squats were started from NO.1 rack, the athletes in NO.2 rack started after 2 min, and the athlete in NO.3 rack started after another 2 min. Other turns were done in the same way.

Athletes were required to keep greater trochanter of femur and knee-joints at the same level while doing deep squats, and then fully stretch knees; meanwhile, while doing bench press, elbow joints of athletes should be completely extended. 50% 1RM deep squats and bench press were repeated 5-10 times as warm-up, then athletes had 60 s rest. Sequence of resistance exercises was deep squats first, and then bench presses. Detailed flow chart has been shown in figure 1.

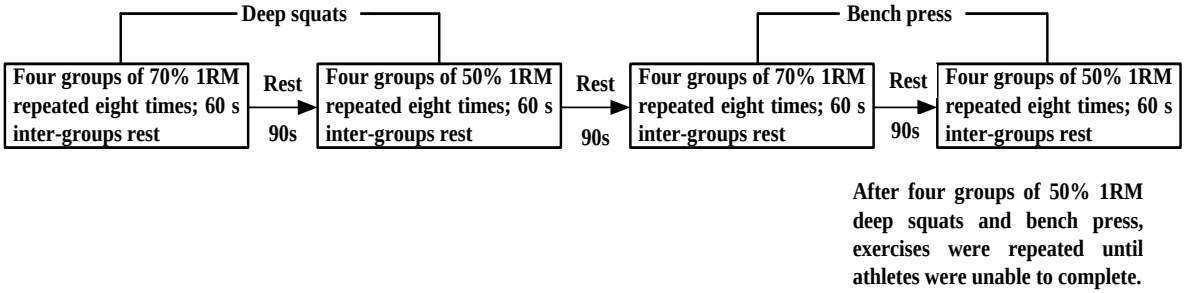

Figure 1. Scheme of acute resistance exercises

2.6. Statistical Methods

K-S test was used to examine whether index data were in accordance with normal distribution, and then parametric test was adopted. A sample was first tested with Mauchly sphericity test, and difference comparison between groups in same time points used one-way analysis of variance (ANOVA). $P<0.05$ indicates significant differences while $P<0.01$ indicates greatly significant difference. The whole statistical process used SPSS19.0 software package and all statistical results were expressed by X±SEM

3. Results and discussions

3.1. Effect of Carbohydrate-Protein Drinks on Total Testosterone and Free Testosterone Level of Athletes after Acute Resistance Exercises

Table 2 showed that total testosterone level of HP group immediately after exercises had no change, and it was significantly lower than the rest value 3 h after exercises (P<0.01) and recovered to basic value in next morning. Total testosterone level of LP group decreased significantly immediately after exercises (P<0.01) and kept decreasing 3 h after exercises, and then rose again in next morning but was still lower than rest value (P<0.01).

Total testosterone level of C group decreased immediately after exercises and significantly decreased 3 h after exercises (P<0.01), and it recovered to basic value in next morning. In inter-groups comparison, no significant difference was found before exercises, and total testosterone level of LP group decreased more significantly than that of HP group and C group immediately after exercises; total testosterone level of all groups decreased significantly, but no difference between groups showed. In next morning after exercises, total testosterone level of HP group and C group recovered to basic value, while total testosterone level of LP group was still lower than basic value (P<0.01).

Table 2. Total testosterone level of each group before and after resistance exercises and during recovery period (ng·dl-1)

	HP group	LP group	C group
Before exercises	699.26±74.34	651.06±65.39	712.09±89.35
Immediately after exercises	706.06±80.24	602.35±67.24*	650.15±83.35*
3 h after exercises	534.68±41.76**. ##	480.23±66.34**. ##	485.19±53.64**. ##
Next morning after exercises	706.67±43.26&&	612.04±51.84&&	672.16±92.46&&

*P<0.05 and **P<0.01, compared to before exercise; ##P<0.01, compared to after exercise immediately; &&P<0.01, compared to 3 h after exercise.

Table 3. Free testosterone level of each group before and after resistance exercises and during recovery period (pg·ml-1)

	HP group	LP group	C group
Before exercises	30.15±2.12	32.91±2.64	32.49±2.68
Immediately after exercises	22.60±1.58**	25.92±4.41*	32.24±1.34@@,$$
3 h after exercises	25.12±2.08	26.99±4.89*	31.02±2.71@@,$$
Next morning after exercises	20.06±2.47*,&	23.42±3.41*,&	28.83±2.35*，#，&，@@，$$

*P<0.05 and **P<0.01, compared to before exercises; #P<0.05, compared to after exercises immediately; &P<0.05, compared to 3 h after exercises; @P<0.05 and @@P<0.01, compared to HP group; $P<0.05 and $$P<0.01, compared to LP group.

Table 3 indicated that each group showed different free testosterone expression before exercises, after exercises and during recovery period: free testosterone level of HP group significantly decreased immediately after exercises (P<0.01), increased 3 h after exercises and decreased in next morning (P<0.05); free testosterone level of LP group significantly decreased immediately after exercises as well as 3 h after exercises (P<0.05) and also decreased remarkably in next morning (P<0.01); free testosterone level of C group had no significant change immediately after exercises and 3 h after exercises, while it

significantly decreased in next morning (P<0.05). In inter-groups comparison, free testosterone level of C group immediately after exercises and 3 h after exercises was significantly higher than HP group and LP group.

3.2. Effect of Carbohydrate-Protein Drinks on Sex Hormone-binding Globulin (SHBG) Level after Resistance Exercises

Table 4 showed that SHBG level of each group before and after exercises as well as during recovery period had different change patterns: HP group and LP group presented same change patterns that SHBG level had no change immediately after exercise, decreased significantly after 3 h (P<0.05) and recovered in next morning (P<0.05); SHBG level of C group significantly decreased immediately after exercises as well as 3 h after exercises (P<0.05), and rose again in next morning while the increase was not obvious (P>0.05). In inter-groups comparison, SHBG level of C group in next morning was significantly lower than HP group and LP group (P<0.05).

Table 4. SHBG level of each group before and after resistance exercises and during recovery period (nmol·1-1)

	HP group	LP group	C group
Before exercises	24.62±1.23	26.34±1.25	24.64±1.33
Immediately after exercises	22.63±0.74	24.71±1.15	21.66±0.96*
3 h after exercises	20.04±0.88*,#	19.22±1.37*,#	18.65±0.99**,#
Next morning after exercises	21.56±0.84*,&	22.46±1.63&	19.64±1.06**,@,$

*P<0.05 and **P<0.01, compared to before exercises; #P<0.05, compared to after exercises immediately; &P<0.05, compared to 3 h after exercises; @P<0.05, compared to HP group; $P<0.05, compared to LP group.

3.3. Effect of Carbohydrate-Protein Drinks on Serum Cortisol Level after Resistance Exercises

As shown in table 5, serum cortisol levels of HP group and LP group had no change immediately after exercises, significantly decreased 3 h after exercises and recovered to the basic value before exercises in next morning. Serum cortisol level of C group decreased significantly immediately after exercises (P<0.01) and continued to decrease 3 h after exercises (P<0.01), and it recovered to the basic value in next morning. Inter-groups comparison indicated that serum cortisol level of C group was significantly lower than HP and LP group immediately after exercises, while no difference of serum cortisol level was found in other time points between three groups.

Table 5. Serum cortisol level change of each group before and after resistance exercises and during recovery period (ug·dl-1)

	HP group	LP group	C group
Before exercises	14.60±0.92	14.64±0.98	14.45±0.66
Immediately after exercises	14.32±0.99	13.88±0.86	11.85±1.11**，@，$
3 h after exercises	8.07±1.04**，##	7.65±0.48**，##	8.68±1.72**，##
Next morning after exercises	14.88±0.88&&	13.06±1.05&&	15.03±0.96&&

*P<0.05 and **P<0.01, compared to before exercises; ##P<0.01, compared to after exercises immediately; &&P<0.01, compared to 3 h after exercises; @P<0.05, compared to HP group; $P<0.05, compared to LP group.

3.4. Effect of Carbohydrate-Protein Drinks on Ratio of Testosterone/Cortisol (T/C) after Resistance Exercises

As shown in table 6, T/C ratios of HP group and LP group had no change immediately after exercises and increased significantly 3 h after exercises (P<0.01); ratios recovered to basic values before exercises in next morning. T/C ratio of C group increased after exercises (P<0.05) and continued to increase 3 h after exercises (P<0.01); the ratio significantly decreased to the basic value in next morning (P<0.01). In inter-groups comparison, no significant difference was found among three groups, while T/C ratio of C group was significantly higher than HP group and LP group immediately after exercises, and T/C ratio of HP group increased more significantly than that of group LP and C after 3 h of exercises. No change showed in other time points among three groups.

Table 6. Change of T/C ratios before and after resistance exercises and during recovery period (10-3)

	HP group	LP group	C group
Before exercises	45.41±4.90	46.11±4.72	45.33±4.13
Immediately after exercises	46.24±4.23	44.65±3.78	55.28±4.89**,@,$
3 h after exercises	73.77±5.08**,##,$,^	63.69±3.15**,#,#	65.37±3.52**,#,#
Next morning after exercises	42.74±3.50&&	49.16±4.85&&	47.20±4.32&&

*P<0.05 and **P<0.01, compared to before exercises; #P<0.05 and ##P<0.01, compared to after exercises immediately; &&P<0.01, compared to 3 h after exercises; @P<0.05, compared to HP group; $P<0.05, compared to LP group; ^P<0.05, compared to C group.

3.5. Effect of Carbohydrate-Protein Drinks on Androgen Level in Urine after Resistance Exercises

Table 7 indicated that androgen (And), etiocholanolone (Etio) and dehydroepiandrosterone (DHEA) of HP group significantly increased after exercises (P<0.05), while 5α-diol, 5β-diol, endothelin (ET) and testosterone (T) had no obvious change. In next morning after exercises, And, Etio, DHEA, 5α-diol, 5β-diol and T significantly increased, and ET increased but had no significant change. And, Etio, DHEA and 5β-diol of LP group increased significantly immediately after exercises (P<0.05); however, except for 5α-diol which increased in next morning (P<0.05), other levels all decreased, and ET and T had no obvious change before and after exercises. And, Etio and DHEA of C group increased significantly while others had no change; And, Etio, 5α-diol, ET and T increased significantly (P<0.01), DHEA decreased (P<0.05) and others had no change. In inter-groups comparison, 5α-diol and 5β-diol of HP group were significantly higher than that of LP and C group in next morning (P<0.05).

Table 7. Androgen level of each group before and after resistance exercises and during recovery period (ng·ml-1)

Groups	Indexes	Before exercises	Immediately after exercises	Next morning after exercises
HP	And	1746.86±345.26	1945.25±450.27*	2556.34±470.16**
	Etio	1506.38±341.29	1687.03±398.37*	2135.11±442.19**
	5α-diol	55.98±12.60	51.62±11.36	87.36±17.23**，##,$,^
	5β-dio	63.96±16.22	60.95±14.61	96.52±21.08**，##,$,^
	DHEA	48.64±13.52	60.81±15.01*	83.04±23.88**，##
	ET	28.59±5.88	27.45±5.86	30.99±3.73
	T	30.16±4.38	28.29±4.95	35.99±3.36*
LP	And	1593.35±145.64	1800.26±257.61*	1648.03±264.89

	Etio	1416.17±306.34	1593.99±439.86*	1473.56±289.34
	5α-diol	51.75±11.55	48.56±12.26	61.74±12.12*,#
	5β-dio	57.35±12.84	71.33±15.03*	66.34±12.25**
	DHEA	49.04±1045	65.42±11.33*	51.81±11.08
	ET	33.62±10.12	20.15±9.83	29.75±7.71
	T	30.67±9.65	30.11±9.40	27.44±8.58
C	And	1902.05±411.56	2379.56±530.26*	2571.91±295.34**
	Etio	1486.68±320.57	1736.98±385.42*	1830.35±542.71*
	5α-diol	53.35±10.86	51.55±14.02	66.79±13.14*
	5β-dio	56.12±6.48	52.86±10.75	52.43±7.15
	DHEA	49.96±4.53	65.46±5.48**	57.34±2.96*,#
	ET	31.66±4.59	29.68±8.13	39.88±7.16**,##
	T	28.30±8.85	31.65±9.46	38.88±10.51**,##

*P<0.05 and **P<0.01, compared to before exercises; #P<0.05 and ##P<0.01, compared to after exercises immediately; &&P<0.01, compared to 3 h after exercises; $P<0.05, compared to LP group; ^P<0.05, compared to C group.

3.6. Effect of Carbohydrate-Protein Drinks on Androgen ratios in Urine after Resistance Exercises

As shown in table 8, T/ET ratio of HP group decreased significantly after exercises (P<0.05) and other androgen ratios showed no significant change. 5α-diol/5β-diol ratio of LP group decreased significantly immediately after exercises and rose to the basic value in next morning. And/Etio ratio as well as 5α-diol/5β-diol ratio of C group was significantly higher than the basic value in next morning after exercises (P<0.05).

Table 8. Changes of androgen ratios of each group before and after resistance exercises and during recovery period

Groups	Indexes	Before exercises	Immediately after exercises	Next morning after exercises
HP	A/Etio	1.24±0.16	1.19±0.18	1.23±0.16
	5α-diol/5β-dio	1.01±0.16	0.93±0.13	0.98±0.16
	T/E	1.10±0.13	1.01±0.14*	1.09±0.14
LP	A/Etio	1.17±0.15	1.13±0.15	1.14±0.21
	5α-diol/5β-dio	0.86±0.05	0.81±0.03*	0.86±0.04
	T/E	1.11±0.12	1.12±0.14	1.21±0.13*
C	A/Etio	1.27±0.07	1.37±0.12	1.42±0.06*
	5α-diol/5β-dio	1.06±0.11	1.16±0.14	1.32±0.17*
	T/E	1.11±0.13	1.07±0.15	1.05±0.16

*P<0.05, compared to before exercises

4. Conclusions

In practical exercises, serum T is used to monitor body function state of athletes during long-term training. Observation of T level after acute exercises in this study aims to compare effect of different nutritional intervention methods on serum T level, as well as to discuss effect of carbohydrate and protein nutrients on exercise fatigue recovery. Serum T level of HP group and LP group had no significant change after a group of resistance exercises, and the cycle T response results in this study are the same as the results found by Stephen P. Bird

(2006) and Hulmi JJ. (2008) (Bird, Tarpenning and Marino, 2006; Hulmi et al., 2008). No explicit explanations of such kind of change are put forward so far, and the reason might be the increase of insulin level due to supplement of carbohydrate and protein. Some reports indicate that insulin level in human body is in negative correlation with T and SHBG (Linnamo et al., 2005). Intake of carbohydrate and protein before, during and after resistance exercises can lead to change of hormone response characteristics, and effect of nutrients on hormone response change after resistance exercises is thought to be able to accelerate assimilation, dissimilation or transformation during several days after resistance exercises (Ratamess et al., 2005).

After resistance exercises, androgen level in urine will increase, decrease or stay the same, which may related to exercises load, exercise intensity and nutritional intervention. The main androgen metabolite And and Etio of each group immediately after exercises all show increase tendency, which is mainly because of nutritional intervention as well as effect from resistance exercises. Experiment shows that 5α-diol and 5β-diol of HP group in next morning are higher than basic value, which indicates that the combination of resistance exercises with nutritional intervention can activate 5α reducing ferments in liver and accelerate transformation of testosterone to dihydrotestosterone (DHT). 5α reducing ferments are mostly found in subcutaneous tissues instead of skeletal muscles, which can accelerate metabolism of adipose tissues through multiple ways, such as accelerating glycolysis, lipid break down, cell reconstruction, cell proliferation and differentiation (Bolduc et al., 2007; Bolduc, Yoshioka and Amand,2007). DHT can inhibit differentiation of mesenchymal cells as well as pre-adipocytes without influencing proliferation of mesenchymal cells (Gupta et al., 2008). Increased content of DHT which can combine with SHBG in the strongest way is beneficial to recovery of athletic ability.

With effect of carbohydrate-protein nutritional interventions in different proportions, different intervention groups show different change tendencies. T/ET ratio of HP group decreases significantly after exercises while other ratios have no change before and after exercises. The ratio change may be related to ratio calculation, and another reason may be that during exercises, ET level is stable, while T has obvious change; the nutritional intervention with high proportion of protein will lead to decrease of T in urine, which may be caused by high use ratio of T in skeletal muscles. Thus, the decrease of T metabolism results in decrease of T/ET ratio, indicating increase of use ratio of testosterone by skeletal muscle tissues. 5α-diol and 5β-diol ratios of LP group decrease significantly after exercises and recover to the basic value in next morning, the reason of which may be related to the effect of nutritional interventions on reducing ferment activity of 5α and 5β in liver, thus leads to change of 5α-diol and 5β-diol ratios. During 24 h recovery period of C group after exercises, And/Etio ratio is significantly higher than basic value, and the reason may be the significant increase of And metabolism caused by fluctuation of adrenal androgen as well as long recovery time due to nutritional interventions (Schumm et al., 2008). Besides, it is difficult to explain changes of different kinds of androgen caused by different carbohydrate-protein nutritional interventions. Based on general change tendency, effects of intervention of carbohydrate and protein on androgen, especially on high content androgens like And and Etio are mild, thus changes of androgen ratios are mainly caused by resistance exercises.

In conclusion, intake of carbohydrate-protein drinks can accelerate body tissue assimilation of male athletes engaging in strength-needed sports items after resistance exercises, as well as accelerate recovery and improvement of athletic ability.

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APPLICATION OF WHEY PROTEIN IN SPORTS DRINK

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ABSTRACT
This study explores the application of whey protein in sports drink. According to the special nutrition principles of sports drink, the single factor experiment method is used to confirm additive amount of all components in whey protein sports drinks, and sensory evaluation is used as the evaluation index to find the best formula of whey protein sports drink. The best formula of whey protein sports tonic drink: 3. 0% of 3.0g/l00ml whey protein; 3.5% of 1:1.5 mixture of sucrose and oligosaccharides; 2.0% of acidulant (a 1:1 mixture of citric acid and malic acid), 0.15% of thickener and 1.2% of salt. Whey protein drinks have positive effect on after-exercise body recovery for athletes.

1. Introduction

When individual is in high temperature environment or do extensive exercise, water desorption, electrolyte loss, protein catabolism strengthening, dysfunction of cell membrane permeability and leakage of intracellular enzyme will appear in human body. In order to satisfy the physiological characteristics and nutrition needs of sports group, meanwhile, to recover the dissipative tissue proteins in movement of sports individual and repair the damaged tissues of individual organism, sports individual have to supplement fluid and protein and increase the nutrition intake (Burke,2007; Jeukendrup, 2014; Burke *et al*., 2012; Bacha, 2013). The latest research of international sports nutrition also shows that for athletes, drinking composite sports drinks that contains a certain percentage of protein and carbohydrates after exercise not only can enhance the body blood's response to insulin and promote the rate maximization of reserving synthetic muscle glycogen, but also it can stimulate the protein synthesis, promote the development of muscle strength, shorten the body physical recovery time after extensive exercise, whose recovery time is shorter than other drinks, and even can prevent excessive training(Cotunga, Vickery and McBee, 2005; Mathew, Casamassimo and Hayes, 2002; Zoorob *et al*., 2013). Scholars at home and abroad have done lots of researches to the influence of sports drink on the exercise capacity. Roderick etc. (Roderick *et al*., 2008) studied the dehydration process of athletes training. It was found that in mild dehydration, for athletes, loss of moist is mainly from extracellular space of engine body. With the increase of the degree of dehydration, the proportion of water loss in engine body cell also increased gradually. In 2008, Friedman R (Friedman and Elliot, 2008) compared the effect of sports drinks and spring water on sport performance. The results indicated that under the condition of without knowing what you have drunk, sport performance of group drinking sports drinks is better than the other group drinking spring water.

At present, the composition of sports drinks on the market is mainly sugar, vitamins and minerals. From the aspect of composition and content, sport drinks have the following disadvantages: single carbohydrate supplement system, lack of amino acid and protein used for repair damaged body muscle tissue, which can not satisfy the needs of professional athletes and fitness crowd, especially for energy and endurance athletes (Von Duvillard *et al.*, 2008; Shirreffs, 2009). Whey protein has the good sports nutrition value, features and functional characteristics of high content of branched chain amino acid, easily absorbed, low fat and the unique space structure, which can satisfy the needs of professional athletes and exercising people for protein (Seydim and Sarikus, 2006). Moreover, whey protein has effect of increasing the body's muscle strength, strengthening the body's immune ability, improving the movement environment of and promoting quick recovery of body strength. Therefore, composite sports drinks with protein, sugar and electrolyte has become a new trend of the development in sports drinks. According to the latest research of international sports nutrition and absorption mechanism of exercise body, this paper developed a new complex sports drinks with protein, sugar and electrolyte for professional sports group and exercising people. The main component of the drink is acid whey protein, so it is called whey protein sports drink.

2. Materials and methods

2.1. Material

Acid whey protein, cane sugar, oligosaccharide, malic acid, citric acid, carboxymethylcellulose (CMC) and salt which can be found on the market are used. All the reagents used in the experiment are analytically pure.

Instruments used include BS224S electronic scales, PHS-3C acidimeter, WYT-IV, SHZ-D (III) circulating water vacuum pump and high pressure homogenizer and capper.

2.2. Experimental Method

Production process of whey protein drinks and the operating points

Production process of whey protein drinks

Whey protein liquid + auxiliary → adjusting pH → filtration → homogeneity → outgassing → encapsulation → sterilization → refrigeration → finished product

The operating point of production process: (1) mixing procedure: first, wetting the acid whey protein completely and high speed stirring. After full dissolution, other mixed materials such as sugar mixture, sour agent, vitamin C, salt and thickener are added.

(2) PH adjustment: to ensure the clarity of Whey protein sports drinks, pH value shall be limited to 3.3 ± 0.1 strictly.

(3) Filtration: filter the dissolved material with 180 purpose strainer to remove the cracking.

(4)Homogeneity and outgassing: homogeneously process the drinks with 25 mpa pressure and degassing it under 0.9 mpa vacuum degree. The aim of homogeneity is to ensure clarity and smooth of drinks and avoid beverage stratification and precipitation after sterilization. Degassing is to reduce or prevent oxidation discoloration.

(5) Encapsulation conditions: 87±2 °C filling temperature, 30s sterilization time with bottle upside down.

(6) Sterilization condition: 95°C±2°C sterilization temperature, 60±l s time.

As high temperature will lead to flocks, high-temperature short-time pasteurization is used.

(7) Storage temperature: wash drinks with flowing water, then immediately cooling drinks and finally store them at 40 °C.

2.2.1. Design of Test

Single-factor test is applied to confirm the suitable additive amount of whey protein (Sanunders, Kane and Todd, 2004), saccharose,

oligosaccharide, acidulant (citric acid and malic acid1:1), and CMC.

(1) Additive amount of whey protein

Compare the influence of different additive amount of whey protein on senses when mixture of sucrose and oligosaccharides (1:1.5), acidulant (citric acid and malic acid 1:1), CMC, salt and vitamin C added is 0.5%, 1.0%, 0.3%, 1.2% and 2.5%. The additive amount of whey protein is 1%, 1.5%, 2%, 2.5%, 3%, 3.5%, 4% and 5% respectively (mass fraction, similarly hereinafter).

(2) The additive amount of saccharose and oligosaccharide

Compare the influence of different additive mixture amount of 1:1.5 Sucrose and oligosaccharides on sense when whey protein, mixture of citric acid and malic acid (1:1), CMC, salt and vitamin C added is 2.5%, 1.0%. 0.3%, 1.2% and 2.5% respectively.

(3) The additive amount of acidulant (citric acid and malic acid1:1)

Compare the influence of different additive amount of acidulant on the senses when whey protein, mixture of citric acid and malic acid (1:1), CMC, salt and vitamin C added is 2.5%, 1.5%, 0.3%, 1.2% and 2.5% respectively. The additive amount of acidulant is 0.5%, 1%, 1.5%, 2%, 2.5%, 3% (mass fraction, similarly hereinafter).

(4) The additive amount of CMC

Compare the influence of different additive amount of thickener on the senses when whey protein, mixture of citric acid and malic acid (1:1), CMC, salt and vitamin C added is 2.5%, 1.5%, 1.0%, 1.2% and 2.5%. The additive amount of thickener is separately 0.05%, 0.1%, 0.15%, 0.2%, 0.25%, 0.3%, 0.35% (mass fraction, similarly hereinafter).

2.3. Sensory evaluation methods

Two groups of people, 10 in each group, made a sensory evaluation on the test samples. Abnormal data were removed. The average score of two groups was taken as the final result. Total score is 100 points. Detailed rules for sensory evaluation are shown in table 1.

Table 1. Detailed rules of production sensory evaluation

Taste	Fragrance	Transparency degree
Cooling Feeling, moderate sweet and sour degree: 30~35	Charming perfume: 25~30	Clear without precipitation and impurities: 30~35
Ordinary taste: 25-30	Ordinary fragrance: 15~25	Good: 25~30
Bad taste: below 25	Mixed smell: below 15	Turbid with sediment: below 25

2.4. Data Analysis

SPSS 17.0 software was used for analyzing data.

3. Results and discussions

3.1. Determination of Whey Protein Content

This test compares the influence of whey protein content on acceptability of beverage flavor, taste, etc, and the results are shown in figure 1.

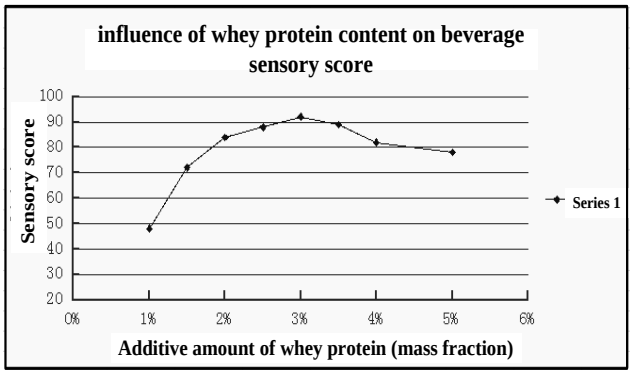

Figure 1. Influence of whey protein content on beverage sensory score

From figure 1, we see that with the increase of whey protein content, sensory score on acceptable degree of the beverage increases. When whey protein content reaches 3 %, the sensory score is the highest and the transparency effect as well as beverage taste and flavor reaches the best level. When the whey protein content exceeds 3 %, things go against the direction. Through the data analysis ($P<0.05$), we found that whey protein content has a significant effect on sensory acceptance degree of beverage, thus the whey protein content of the beverage is determined to be 3%.

3.2. Determination of Sucrose and Oligosaccharides Content

The test compares the influence of sucrose and oligosaccharides content on sensory acceptable degree of drinks, test results are shown in figure 2.

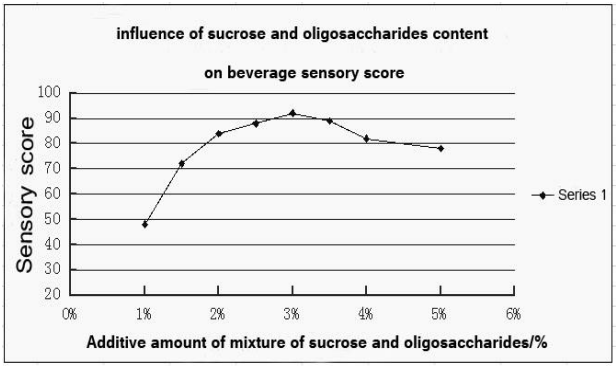

Figure 2. Influence of sucrose and oligosaccharides content on beverage sensory score

From figure 2, we see that with the increase of sugar mixture content, acceptable degree sensory score increases as well. When the sugar mixture content reaches 3.5%, the sensory score reaches the highest point and the transparency effect as well as beverage taste and flavor reaches the best level. However, after this point, the sensory score begins to decline with the increase of sugar mixture content. Through the data analysis ($P<0.05$) we found that sugar mixture content has significant influence on sensory acceptable degree of drinks, thus the sugar mixture content is determined to be 3.5%.

3.3. Determination of Citric Acid Content

Mixture of citric acid and malic acid (1:1) is used as the acidulant for the test. We compare the influence of acidulant content on sensory acceptable degree of drinks; test result is shown in figure 3.

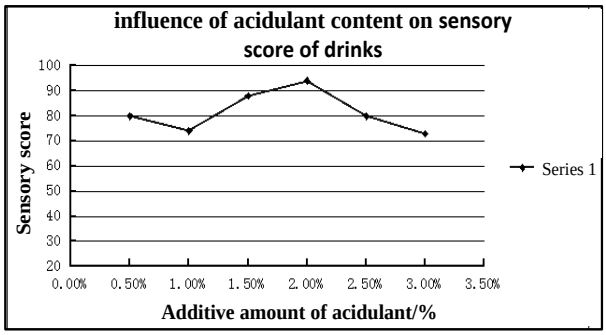

Figure 3. Influence of acidulant content on sensory score of drinks

From figure 3, we can see that with the increase of acidulant content, the acceptable degree sensory score increases as well, and when it reaches 2.0%, the sensory score reaches the highest point and the transparency effect as well as beverage taste and flavor reaches the best level, and PH value at this point is 3.2. However, after this point, the acceptance sensory score decreases with the increase of acidulant content. Through the data analysis ($P<0.05$) we found that acidulant content has a significant influence on the sensory acceptable degree of drinks, thus the acidulant content in the drink is determined to be 20.%.

3.4. Determination of CMC Content

The test compares the influence of thickener content on sensory acceptable degree of drinks, and results are shown in figure 4. In figure 4, we can see that with the increase of thickener content, the acceptable sensory score increases as well. When the thickener content reaches 0.15%, the sensory score reaches the highest point and the transparency effect as

well as beverage taste and flavor reaches the best level.

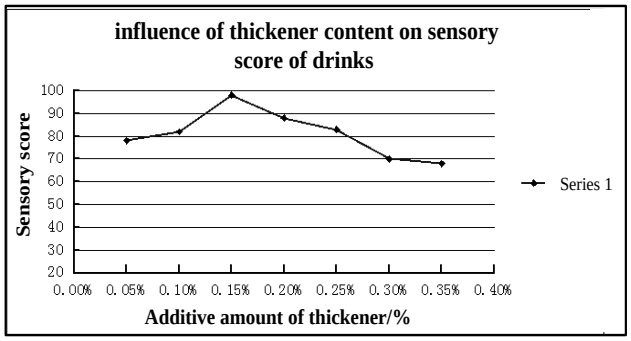

Figure 4. Influence of thickener content on sensory score of drinks

However, after this point, the acceptable sensory score decreases with the increase of thickener content. Through the data analysis ($P<0.05$) we found that thickener content has a significant influence on sensory acceptable degree of drinks, thus the thickener content is determined to be 0.15%.

Through single factor experiment, the content of main components of drinks is determined. The test result shows that the optimum formula for whey protein sports tonic drink is: 3.0% of 3.0g/l00ml whey protein, 3.5% of 1:1.5 mixture of sucrose and oligosaccharides, 2.0% of acidulant (citric acidand and malic acid: 1: 1), 0.15% of thickener, 1.2% of salt. This drink contains rich nutrient substance which is essential for individual movement with a good taste. Besides, it makes full use of the nutritional value and the physical and chemical properties of whey protein (Van Loon et al., 2000); therefore it can quickly replenish the body physical ability, promote the body's normal metabolism and thus has a high market recognition. In addition, due to the simple production technology and equipment requirements and good universality of the corollary equipment, general beverage manufacturers can meet these conditions, so the product has a good market development prospect.

3.5.Influence of Whey Protein Drinks on Physical Energy Recovery and Fatigue Elimination of Exercise Body

Through voluntary principle (Ali *et a*l., 2011), select 16 athletes to participate in the provincial track meet, the concentrated training time is 6 months; they were randomly divided into test group (8 people) and control group (8 people). The control group is with an average age of 18.21±1.05 years old; average height is 169.88±8.77cm; average weight before test is 64.23±6.98kg. For the test group, the average age is 18.33±0.68 years old; average height is 171.12±6.03cm; average weight before test is 62.44±8.28kg. There is no significant difference on the age, height and weight of the two groups.

Two groups of athletes are given the same training task every day, training twice a day, 2. 5 hour each time. During the training, the athletes in the test group drink 800ml of whey protein drinks one hour before and after the training everyday and 400 ml of whey protein drinks one hour before sleep. And for the athletes in control group, they drink the same amount of pure water and the taking time is consistent with the test group. The test time lasts for 12 weeks and all the athletes are required to have meals at the student canteen during the test, the food price is controlled between 15 and 17 Yuan, with no additional nutritional supplements.

Two groups of athletes have to accept the same training program every day and the training project includes: load cycle racing, standing long jump, 3min push-up, 3 min sit-up, stand-able style 3 m running, 5 ×25m shuttle running, 12min running, body anteflexion, conversion running, etc. then test the blood composition, blood biochemical indexes, body composition indicators, aerobic capacity indexes (Temelli, Bansema and Stobbe, 2004)of the athletes of the two groups before and after the training.

3.6. Influence of Supplementary of Whey Protein Drinks on Blood Biochemical Indexes of Track and Field Athletes

The test studies the influence of supplementary of whey protein drinks on blood biochemical indexes of track and field athletes, the results are shown in table 2 and table 3.

Table 2. Comparison of blood composition of athletes of the two groups before and after the training (mean ±SD)

	Control group		Test group	
	Before test	After test	Before test	After test
Hb (g/1)	133.8±7.55	127.09±6.84*	134.86±1.68	137.63±0.73**
RBC (10^{12}/1)	4.46±0.31	4.15±0.22	30.55±2.19	38.34±1.52
HCT (%)	30.55±0.48	34.35±2.23	30.66±1.54	33.21±1.02
MVC (%)	70.39±6.21	76.57±6.96	72.29±0.25	71.77±3.12

Note： * P<0.05 in comparison before and after test; ** P>0.05 in comparison before and after test

Table 3. Comparison of Blood biochemical indexes of athletes of the two groups before and after the training (mean ±SD)

	Control group		Test group	
	Before test	After test	Before test	After test
Bla (mmol/l)	2.35±0.21	9.77±0.11*	2.59±0.14	7.15±0.12**
CK	300.23±80.3	371.44±55.1*	297.66±19.3	305.63±1.87**
BUN	3.15±1.02	3.57±0.26*	3.12±0.15	3.25±0.64**
Blood sugar (mmol/l)	4.16±0.48	3.47±0.65*	4.39±0.58	4.55±0.46**

Note: * P<0.05 in comparison before and after test; ** P>0.05 in comparison before and after test.

Through the test, we found that the blood index changes of control group are as follows: a 4.51% drop in hemoglobin (HB) level (P<0.05), 6. 28% increase in HCT (hematokrit) (P<0.05), no significant change in number of red blood cells (RBC) and average volume of red blood cells (MVC) (P>0.05). While for test group, the blood index changes are as follows: no significant change in hemoglobin (HB) level, number of red blood cells (RBC) and average volume of red blood cells (MVC), (P<0.05); while there is a 3.8% rise in HCT (hematokrit) (P<0.05), it suggests that the supplementary of whey protein drinks can prevent the obvious decline of hemoglobin level and sustain function of red blood cells.

From table 3, blood biochemical index changes of control group are as follows: 20.9% rise in (P>0.05) serum creatine excitation (CK) level and 10.3% rise in serum urea nitrogen (BUN) (P>0. 05).

And the changes of test group are as follows: there were no significant changes in CK values and BUN values. And it was found through a quantitative load exercise test for the two groups that the blood lactate acid density increases by about 2.5 times for the athletes in the control group while that of the test group increase by about one time (P<0.05). This suggests that after quantitative load training, supplementary of whey protein drinks can improve aerobic capacity of skeletal muscle of athletes.

From table 3, we see that blood sugar concentration of control group are respectively 4.16±0.48mmol/l and 3.47±0.65mmol/l, which means a 17.5% decline (P<0. 05); While that of the test group are 4.32±0.65 mmol/1 and 4.55±0.46mmol/l, which means a 3.4% rise

(P<0. 05). It indicates that the supplementary of whey protein drinks can maintain stable blood sugar levels of the athletes during training and those with no supplementary of whey protein drinks show a decrease in the level of blood sugar levels.

3.7. Effect of Whey Protein Drinks on Body Composition of Track and Field Athletes

This test studies the effect of whey protein drinks on body composition of track and field athletes, the results are shown in table 4.

Table 4. Comparison of body composition indicators of two groups before and after training (mean ±SD, n=8)

n	Fat Free Mass		Body fat%	
	Before test	After test	Before test	After test
Control group(n=8)	50.74±2.31	51.77±2.55	12.35±3.52	11.75±0.65
Test group (n=8)	50.98±1.85	53.21±0.65*	15.00±1.98	16.69±3.79**

Note: * P<0.05 in comparison before and after test; ** P>0.05 in comparison before and after test.

From table 4, we can see that there is a 4.77% of rise in the Fat Free Mass of athletes in the test group (P<0. 05) and a 8.36% of decrease in percent body fat (P<0. 05); while the athletes in the control group experienced a 1.55% of rise in Fat Free Mass (P>0.05) and a 1.02% of decrease in percent body fat (P>0.05). The results suggest that supplementary of whey protein drinks can promote the growth of the body's muscles, reduce body fat content and increase Fat Free Mass.

3.8. Influence of Whey Protein Drinks on Aerobic Capacity Indicators of Track and Field Athletes

The test observes the influence of whey protein drinks on aerobic capacity indicators of track and field athletes and the results are shown in table 5.

Table 5. Comparison of Aerobic capacity indicators of two groups before and after training (mean ±SD, n=8)

		Control group		Test group	
		Before test	After test	Before test	After test
Resting heart rate		55.35±5.92	55.13±6.44	54.57±6.15	54.17±7.18
Heart rate in loading exercise (b/min)	50W	80.14±7.45	81.32±7.33	79.02±6.86	82.75±7.76
	100W	118.32±7.71	119.94±8.45	115.97±8.25	121.16±6.53
	150W	144.4±11.9	142.3±12.3	142.82±10.31	141.32±11.65
Heart rate in recovery period (b/min)	1min	90.64±12.56	108.62±12.43	92.47±12.19	106.95±1.71
	3min	82.37±14.98	101.15±13.28	80.47±12.19	85.16±11.35
	5min	78.59±16.12	88.08±16.88	77.18±11.35*	80.37±17.38**

Note: * P<0.05 in comparison before and after test; ** P>0.05 in comparison before and after test.

From table 5, we see from the load exercise test that exercise training improves the cardio-vascular function of both two groups.

4. Conclusions

There is no significant difference on heart rate recovery between the two groups in the first minute of the recovery phase. In the third and fifth minute, there is a significant difference in heart rate between two groups ($P<0.05$). Moreover, athlete's heart rate in the test group recovers fast after progressive increasing load training, the results show that supplementary of whey protein drinks has a positive role in promoting the after- exercise body recovery for athletes.

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PREPARATION OF ANTIOXIDANT SPORTS FOOD SOYBEAN PEPTIDES

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ABSTRACT
Using soybean protein as substrate, this study hydrolyzes pepsase, papain, bromelain, neutral protease and alkaline protease under most suitable conditions to compare antioxidant activity of their hydrolysates. Results indicate that hydrolysates of bromelain, neutral protease and alkaline protease have stronger reducing capacity as well as ability of eliminating superoxide anion free radicals and hydrogen peroxide than others. Therefore, highly effective antioxidant soybean peptides products can be obtained through screening hydrolase and hydrolysis conditions of making soybean peptides.

1. Introduction

Soybean protein is the best kind of vegetable protein on account of its complete amino acid composition needed by human body (Diftis and Kiosseoglou, 2003; Li *et al.*, 2007; Puppo *et al*, 2004; Gizzarelli *et al.*, 2006); however, due to some defects of soybean protein functions, its use ratio is limited. Researches have found that some low molecular weight peptides can not only support human body with essential nutrients needed by body growth, but are also easy to be digested and adsorbed; meanwhile, it has functions like medical treatment, disease prevention and physiological accommodation. Therefore, the soybean peptides hydrolyzed from soybean protein using modern protein hydrolysis technology will become the main method of improving functions of soybean protein as well as broaden its application field (Ma *et al.*, 2013; Ma *et al.*, 2013).

In recent years, many bioactive peptide products are widely developed and applied in sports practices. Soybean peptides can be applied to production of powder, sliced and granular food, protein strengthened food as well as energy-supply drinks (Chuan, 2015). Besides, soybean peptides can be used to produce acid drinks due to characteristics like low viscosity and easy dissolving in acid. In 2001, international corporation Quest of England (Ramalingam *et al.*, 2005; Van Nieuwenhoven *et al.*, 2005) developed hyprol peptide-contained sports drinks which could reduce physical recovery time of athletes from 24 h to 10~15 h as well as prevent bad effect on athletes after high intensity exercises.

On the basis of researches in China and abroad, this study explored the relationship between molecular structures of antioxidant peptides and antioxidant physiological functions and activity indexes, screened out types of proteases as well as obtained antioxidant soybean peptides through enzyme hydrolysis. Main factors of hydrolysis process selection include temperature, PH value, amount of enzyme, concentration of substrate and time.

2. Materials and methods

2.1. Materials

Materials used in the study were as follows: entirely dissolved soybean protein powder, bromelain (EC 3.4.22.32), neutral protease (EC 3.4.23.6), alkaline protease (EC 3.4.21.62); anti-superoxideanion free radicals and superoxideanion free radicals production test boxes, hydrogen peroxide test box; Tris(hydroxymethyl)methyl aminomethane; tyrosine; sodium carbonate, sodium hydroxide, methanal solution, potassium ferricyanide, trichloroacetic acid (TCA), hydrochloric acid, disodium hydrogen phosphate, sodium dihydrogen phosphate, ferric trichloride, etc.

2.2. Methods

(1) Preparation of soybean protein hydrolysates

Soybean protein powder was dissolved in Tris-HCl buffer solution and processed in 90 °C for 5 min. After being cooled to a certain temperature, the solution was diluted to a constant volume and its pH was adjusted to the most suitable value. Then the solution was put in water bath with constant temperature to be adjusted to the best temperature and was then added with protease to activate hydrolysis reaction. After the completion of hydrolysis, enzymes were destroyed in 100 °C for 10 min. After cooling, the solution was centrifuged in 4 °C and 5000 r/min for 15 min. Clear liquid of top layer was frozen and dried for standby application.

(2) Kjeldah method was used in measure of protein content in soybean protein.

Measure of enzyme activity

(3)Enzyme activity refers to the ability of enzymes catalyze certain chemical reactions. Under specific conditions, the amount of enzymes needed in transforming 1 μmol substrate in 1 min is regarded as one activity unit (U) (Zhang *et al.,* 2015). This study used foline-phenol method to test activity of pepsase, papain, bromelain, neutral protease and alkaline protease.

(4)Formol titration method was used in the study to measure degree of hydrolysis (Tomčík *et al.,* 2005).

(5) Measure of antioxidant ability

Reducing capacity of sample A: the amount of 20 mg sample was dissolved in 1 ml distilled water, and then the solution was added with 2.5 ml 0.2 mol/L phosphate buffer saline (PBS) (pH 6.6) and 2.5 ml 1% potassium ferricyanide solution. After being blended, the 1 ml obtained solution was taken out and added with 0.2 ml 0.1% ferric trichloride solution. Next, the solution was added with 1 ml distilled water and blended. Then distilled water was used for zero setting and absorbance was measured at 700 nm. Higher absorbance indicates stronger reducing capacity of the sample.

Anti-superoxideanion free radicals ability of sample B: methods are referred to specification of test box. In the reaction system, the anti-superoxideanion free radicals ability was the ratio of superoxideanion free radicals inhibited by 1 mg sample in 37 °C for 40 min and superoxideanion free radicals inhibited by 0.0075 Vitamin C.

Ability of C sample eliminating hydrogen peroxide: methods are referred to specification of test box. In the reaction system, hydrogen peroxide eliminating ability was the elimination percentage of hydrogen peroxide in reaction system by 2 mg sample in 37 °C for 1 min.

2.3. Data Analysis

SPSS 17.0 software was used for statistical analysis.

3. Results and discussion

3.1. Protein Content of Soybean Protein Powder

Detection showed that the total nitrogen content of soybean protein powder selected in this study was 148.5448 mgN/g, thus the percentage of protein was 92.84%.

3.2. Screen of Enzyme

Due to different specificity as well as different enzyme cutting sites of different proteases, the polypeptides in hydrolysates are different and thus the amount and activity of obtained antioxidant soybean peptides are varied (Fischl *et al.,* 2008). Therefore, the selection of proteases is critical. On the basis of structures of antioxidant active groups, two aspects should be considered during the selection of hydrolases. First, occurrence rules of active groups should be followed. For example, exopeptidase should not be selected if active peptides products are needed as much as possible (Tie *et al.,* 2012); Trp (tryptophan) or Tyr (tyrosine) should appear at C-terminal as much as possible to obtain peptides with high free radicals elimination ability. Second, the most suitable conditions for enzyme should also be considered from aspects of practical production condition and production cost.

Same amount of pepsase, papain, bromelain, neutral protease and alkaline protease were used for enzymolysis of soybean protein under the most suitable temperature and pH values. Reducing capacity, ability of eliminating superoxide anion free radicals and ability of eliminating hydrogen peroxide were taken as indexes to screen suitable proteases.

(1) Measure of reducing capacity (Buddrick *et al.*, 2015):

$K_3Fe(CN)_6 + Sample \rightarrow K_4Fe(CN)_6 + Oxide\ of\ sample$ (2-1)

$$K_4Fe(CN)_6 + Fe^{3+} \rightarrow Fe[Fe(CN)_6]_3 \quad (2\text{-}2)$$

Sample offered electrons to reduce Fe^{3+} to Fe^{2+}. Absorbance of the final reactant was measured at 700 nm, and bigger absorbance means that more Fe^{3+} were reduced to Fe^{2+}, which indicated stronger reducing capacity. Generally speaking, reducing capacity of samples is in direct proportion to its antioxidant ability.

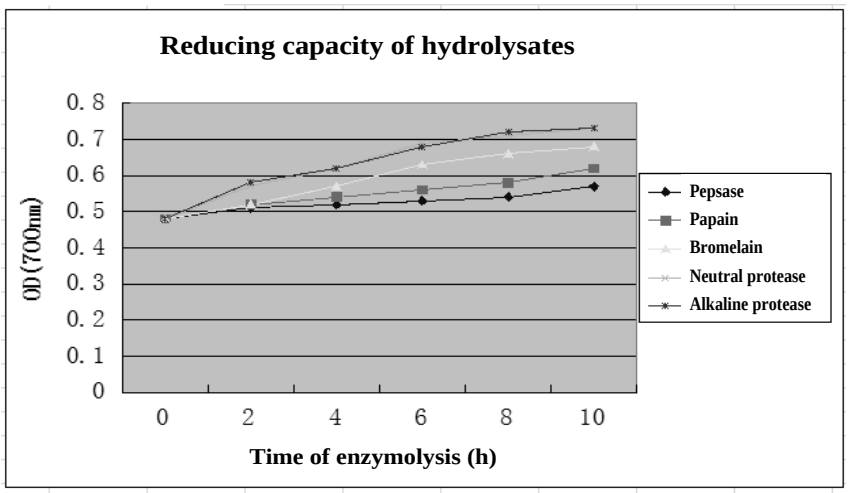

Figure 1. Reducing capacity of hydrolysates

Figure 1 shows that with the increase of time of enzymolysis, soybean peptides obtained from these proteases presented gradually increasing reducing capacity, and the reason might be that with the increase of hydrolysis degree, more active groups and sites were exposed, thus ability of supplying electron increased, which resulted in stronger reducing capacity. Hydrolysates of neutral protease and alkaline protease showed stronger reducing capacity than others, and bromelain followed behind while reducing capacity of pepsase and papain was the weakest. The reason might be related to the stronger hydrolysis of former three enzymes that more active groups of them were exposed during the same period of time;

another reason might be that enzyme cutting sites of former three enzymes were more beneficial to expose active groups or active cites. Therefore, from the aspect of reducing capacity, this study chose neutral protease, alkaline protease and bromelain.

(2) Measure of ability of eliminating superoxide anion free radicals

Superoxide anion free radical is a kind of harmful radical in metabolism, and the ability of eliminating superoxide anion free radicals is an important index in detecting antioxidant ability of samples.

Figure 2 shows that with the increase of time of enzymolysis, soybean peptides obtained from these proteases presented gradually increasing ability of eliminating superoxide anion free radicals and the increasing tendency was obvious at 10 h after enzymolysis. Therefore, enzymolysis could be continued if soybean peptides with stronger ability of eliminating superoxide anion free radicals were needed. Hydrolysates of neutral protease, bromelain and alkaline protease showed stronger ability of eliminating superoxide anion free radicals than other enzymes, and elimination ability of pepsase was the weakest. Therefore, from the aspect of superoxide anion free radicals elimination ability, neutral protease, alkaline protease and bromelain should be chosen in this study.

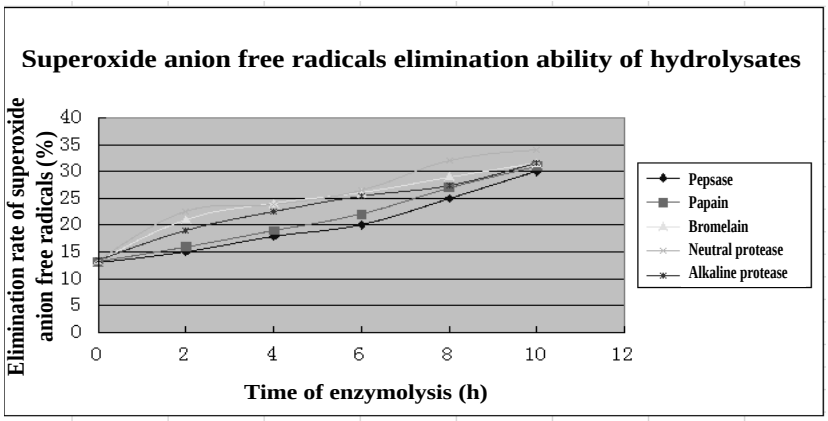

Figure 2. Superoxide anion free radicals elimination ability of hydrolysates

(3) Measure of ability of eliminating hydrogen peroxide

Peroxide chains retained and transferred to molecules of samples during the reaction between hydrogen peroxide and samples, thus new peroxides were produced. More transferred peroxide chains means stronger accepting ability of samples on peroxide chains, thus the antioxidant ability of samples was stronger.

Figure 3 shows that with the increase of time of enzymolysis, soybean peptides obtained from these proteases presented gradually increasing ability of eliminating hydrogen peroxide. Pepsase showed slow increase tendency of elimination ability after 8 h of enzymolysis while other four enzymes still showed obvious increasing tendency. Therefore, enzymolysis of other four enzymes could be continued if soybean peptides with stronger eliminating ability of hydrogen peroxide were needed. Hydrolysates of neutral protease and alkaline protease showed stronger ability of eliminating hydrogen peroxide than others, and bromelain followed behind; however, ability of eliminating hydrogen peroxide of bromelain was stronger than that of neutral protease after 7 h, while ability of eliminating hydrogen peroxide of pepsase and papain was the weakest. Therefore, from the aspect of eliminating hydrogen peroxide, neutral protease, alkaline protease and bromelain should be chosen in this study.

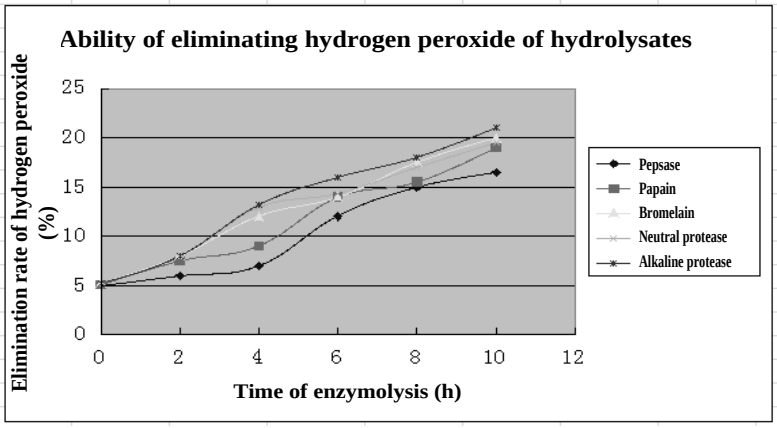

Figure 3. Ability of eliminating hydrogen peroxide of hydrolysates

3.3. Screen of Enzymolysis Conditions

(1) Screen of enzyme amount

Due to high cost of enzymes, the selection of enzyme amount should be able to ensure good hydrolysis degree of soybean protein as well as the cost in practical production. From above two aspects, alkaline protease, neutral protease and bromelain were acted on soybean protein in amount of 1000 U/g, 2000 U/g and 3000 U/g respectively to find out the best enzyme amount.

As shown in figure 4, with the increase of time of enzymolysis, soybean hydrolysis degrees of alkaline protease in three different amounts showed increasing tendency but the increase slowed down at 6 h. Thus, hydrolysates of alkaline protease in 1000 U/g, 2000 U/g and 3000 U/g at 6 h were tested by Student's t test (t-test). Results indicated that when significant level was $\alpha=0.05$ and df=4, hydrolysis degrees of 1000 U/g and 2000 U/g were significantly different; while hydrolysis degrees of 2000 U/g and 3000 U/g had no significant difference. Therefore, 2000 U/g was the best enzyme amount of alkaline protease.

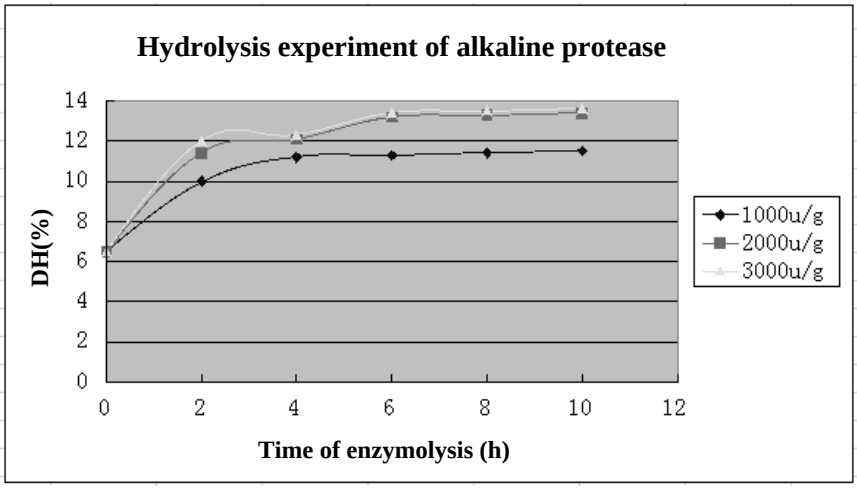

Figure 4. Hydrolysis experiment of alkaline protease

As shown in figure 5, with the increase of time of enzymolysis, soybean hydrolysis degrees of neutral protease in three different amounts showed increasing tendency. Hydrolysates of neutral protease in 1000 U/g, 2000 U/g and 3000 U/g at 6 h had t-test and

results showed that when significant level was α=0.05 and df=4, hydrolysis degrees of 1000 U/g and 2000 U/g were significantly different; while hydrolysis degrees of 2000 U/g and 3000 U/g had no significant difference. Therefore, 2000 U/g was the best enzyme amount of neutral protease.

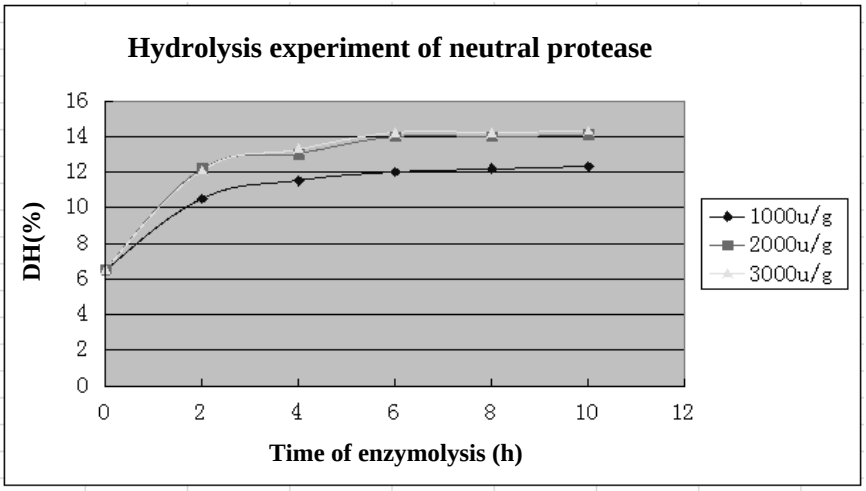

Figure 5. Hydrolysis experiment of neutral protease

As shown in figure 6, with the increase of time of enzymolysis, soybean hydrolysis degrees of bromelain in three different amounts showed increasing tendency. Hydrolysates of bromelain in 1000 U/g, 2000 U/g and 3000 U/g at 6 h had t-test and results showed that when significant level was α=0.05 and df=4, hydrolysis degrees of 1000 U/g and 3000 U/g had no significant difference. Therefore, 1000 U/g was the best enzyme amount of bromelain.

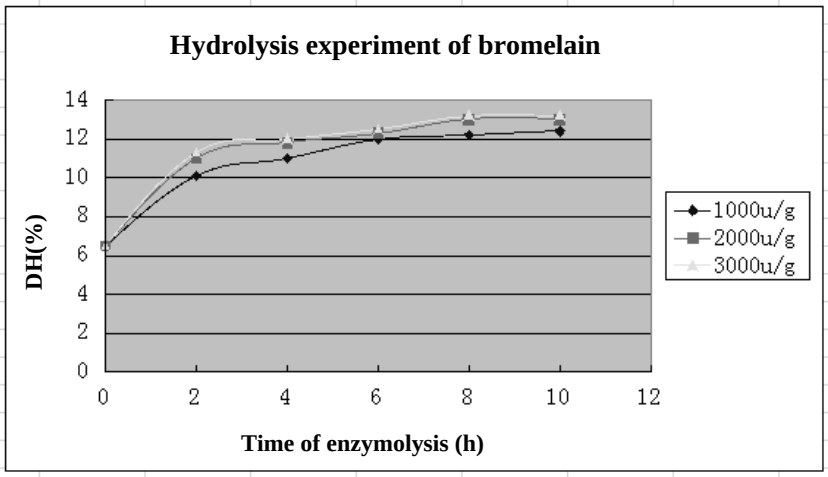

Figure 6. Hydrolysis experiment of bromelain

(2) Screen of pH value, concentration of substrate and temperature

PH value, concentration of substrate and temperature are important influencing factors of enzymolysis of soybean protein (Motoyama, 2009). The most suitable enzymolysis conditions can guarantee high efficiency of enzymolysis. This study chose $L_9(3^4)$ orthogonal tables and took hydrolysis degree as the index to screen pH values, concentrations

of substrate and temperatures of 2000 U/g alkaline protease, 2000 U/g neutral protease and 1000 U/g bromelain at 6 h of enzymolysis. Details are shown in table 1 and table 2.

Table 1. $L_9(3^4)$ orthogonality experimental factor level design

Levels	Factors		
	A	B	C
	PH	Temperature (°C)	Concentration of substrate (%)
1	6	40	4
2	7	50	6
3	8	60	8

Table 2 showed that the best enzymolysis conditions were 6.0 pH, 50 °C of temperature and 8.0% concentration of substrate. Statistical analysis showed that primacy sequence of these factors was concentration of substrate> pH> enzymolysis temperature, which means concentration of substrate has great influence on hydrolysis degrees while pH and enzymolysis temperature have small effect on hydrolysis degrees.

Table 2. Analytical table of orthogonality experimental results

Test number	Factors				Hydrolysis degree (%)
	A	B	C	D	
	PH	Temperature (°C)	Concentration of substrate (%)		
1	1	1	1	1	16.61
2	1	2	2	2	18.69
3	1	3	3	3	20.31
4	2	1	2	3	17.66
5	2	2	3	1	20.56
6	2	3	1	2	16.09
7	3	1	3	2	18.79
8	3	2	1	3	1655
9	3	3	2	1	17.46
Mean value K_1	18.55	17.70	16.42	18.22	
Mean value K_2	18.11	18.61	17.95	17.86	
Mean value K_3	17.61	17.96	19.90	18.18	
Range R	0.84	0.91	3.48	0.36	

(3) Screen of time of enzymolysis

With the best enzymolysis conditions of temperature, pH and concentration of substrate, Soybean protein can obtain high-efficiency enzymolysis. In order to obtain soybean peptides with strong antioxidant ability effectively in short period of time, reducing capacity, ability of eliminating superoxide anion and hydrogen peroxide were taken as indexes to screen out time of enzymolysis.

a. Measure of reducing capacity

In figure 7, reducing capacity of soybean protein without enzymolysis was 0.47, which was weaker than reducing capacity of soybean protein enzymatic hydrolysate. The strongest

reducing capacity of soybean protein enzymatic hydrolysate was 0.89, which showed at 4 h after enzymolysis and was 1.91 times stronger than reducing capacity of soybean protein without enzymolysis. Reducing capacity of soybean protein enzymatic hydrolysate decreased gradually 4 h after enzymolysis, and the reason might be that more active groups and sites with reducing capacity were exposed in enzymatic hydrolysate after 4 h; however, with the increase of hydrolysis degree, some active structures were destroyed and reducing capacity of exposed active groups and sites was not able to make up reducing capacity of destroyed active structures. Therefore, results indicated that the most suitable preparation time of antioxidant soybean peptides was 4 h after enzymolysis.

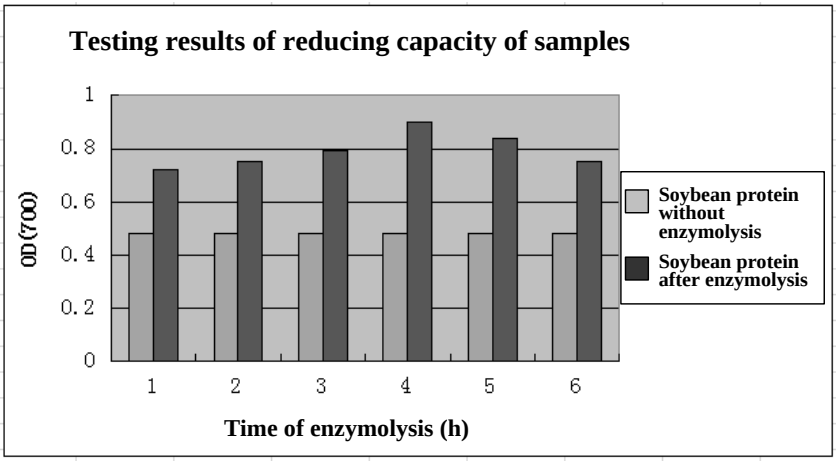

Figure 7. Testing results of reducing capacity of samples

b. Measure of Ability of Eliminating Superoxide Anion Free Radicals

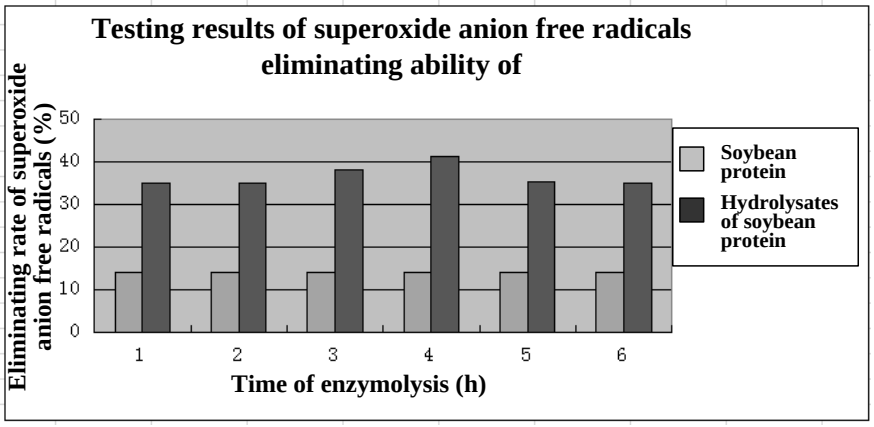

Figure 8. Testing results of superoxide anion free radicals eliminating ability of samples

As shown in figure 8, eliminating rate of superoxide anion free radicals of soybean protein without enzymolysis was 13.18%. Thus, ability of eliminating superoxide anion free radicals of soybean protein enzymatic hydrolysate was significantly stronger than that of soybean protein without enzymolysis. Besides, the strongest ability of eliminating superoxide anion free radicals of soybean protein enzymatic hydrolysate was 40.94%, which showed at 4 h after enzymolysis and was 3.12 times stronger than that of soybean protein

without enzymolysis. After that, the eliminating ability began to recede. Therefore, soybean peptides that had strong ability of eliminating superoxide anion free radicals could be obtained 4 h after enzymolysis.

c. Measure of Ability of Eliminating Hydrogen Peroxide

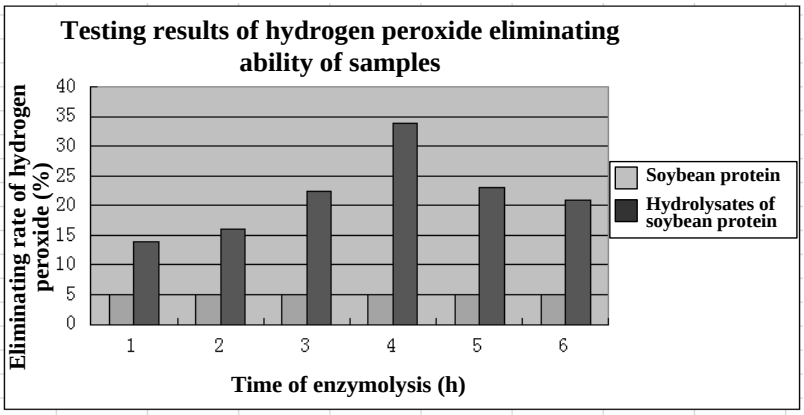

Figure 9. Testing results of hydrogen peroxide eliminating ability of samples

Figure 9 shows that eliminating rate of hydrogen peroxide of soybean protein without enzymolysis was 5.21%. Thus, ability of eliminating hydrogen peroxide of soybean protein enzymatic hydrolysate was significantly stronger than that of soybean protein without enzymolysis. Besides, the strongest ability of eliminating hydrogen peroxide of soybean protein enzymatic hydrolysate was 33.41%, which showed at 4 h after enzymolysis and was 6.45 times stronger than that of soybean protein without enzymolysis. After that, the eliminating ability began to recede. Therefore, soybean peptides that had strong ability of eliminating hydrogen peroxide could be obtained 4 h after enzymolysis.

In conclusion, taking reducing capacity, ability of eliminating superoxide anion free radicals and ability of eliminating hydrogen peroxide as indexes, soybean peptides that went through 4 h of enzymolysis had the strongest antioxidant ability.

4. Conclusions

To sum up, reducing ability, eliminating ability of superoxide anion free radicals and hydrogen peroxide are the strongest when 1000 U/g bromelain, 2000 U/g neutral protease and 2000 U/g alkaline protease have enzymolysis in 6.0 pH, 50 °C and 8.0% concentration of substrate for 4 h, which are 0.89, 41.05% and 33.43%, respectively, and obtained soybean peptides show strong antioxidant ability; antioxidant ability of soybean protein enzymatic hydrolysate is significantly stronger than that of soybean protein without enzymolysis, whose reducing capacity, ability of eliminating superoxide anion free radicals and hydrogen peroxide are 1.91, 3.12 and 6.45 times stronger than that of soybean protein without enzymolysis, respectively.

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APPLICATION OF HAZARD ANALYSIS AND CRITICAL CONTROL POINT IN QUALITY OF MINERAL WATER FOR ATHLETES

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ABSTRACT

Mineral water, a precious underground resource, contains multiple trace mineral elements. With the rapid development of sports cause in China, sports requires higher on the quality of mineral water, leading to consumption structure of mineral water. Quality of mineral water for athletes is attached more importance. Therefore, establishing hazard analysis and critical control point (HACCP) system is of great significance to improve quality of mineral water for athletes. This study made hazard analysis on the processing process of mineral water for athletes and confirmed CCP1 was water source, CCP2 was disinfection and sterilization of pipeline, CCP3 was disinfection and sterilization with ozone, CCP4 was disinfection and sterilization of bottle and bottle cap and CCP5 was filling environment. Through investigating source of mineral water, we found that, physical and chemical indexes of water quality were qualified, but microbiological index was a little higher (*Escherichia coli* 27 MPN/100mL). The best combination of ozone for sterilization was 0.6 mg/L ozone, 12 min and 4,500 L/h water flow. Additionally, sterilization effect of concentration of chlorine dioxide, sterilizing time and water temperature on bottle and bottle cap was discussed taking total bacterial count and free residual chlorine as indexes. Test of comparison of water quality before and after implementation of HACCP demonstrated that, bacterial count decreased from 100 cfu/mL to 10 cfu/mL. This study tries controlling the quality of mineral water for athletes by applying HACCP system, which improves quality and safety of akaline mineral water and ensure safety of athletes.

1. Introduction

Mineral water, one precious underground resource, is generally considered as underground water produced from underground bedrock, poured out from underground or revealed by human and being characterized by degree of mineralization and water chemical elements. It contains certain amount of mineral salt, microelement or carbon dioxide; generally, its chemical components, flow and temperature fluctuate stably within a natural scope. Mineral water containing specified mineral substance and indexes forms deep water circulation. Based on physical conditions and difference of regional drinking water, athletes can select suitable mineral water for drinking to supplement mineral substance, especially microelement. Water quality is the determining factor of mineral water (Jie et al, 2010; Hong, 2014).

Water is the important carrier of soluble hazardous substance and microorganism; water even with micro hazardous substance can also severely threaten health of human being and affect normal activities (Yunmu et al, 2010; Li and Liya, 2007). Thus we doubt the quality of

drinking water and pay attention to the quality of bottled drinking water which is drank during sports. Enterprises producing bottled drinking water are suggested to establish competitive advantages in production, control quality of drinking water for athletes with HACCP, keep the key control points (Limei and Ruiying, 2002; Zhirong et al, 2001; Chunli, 2004) and concern results and product equally, thus to eliminate risk factors influencing safety of drinking water for athletes in production process. This study tested quality of drinking water for athletes with the confirmed major items and methods and attempted to establish assessment system for quality of drinking water for athletes. This study controlled quality of drinking water for athletes with HACCP method, performed establishment and analysis of HACCP system in production of drinking water and finally confirmed the operation and application effect of HACCP system in production of drinking water for athletes.

2. Materials and methods

2.1. Experimental materials

Water tested in the study was shallow groundwater from Ganjiang, Ganzhou, Jiangxi, China. It was found through water quality investigation that, water in this area contains microelement conforming to criteria of mineral water.

2.2. Test method

First was flora test. The water was filtered by millipore filter with pore diameter of 0.45 pm; then the filter was pasted on selective medium adding with lactose and cultured at 37 °C for 24 h to form Gram negative non-spore-bearing bacillus which can be used for detecting total coliform group in the water. Procedures for detection were as follows. First, 100 mL water was filtered by filter machine. Then the sterilized filter membrane was cultured on Fuchsin Basic Sodium Sulfite Agar at 37 °C for 24 h. Finally, it was observed under microscope to count the amount of total coliform group.

Next was test of *Escherichia coli*. The water was filtered by millipore filter with pore diameter of 0.45 pm; then the filter was pasted on selective medium adding with lactose and cultured at 37 °C for 24 h to form Gram negative non-spore-bearing bacillus which can be used for detecting thermo-tolerant coliform bacteria in the water. Procedures for detection were as follows. First, 100 mL water was filtered by filter machine. Then the sterilized filter membrane was cultured on Fuchsin Basic Sodium Sulfite Agar at 37 °C for 24 h. Finally, it was observed under microscope to count the amount of total coliform group.

Then test of Salmonella enteric was performed. Test strain was inoculated in 5 ml nutritional broth medium, followed by shaking culture at 37 °C for 12 h ~ 16 h; content of bacteria in bacterium solution was 1×109-20×109 ml; 0.1 mL test strain was added into top agar preserved at 37 °C; 0.1 mL water was added and mixed; bottom agar plate was poured into it and spread; after top agar top agar was congealed, it was cultured in an incubator at 37 °C for 48 h and then count the amount of Salmonella bacteria colony; moreover, dimethylsulfoxide was used to perform blank experiment; TA 98 strain used picrolonic acid for positive control and TA100 strain used sodium azide for positive control.

Test of *Costridium perfringens* used filter membrane method. 50 mL water was filtered by filter membrane with pore diameter of 0.22 μm and then the filter membrane was placed on SPS agar medium upside down at 36 ± 1 °C for 24 h- anaerobic culture; then black colony was counted; 3~5 black colonies that grew on the filter membrane was randomly selected and inoculated in fluid thioglycollate (FT) medium for 18 – 24 h of anaerobic culture at 36 ± 1 °C; finally, confirmatory test was performed with culture to confirm the existence of *Costridium perfringens.*

Test of *Streptococcus faecalis* also used filter membrane method. 250 ml water was

filtered by filter membrane with pore diameter of 0.45 μm, and then the filter membrane was cultured on KF Streptococcus agar in an incubator at 36 ± 1 °C for 48 h; if red or pink colony grows, they should be moved to brain-heart extraction agar medium for confirmatory test; if catalase reaction was negative and moreover, the colonies could grow in brain-heart extraction agar medium at 45 °C, then existence of *Streptococcus faecalis* was proved and the test result was positive.

Pseudomonas aeruginosa was tested with filter membrane method. 250 mL water was filtered by filter membrane with pore diameter of 0.45 μm and then the filter membrane was cultured on CN agar selective medium in an incubator at 36 ± 1 °C for 48 h; typical colony could grow on CN agar selective medium and produce pyocyanine or produce Gram negative no-sporeforming bacilus which could produce ammonia using acetamide and then proved as *Pseudomonas aeruginosa* and the test result was positive.

2.3. Establishment of HACCP system for drinking water for athletes

Before establishing HACCP system, we should know technological process of drinking water provided for athletes including all production and processing procedures by investigating production field and production technique of drinking water. In the process of establishment, we compared drinking water technological procedures and practical operation to confirm the technological procedures are correct and completed. Technological processes (Weimin, 2010; Xunliang, 2005; Wei, 2003) could be modified to some extent when technique changes. Technological process of bottled mineral water is shown in the following (Ji, 2008).

(1) raw water: other water can be selected if pesticide residue exceeds the specified content, as pesticide cannot be eliminated by ozone sterilization.

(2) sand leach: raw water is filtered by quartz sand to block, sediment, dust and impurities.

(3) activated carbon adsorption: organic and inorganic substances with small molecular weight is absorbed by activated carbon to remove pigment and foreign matter.

(4) rough filtration (20 μm) and refined filtration (1-10 μm): rough and refined filtration are used to remove suspended particles and large-diameter microorganism to prevent water pollution and prevent foreign matter to block filter membrane.

(5) hollow ultrafiltration (0.0001-0.001μm): hollow ultrafiltration can filter macromolecular organic matter and microorganism.

(6) ozone disinfection: ozone is prepared by high-pressure discharge using ozonator; sterilization is achieved by controlling water flow speed and ozone flow.

(7) pipeline sterilization and washing: pipeline is washed by disinfectant and water without disassembling equipment.

(8) sterilization of bottle and bottle cap: bottle and bottle cap are sterilized by disinfectant; then bottles are put into automatic bottle washing machine, washed by ozone water for 30 s and then put into filling line; bottle caps are put into cap screwing machine after washed by ozone water for 30 s.

(9) filling and cap screwing: filling and cap screwing are fulfilled automatically in filling workshop and ultraviolet disinfection lamp equipped in workshop is used for sterilization.

HACCP system is established by carrying out quality hazard analysis on major procedures and confirming key control points based on analysis conditions of key control point decision-making tree, as shown in figure 1.

2.4. Confirmation of critical limit

It has been reported that (Zheng, 2008), concentration of ozone, sterilization time and water flow quantity have relative large influence on sterilization effect, thus single factor experiment and orthogonal experiment are required to confirm the best sterilization

conditions. Optimal sterilization conditions are confirmed taking qualified rate of microorganism tested in water as criteria (Ting, 2013).

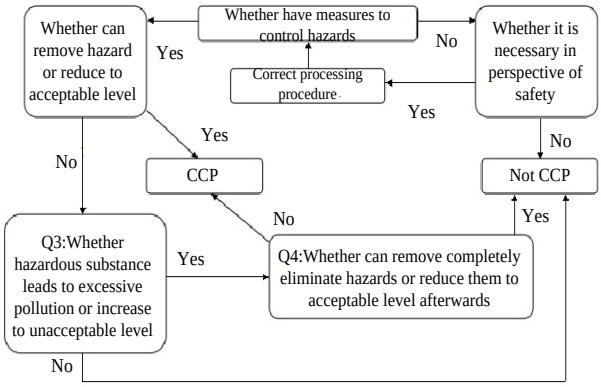

Figure 1. Key point control decision-making tree

3. Results and discussions

3.1. Investigation of water quality

It can be seen from investigation results of water quality that, the water is conformed to requirements of physicochemical indexes stipulated by Standards of Natural Mineral Water (Lan, 2010; Jun, 2011). Standards of Natural Mineral Water states that, limit criteria for Se is no less than 0. 01mg/L and less than 0.05 mg/L and metasilicic acid is no less than 25 mg/L. Total bacterial count and *Escherichia coli* exceeds standard.

Table 1. Drinking water quality investigation report

Item	Limiting value	Result	Item	Limiting value	Result
Chromaticity	15 degree	5 degree	Oxygen consumption	3mg/L	0.64mg/L
Turbidity degree	1NTU	0.94NTU	Iron	0.3mg/L	< 0.05mg/L
Foul smell	Non	Non	Manganese	0.1mg/L	< 0.05mg/L
pH	6.5-8.5	7.18	Sulfate	250mg/L	23mg/L
Total hardness	450mg/L	430mg/L	Residual chlorine	< 0.05mg/L	< 0.05mg/L
Dissolved solids	1000mg/L	1240mg/L	Nitrate	10mg/L	2.10mg/L
Chloride	250mg/L	7mg/L	Nitrite nitrogen	1mg/L	< 0.001mg/L
Fluoride	1.0mg/L	< 0.20mg/L	Cyanide	0.05mg/L	< 0.002mg/L
Arsenic	0.01mg/L	< 0.01mg/L	Selenium	0.01mg/L	0.27
Mercury	0.001mg/L	< 0.001mg/L	Cadmium	0.005mg/L	< 0.005mg/L
Hexavalent chromium	0.05mg/L	< 0.004mg/L	Lead	0.01mg/L	< 0.01mg/L
Zinc	1.0mg/L	0.22mg/L	Copper	1.0mg/L	< 0.02mg/L
Metasilicic acid	≥25mg/L	45mg/L	Synthetic detergent	0.3mg/L	< 0.05mg/L
Total bacterial count	100CFU/mL	145CFU/mL	Total coliform group	Non	27MPN/100mL

3.2. Ozone sterilization test results

It can be seen from table 2 that, when concentration of ozone is 0.4 mg/L, qualified rate of water is low, indicating incomplete sterilization, but sterilization effect becomes better as concentration becomes higher; when it is 0.6 mg/L, qualified rate is the highest, but the rate decreases as concentration increases, which is caused by bromide reaction. When ozone has been released for 4 min, quailed rate is low; but sterilization becomes more thorough and qualified rate improves as time goes on; when it is 12 min, qualified rate is the highest, but then qualified rate gradually decreases due to higher content of bromated; when water flow is 3,000 L/h, qualified rate of water is low; but qualified rate reaches the highest when water flow is 4,500 L/h; when it is 5,500 L/h, qualified rate is the lowest, because ozone has not killed bacteria thoroughly; when water flow becomes more, content of bromated keeps decreasing. Therefore, we conclude that, the suitable conditions to obtain the highest quailed rate is 12 min ozone action time, 0.6 mg/L of ozone concentration and 4,500 L/h water flow.

Table 2. Data of ozone sterilization

	Ozone action time (min)				
	4	8	12	16	20
Bromate (mg/L)	0.0051	0.0074	0.0088	0.0101	0.0109
	Ozone concentration (mg/L)				
	0.4	0.5	0.6	0.7	0.8
Bromate (mg/L)	0.0064	0.0073	0.0084	0.0100	0.0118
	Water flow (L/h)				
	3000	3500	4000	4500	5000
Bromate (mg/L)	0.0125	0.0109	0.0086	0.0069	0.0052

3.3. Chlorine dioxide sterilization test results

Table 3 demonstrates that, when concentration of chlorine dioxide is 1.5 mg/L, removal rate of bacteria is relatively, showing up incomplete sterilization, but sterilization effect becomes more effective as concentration increases; when it is 3.5 mg/L, removal rate is the highest; but then the rate changes little as concentration becomes higher, which may be because the bacteria categories that can be killed by chlorine dioxide is limited or sterilization effect of chlorine dioxide only play functions under certain concentration; as concentration of chlorine dioxide becomes higher, amount of free residual chlorine also constantly increases, and they shows a direct ratio relation; when concentration of chlorine dioxide increases from 1.5 mg/L to 4.5 mg/L, amount of free residual chlorine increases from 0.023 mg/L to 0.058 mg/L which exceeds the limiting value 0.05 mg/L. Thus to reduce free residual chlorine content in water, we should control concentration of chlorine dioxide. When sterilization time is 20 min, sterilization is not enough; but as sterilization time prolongs, sterilization becomes thorough and removal rate of bacteria improves. When it is 35 min, removal rate is the highest, but it changes little if sterilization time is longer than 35 min. That may because that sterilization ability of chlorine dioxide can only play functions within certain time period, or categories of bacteria that it can kill is limited. Free residual chlorine reduced from 0.057 mg/L to 0.024 mg/L, indicating chlorine dioxide and chlorine are gradually consumed as sterilization time becomes longer.

Table 3. Data of chlorine dioxide sterilization

	Concentration of chlorine dioxide (mg/L)				
	0.5	1.5	2.5	3.5	4.5
Removal rate (%)	92.3	95.1	98.0	99.7	99.9
Free residual chlorine (mg/L)	0.023	0.035	0.039	0.046	0.058
	Sterilization time (min)				
	20	25	30	35	40
Removal rate (%)	91.8	93.1	97.6	98.3	99.7
Free residual chlorine (mg/L)	0.057	0.048	0.035	0.029	0.024
	Temperature (°C)				
	5	10	15	20	25
Qualified rate (%)	93.0	94.8	96.7	97.9	98.3
Free residual chlorine (mg/L)	0.048	0.041	0.035	0.029	0.022

When sterilization time was 40 min, free residual chlorine changes little and may be unable to play function. When water temperature increases from 5 °C to 25 °C, removal rate of chlorine dioxide to bacteria increase from 93.0% to 98.3%, but when temperature turns from 20 °C to 25 °C, nearly no change occurs. It indicates that, within this temperature scope, chlorine dioxide has stronger sterilization effect as temperature increases, but sterilization effect does not change at certain temperature. This may be because that, chlorine dioxide has killed all bacteria within its sterilization scope in that temperature interval and the other reason is that, when temperature reaches certain value, sterilization effect of chlorine dioxide will have no influence. As water temperature increases, digestion amount of chlorine dioxide constantly increases but free residual chlorine gradually decreases from 0.048 mg/L to 0.022 mg/L. When water temperature increases from 20 °C to 25 °C, free residue chlorine changes little. Thus it is concluded from above analysis that, qualified rate can be the highest under the conditions of 2.5 mg/L chlorine dioxide, 30 min of sterilization time and 20 °C of water temperature.

3.4. Comparison of water before and after application of HACCP

Table 4. Comparison of microbiological indexes of water before and after application of HACCP

Test items	Before application of HACCP	After application of HACCP
Total bacterial count	< 100CFU/mL	< 10CFU/mL
Escherichia coli	3MPN/100mL	Not detected
Pseudomonas aeruginosa	Not detected	Not detected
Streptococcus faecalis	Not detected	Not detected

Table 4 reveals that, water quality after application of HACCP is much better than before application of HACCP (Wallace, 2014); quality of mineral water conforms to standards of drinking natural mineral water, microbiological index of water after application of HACCP, significantly decreases and qualified rate of water improves dramatically, which proves that, HACCP plays an important role in controlling safety of drinking water for athletes.

3.5. Discussion

The current study makes a detailed analysis on key control points of drinking water for athletes and then confirms water flow, ozone concentration and sterilization time of ozone as the key control points. Set of limiting value of key control points facilitates quality monitoring; if there is bad deviation, controller should immediately correct through proper measures to eliminate unbeneficial factors (Moreno Guavita, 2012), thus to effectively perform timeliness of HACCP system. Applying HACCP in enterprises engaging in producing bottled mineral water can not only avoid a large number of finished product inspection to lower test cost but also can effectively prevent large loss caused by unqualified hygienic quality, thus to improve reputation, reliability and production efficiency of products and produce huge economic benefits.

This study studies the application of HACCP system in production of drinking water for athletes and tracks timeliness and implementation situation of the system. To be specific, hazard analysis is made on technological process, and then water source is confirmed as CCP1, disinfection and sterilization of pipeline as CCP2, disinfection and sterilization with ozone as CCP3 and filling environment as CCP5. It is found from investigation of water quality that, physical and chemical indexes are qualified but microbiological index have not met the requirements (*Escherichia coli* 27 MPN/l00mL) (Vesna and Dragana, 2014). This study considers sterilization time of ozone as the most important factor influencing sterilization effect, followed by concentration of ozone and then water flow and confirms that the best parameters are 12-min sterilization time, 0.06 mg/L ozone concentration and 4,500 L/h water flow. Besides, influence of factors on sterilization effect of bottle and bottle cap are confirmed as sterilization time > water temperature > concentration of chlorine dioxide and the best parameters are 30 min of sterilization time, 20 °C water temperature and 2.5 mg/L of chlorine dioxide concentration. Comparing quality of water before and after application of HACCP, we found that, total bacterial count of water reduces from 100 cfu/m to l0 cfu/mL and moreover, *Escherichia coli* and *Pseudomonas aeruginosa* are not detected out.

4. Conclusions

This study attempts preventing and controlling the possibility of drinking water being polluted by hazardous substances from entering factory to leaving factory by finding out key control points and adopting effective measurements. The method focusing on prevention improves quality of drinking water for athletes. Thus HACCP is considered as a feasible method for controlling quality of drinking water.

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HUMAN RESOURCE INFORMATION MANAGEMENT AND INFORMATION MODEL CONSTRUCTION IN FOOD ENTERPRISE BASED ON DATA MINING TECHNOLOGY

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ABSTRACT

As China joined in World Trade Organization (WTO), food enterprises attach more importance to human resource and input increasing fund in it; however, feasible and practical operation methods are lack of. To realize leap-type promotion of human resource management and development level in food enterprise, it is necessary to establish human resource information system to optimize business process, perfect service quality and improve working efficiency. This study made a demand analysis on the construction of human resource information system taking human resource information system of a food enterprise in Henan as an example, based on the basic concept of data mining technology, in order to construct a set of advanced and scientific human resource information system to provide a rapid and accurate theoretical guidance for decision of food enterprises.

1. Introduction

With the deepening of economic system reform, food enterprise management system has undergone a fundamental change and the focus of food enterprise competition turns from materials and equipment resources like fund and materials to human resource. Therefore, human resource management has become an important content of food enterprise management and success or failure of enterprises depends on the input of staff to works to a large extent (Zhang et al., 2006). How to keep working responsibility of staff in food enterprise, motivate their enthusiasm and reduce talent outflow has become an increasingly tough problem faced by decision maker and human resource manager from food enterprise. Fairness, justice and reasonability are important principles of food enterprise management. Regulations and policies only are not enough to realize the above principles. A set of scientific security system should be established by setting up human resource information system, in order to realize these principles and avoid risks of operation and labor trouble (Moallem, 2007).

Human resource information system guided by modern human resource management theory starts from human resource planning of food enterprises including employment, position description, training, skills, performance assessment, individual information, salary and welfare, personnel management, which are stored into concentrated database in a compatible, consistent, shared and accessible way, thus to uniformly unify all information of staff (Megri, 2014). As human resource information system is able to manage complete human resource data and salary data, comprehensive report can also be generated by it, such as average historical salary chart, staff allocation analysis chart, individual performance, education, skills, working experience and training, etc, as a reference for

decision makers in enterprises (Jie et al., 2012). Benefiting from the flexible report generation and analysis function, human resource managers free from daily working, and devote their vigor into more challenging and creative human resource analysis and planning, staff motivation and strategies.

2. Materials and methods
Theoretical basis of data mining technology

2.1. Definition of data mining

Data mining means to extract hidden, unknown but useful information and knowledge from a large amount of incomplete, noisy, fuzzy and random data. In view of commerce, data mining, a new information processing technology, is featured by extracting key data used for assisting business decision by extracting, converting and analyzing a large amount of business data in commercial database (Stephen, 2012).

Compared with traditional data analysis such as query, report, online application analysis, and data mining searches data and discovers knowledge without definite assumption. Information obtained by data mining should be previously unknown, effective and practical (Junkai, 2012). Previously unknown information means the information is unexpected previously. Data mining aims to find information or knowledge which can be found by intuition or even violates intuition. Unexpected information is thought to have more value.

2.2. Data mining process

A complete data mining is to dig previously unknown, effective and practical information from large-scale database and then make decision or enrich knowledge by these information, as shown in figure 1.

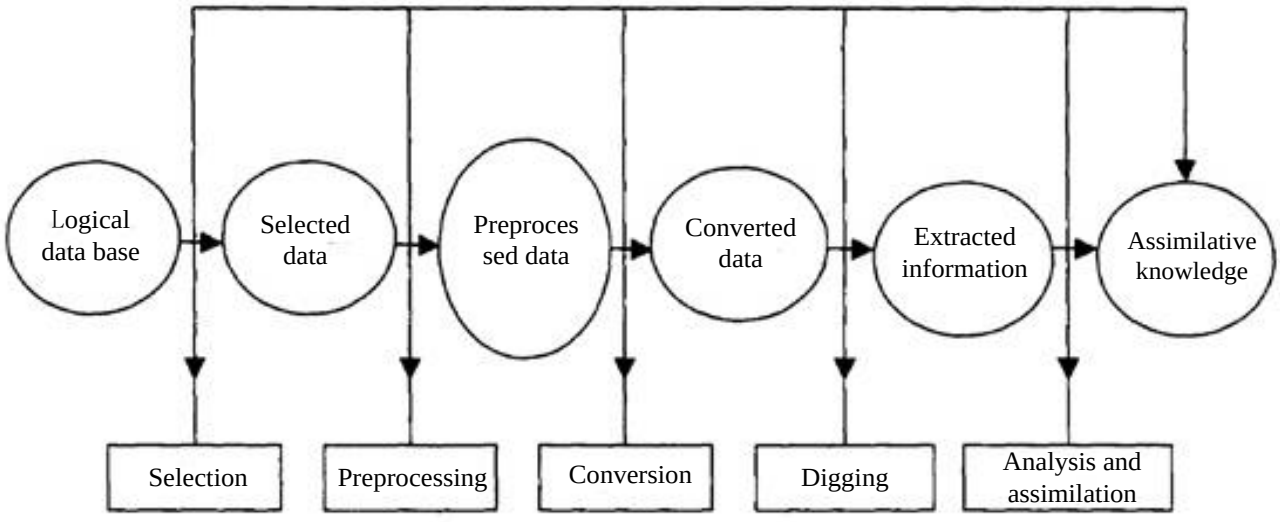

Figure 1. Basic process and major procedures of data mining

2.3. Overall design of human resource information system

To better describe the construction of human resource information system in this study, we illustrate taking the human resource information system from Henan Polytechnic College as an example. Overall target of the system construction is to establish a set of scientific, high-efficient, stable and reliable informatization management system providing decision support and service for Henan Polytechnic College starting from the practical demand of the college.

2.3.1. Overall design of system

Functions of every module are divided into different levels according to the characteristics of functions, i.e., presentation layer, business logic layer and data layer. Presentation layer focuses on interaction between users and system and simple data processing. Business logic layer aims at complex application, such as integrating server-side component; and it is responsible for assigning interaction middleware of database. Data layer, a database management system (DBMS) consisting of data sheet and view can package stored procedure for call.

2.3.2. Architecture of system

Information system usually has centralized architecture, two-layer architecture of client/server (C/S) and multi-layer architecture of "browser/server". Making full use of software and hardware resources of client and server, C/S, well-known software system architecture, lowers communication cost of the system by reasonably allocating tasks to client and server. B/S is an improved structure developing with the emergence of Internet; and its architecture is shown in figure 2.

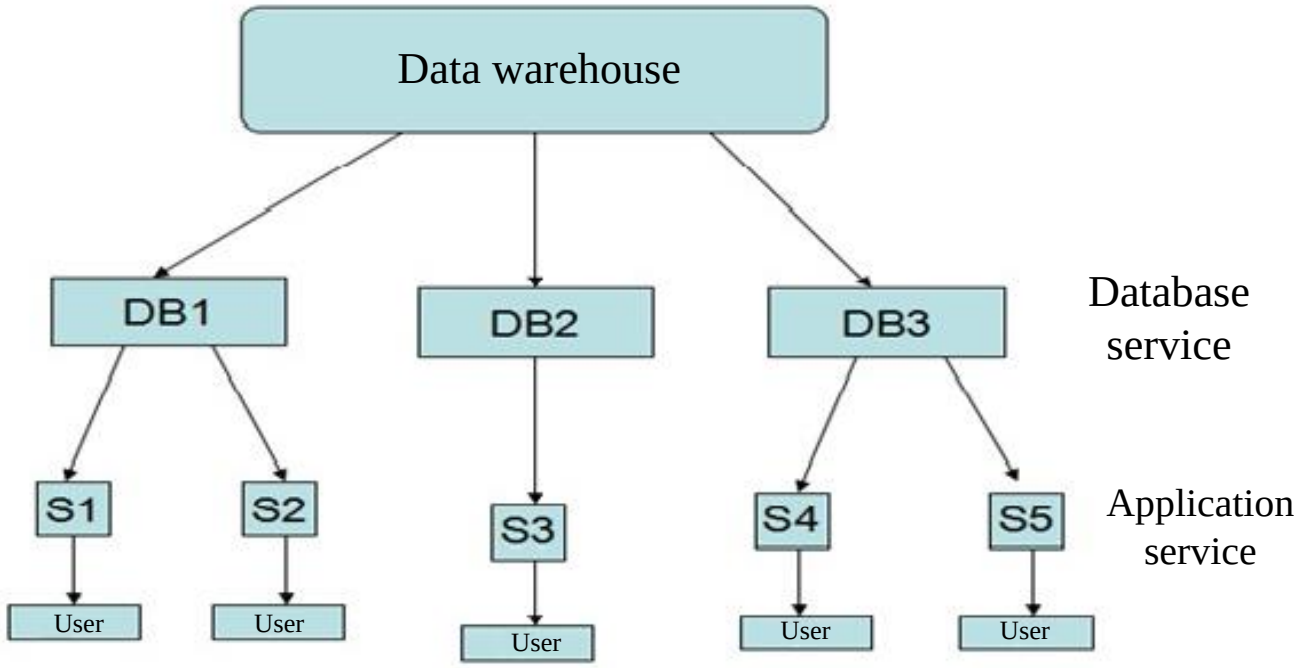

Figure 2. Three-layer architecture

In the structure shown in figure, user interface is realized completely by WWW browser. A part of business logic is realized in client, but the main business logic is realized in server, forming three-layer architecture. B/S architecture is a brand –new software system construction technology achieving strong functions which should be realized by complex special software previously with constantly mature and widespread browser technology. The Human resource information system of Henan Polytechnic College exactly uses such three-layer architecture to overcome and exceed limitations like management gap, irregular information measuring caused by several years' manual management, which meet the demand of individual micromanagement and colonial micromanagement.

2.4. Data flow diagram and module chart of human resource information system in food enterprise

Logic model of this system is mainly expressed by DFD. Based on the business analysis of the human resource management, data flow diagram of the human resource information system is shown in figure 3.

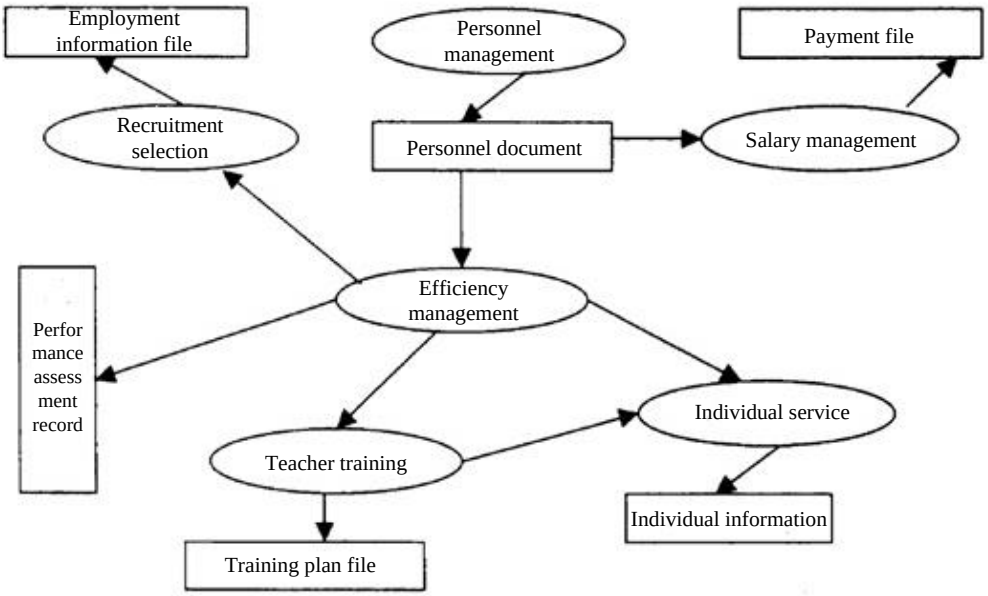

Figure 3. Data flow diagram of the human resource information system in food enterprise

Module structure of the human resource information system in food enterprise is shown in figure 4.

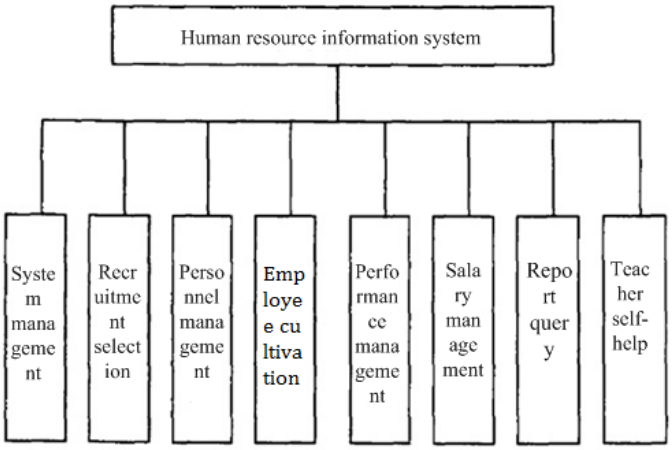

Figure 4. Module structure of the human resource information system in food enterprise

3. Results and discussions

Database design of the human resource information system

3.1. Database design method

Basic task of database design is to design data pattern including external schema, conceptual schema and internal schema and typical application program according to information demand, processing demand and database support environment of the college. Reasonable structure, convenient usage and high efficiency should be achieved during designing. Database design is shown in figure 5.

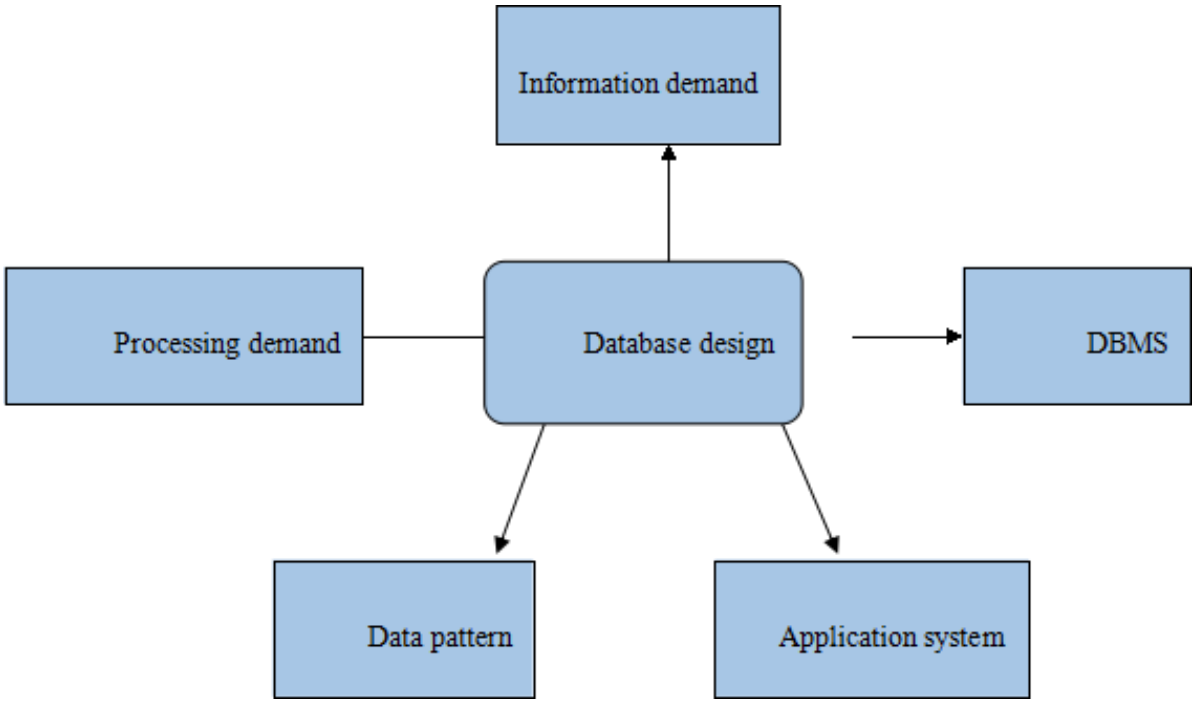

Figure 5. Database design

3.2. Database design of the human resource information system in food enterprise

As modules of the design of the human resource information system of Henan Polytechnic College are so many, data sheet of only a part of modules are listed in the following:

Basic information: employees' number, name, gender, nationality, native place, date of birth, ID number;

Resume information: start date, end date, work unit, positions and levels, etc;

Social relationship information: name, relation with himself, work unit, position, title, contact phone number and Email Address, etc;

Positions and technical titles: name, acquisition way, acquisition date, employment unit, technical position, employment start data, employment end date, etc;

Rewards and punishment information: date of rewards and punishments, types of rewards and punishments, levels of rewards and punishments, content of rewards and punishments, reasons of rewards and punishment, approval unit, revocation date, cancellation reason, etc;

Transfer information: date of transfer, types of transfer, unit before transfer, unit after transfer;

Further education information; start date, end date, contents of further education, place of further education, results of further education, etc;

Specialty information: individual specialty information record;

Language information: types of language, proficiency degree, etc;

Assessment information: assessment date, start and end date of assessment, assessment unit, results of assessment, etc;

Position information: code of position, position title;

Training information: further education or training;

Organizational structure information: organizational structure chart, department information, information of fixed personnel and position, etc;

Salary information: salary level, salary projects, welfare projects, etc;

3.3. Software design for the human resource information system

In human resource information system in food enterprise, operation system used in server side is Windows2003 server. Database server used is SQLSevrer2000, a Chinese database management system. Web server is IISS6.0 and front end development tool used is Powerbuilder8.0. Users (computer in client side) can use the system through ordinary IE browser (Assaf and Ran, 2012).

SQLSever2000 is being widely applied for its excellent functions and superior performance. Its market occupation has ranked the first over years. It supports multiple databases to store relevant or irrelevant data from other databases. It provides new data warehouse function for analysis services including integrated data mining, OLAP service, safety services and visit and link of multi-dimensional data set by Internet. SQLSever2000 allows high-performance and standard-based safety visit on Web through HTTP protocol and is able to support firewall. Web-based server possesses complete ability of visiting relational data storage and analysis services.

Powersuilder8.0 is a new generation database forefront development tool developed by Sybase, and also a development tool for solving C/S structure calculation mode under distributed environment. It can provide powerful support for database application and perfect solutions for distributed calculation environment.

4. Conclusions

This system integrates the latest ideas produced during practice of human resource and the most complicated and advanced technologies. Human resource managers can devote most vigor and creativity into activities which can ensure maximum profits, when personnel officers and personnel leaders can directly participate in administrative matters of human resource management in the aspects of policy, procedure and information (Mohammed, 2012). Immeasurable values can be created when an organization attracts, trains, allocates, assesses and reward faculty members more effectively and meanwhile, personnel officers and human resource managers involve in the practice of human resource management together (Nagiza, 2012). Applying different tools, this study provides the most complete and latest information about human resource for food enterprise, which ensures timeliness and accuracy of decision.

To sum up, the human resource information system in food enterprise integrates information about all levels and all positions into the procedures of human resource management, and meanwhile, organic combination of the system and all management steps effectively prevents sealing, isolation and dispersion of relevant information, which ensures the implementation of human resource management strategy in food enterprise.

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ANALYSIS OF AQUATIC FOOD QUALITY AND ITS MARKET ECONOMIC SITUATION ANALYSIS AND PROSPECT

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ABSTRACT

This research introduces the development status of Chinese aquatic products market and evaluates comprehensively towards export trade of the Chinese aquatic products. Then, taking the ice fresh hairtail as raw materials, using liquid nitrogen spray freezing equipment to deal with samples. In comparison with flat freeze, freezers frozen sample, these different frozen samples are all placed under - 18 ℃ to store for 150 days. The paper measures the total content of the hairtail fish, salt soluble protein concentration, data of Ca2+-ATPaSe enzyme and so on, combined with texture properties like hardness, elasticity, chewiness and resilience and observe the structural changes of microstructure of the samples in the low temperature cold storage by optical microscope so as to comprehensively analyze the internal causes of the changes of the quality of frozen hairtail muscle and offer the oretical basis about fish preservation technology. Liquid nitrogen cryogenic frozen has a good protective effect on the improvement of the quality of aquatic products, protein level, texture properties and microstructure and a good application potential and popularization value as well. At last, this paper proposes the developing advantages, restriction factors and development ideas of Chinese aquatic products.

1.Introduction

1.1. Brief Introduction

Recently, China's economy has steadily increased and positively varied. With reinforce of macro policy of each country, domestic and foreign condition of aquatic product has been improved and the world economic downturn has been remitted. At the same time, we notice that the impetus for world economic recovery is insufficient, the oversea market demand is low and can hardly be improved fundamentally and inflation of many countries stays at the high-order, which brings risks and challenges to the steady development of our aquatic product market (Chen, 2008; Wen, 2003; Haowei, et al., 2015).

China is rich in aquatic resources and has a wide variety of aquatic products (Jianrong, et al., 2008; He, 2009). However, due to the regional and seasonal of fishery production, aquatic products are easy to rotten. So it is very necessary to strengthen the freshment and aliveness of the aquatic products (Jiehong, et al., 2013). With the constant improvement of people's living standard, the aquatic products of good freshment are not only sold well but also price-cheap while those not fresh are just the opposite. This shows that freshment is the main quality target whether it the quality of aquatic products are good or poor. And it is the main factor to determine the price of them (Xiaoshuan, et al., 2005). Hairtail is Chinese

leading Marine with high economic value but cheap price, which is popular among the public and sold very well as well. In addition, it is not only ate by domestic people but also exported largely to foreign countries and its edible value and economic value is very high (Yunrong, et al., 2011). In recent years, due to the catching list form and characteristic of fishery development, the quantity and quality of the hairtail has reduced constantly. It is very possible to restrict the development of hairtail industry if we don't take an efficient way of frozen. And it will surely step the value waste of the products (Xiuying, et al., 2012). This paper takes the hairtail as a research object and measures the total content of the hairtail fish, salt soluble protein concentration, data of Ca2+-ATPaSe enzyme so that to explore the effective way of frozen hairtail and freshment keeping. It is believed hat hairtail will bring considerable economic income for China in this way.

1.2.Overall situation of domestic aquatic product market

According to the aquatic production status published by Ministry of Agriculture, the gross output in 2012 was 59.06 million tons, with a year-on-year growth of 5.4%. Among them, year-on-year growth of 7%; fishing product was 14.83 million tons, almost hold the line. As estimated, per capita net income of Chinese fisherman in 2012 maintained above 10 thousand and researched 11.256 thousand, 12.44 hundred more than that of 2011. Total out-put value continuously increased and reached 172.55 billion, with a growth rate of 15%. After Spring Festival, the price of aquatic product uncharacteristically increased and in June, as the increasing landings of adult fish, the price of aquatic product tended to be steady gradually but still more than the corresponding period of 2011. Price monitoring data of wholesale market in China's agriculture information website shows, the total trading volume of 31 kinds of aquatic products we

breeding output was 43.05 million tons, with a year-on-year growth of 7%; fishing product was 14.83 million tons, almost hold the line. As estimated, per capita net income of Chinese fisherman in 2012 maintained above 10 thousand and researched 11.256 thousand, 12.44 hundred more than that of 2011. Total out-put value continuously increased and reached 172.55 billion, with a growth rate of 15%. After Spring Festival, the price of aquatic product uncharacteristically increased and in June, as the increasing landings of adult fish, the price of aquatic product tended to be steady gradually but still more than the corresponding period of 2011. Price monitoring data of wholesale market in China's agriculture information website shows, the total trading volume of 31 kinds of aquatic products we mainly monitored in 2012 was 1165.5 thousand tons, with a average price of 16.56 yuan/kg, and a year-on-year growth of 7.79% and 17% respectively. Besides, cost of production processes such as aquatic feed, pond rent, labor costs have comprehensively increased, especially the input cost of feed has generally increased. The increase of fishery cost especially the continuous increase of price of aquatic feed has elevated the price of aquatic products.

2. Materials and methods

2.1. Principal raw material and reagent

Zhoushan chilled fresh hairtail, purchased from international aquatic product city, Zhou fishing fresh aquatic food, Zhoushan, Zhejiang. We selected the fresh hairtail which had full abdomen, amaranth gill, plump eyes, bright surface, intact scales and no liquid. Adenosine Triphosphate (ATP), bovine serum albumin purchased from Sigma company; citric acid, rod sodium citrate, KOH solid, KCl solid, ATP solid, NaOH solid, KH2PO4 solid, K2HPO4 solid, HCIO3, liquid nitrogenm, CuS04 solid and other chemical reagents all were analytically pure, which were purchased from

traditional Chinese medicine group chemistry reagents limited company.

2.2. Sample treatment

Put the chilled fresh hairtail went ashore on the wharf in the iced boxed within 20 minutes and took it to the laboratory. Then, we removed the head, tail and viscera of the hairtail instantly, cleaned the hairtail up under low temperature running water and made different subzero treatment.

Liquid nitrogen quick freezing: the sample washed by source water and packaged in the -18°C refrigeratory. We set liquid nitrogen spray procedure and made the core temperature of fish body to -40°C and made liquid nitrogen quick freezing operation. Then, we took 2% mycose ice water solution out, packaged in to the bag and seal package (sample sign was N.D).

Slab quick-freeze: we washed the sample by source water, and panning to -18°C refrigeratory. The fish entered the quick-freezing plant, and when the central temperature of the fish reached -20°C, we took out the split charging and sealed (sample sign was P.D).

Freezer freeze: we put the disposed sample into -18°C refrigerator. When the central temperature of the fish reached -18°C, we packaged and sealed the sample (sample sign was B.D) .

The above 3 samples under precooling treatment should be put in -18°C refrigeratory and made experiment index measurement.

2.3.The measurement of salting-in protein level

We should weigh two 2g the flesh of fish, and add 20ml low ion acid buffer solution and high ion acid buffer solution respectively, then cost 5 minutes to make them mixed. Next, we centrifuged them 10 minutes under the condition of 4000r/min in 1 hour and 3 hour respectively. We extracted supernate and added 15% trichloroacetic acid to precipitate protein. We extracted 1M NaOH to resolve fish protein, and make the constant volume to 50ml by low acid buffer solution and high acid buffer solution respectively. All the operation should finish under 4℃. The content of salting-in protein was measured by biuret method, and the answer was high saline ions protein content minus low saline ions protein content. The preparation of protein standard curve and bovine serum albumin were regarded as pre-standard substance. We fetched 4 mg/ml BSA solution and made 1, 2, 3, 4 and 5mg/ml 5 protein solutions in different concentration, then added 5 ml biuret reagent respectively. The another contract group adopted 5ml distilled water, made them mixed, measured absorbancy and drew standard curve the at the number of 540 nm.

2.4. Detection of Ca2+-ATPase activity

20mMTris-HC12.5mL (pH 7.0), 0.05MCaCt l.0mL, 4MKCl l.0mL and 6.67mM ATP-Na2 1.5M were added into blank tubes. Then 4 mL myofibril protease was added. The mixture was placed into water bath pot (28℃) for 30 min. Afterwards, 1.0 mL trichloroacetic acid was added to stop the reaction. After being filtered by double-layer filter paper, the solution was detected at wavelength of 640 mn. Activity of Ca2+-ATPas was expressed by content of inorganic phosphorus produced by 1 mg zymoprotein in 1 min. Then the standard curve was plotted with 0.5 mM standard solution made of KH2PO4 solution which was dried for 2 h and cooled to room temperature.

2.5.Determination of the total sulfydryl content

1 mL of fibrillin solution was mixed with 9 mL of Tris-HCL (0.2 mmol/L). Then, 4 mL of the mixed liquor (Tris HCL) was mixed with 0.4mL of 0.1% 2- nitrobenzoic acid. The reaction mixture was kept warm at 40℃ for 25 minutes, and absorbancy could be determined where wave length was 412 nm, with the vacancy substituted by the solution KCl (0.6mol/L). Samples in each group were measured for three times and the result was the

average. Sulfydryl content was calculated based on the following formula:

Sulfydryl content= $(A \times n)/(\varepsilon \times \rho)$

In the formula, A refers to the absorbancy where wave length was 412 nm; N refers to the dilution multiples; ε refers to molar absorption coefficient 13600 / (17 (mol·cm)); ρ refers to protein mass concentration/ (mg/mL).

2.6. Statistical method

Data analysis methods needed to be repeated at least three times in all experiments, and the data were expressed as average value and variance. Excel 2007, SPSS16.0 and analysis of variance (ANOVA) were adopted in data processing and significance analysis. When P <0.05, it means the difference is significant.

3. Results and discussions

3.1. The influence of freezing method on the content of salt soluble protein (EPN) in hairtail

As is shown in Figure 1, EPN values of hairtails in Group N, Group P and Group B decline sharply by 75.21%, 81.54% and 85.19% in the first 90 days; afterwards, EPN values tend to flat (5.50, 4.19, 3.02 mg/g at 150 d); differences in EPN values of three groups of hairtails within 90d are more obvious, while the EPN value of sample in Group B is the lowest. As a whole, EPN values of samples in Group N are higher than the other two groups.

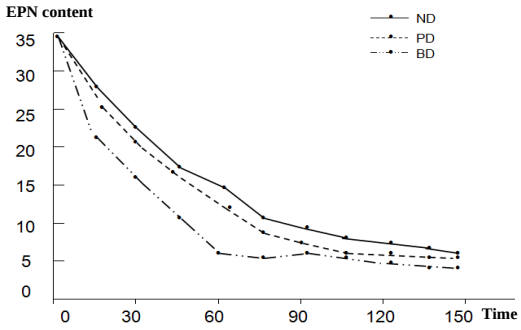

Figure 1. The influence of freezing method on EPN content during hairtail preservation

3.2. The influence of freezing method on the enzyme activity of Ca2+-ArPase in hairtails

It can be seen from Figure 2 that Ca2 + -ArPase in hairtails first increases and then decreases. Ca2+-ArPase activity of hairtails in Group N, P and B are respectively 0.390, 0.385, 0.392 umDl/min/mg at 0d, and decrease to 0.065, 0.056, 0.025 umol/min/mg (decrease by by 83.33%, 85.45%, 93.62%) at 150d.

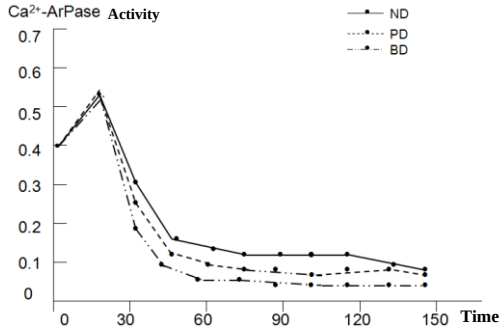

Figure 2. The influence of freezing method on the enzyme activity of Ca2+-ArPase in hairtails

3.3. The influence of freezing method on total sulfydryl content (-SH) in hairtails

Figure 3 shows that the total sulfydryl content first increases and then decreases with the time increasing; on the 30th day, the total sulfydryl content in the group of Group N, P and B (respectively 0.265, 0.245, 0.227mg/g) are up to maximum during hairtail preservation; the total sulfydryl content of liquid nitrogen frozen samples declines most slowly, followed by tablet group and freezer group, and the content are respectively 0.069, 0.047 and 0.013 mg/g at 150d.

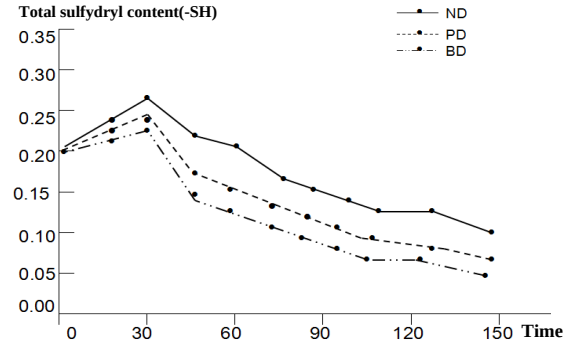

Figure 3. The influence of freezing method on total sulfydryl content in hairtails during preservation

4. Conclusions

Now China is the only one fishing country whose aquaculture production has exceeded capture yield (Gongming, et al., 2014). China has diverse aquatic product and the leading aquaculture species have formed (David, et al., 2014; Ling, et al., 2007). In recent years, China tends to have stable economical growth. As macro policy in all countires becomes more intensive, environemnt for aquatic product trade development also improves. But the recovery power of world economy is still insufficient, overseas market demand is hard to be imprpved. Based on the above situation, aquatic product market and trade is expected to keep a stablly growth tendency, but is hard to increase in high speed like the past years (Edward, et al., 2010; Yao, et al., 2010; Yongmei, 2015).

Rules of EPN decline of hairtails in the experiment may be that degradation of muscle protein during refrigeration depends on species and tissues, i.e., differences of different species and tissues are resulted from different types and amounts of proteases in the body. Fast decline and low content of EPN of two refrigerated samples indicate high protein degradation and degeneration. Content of salt-soluble protein is the same as evaluation result of freshness, which fully demonstrates that copious cooling and quick freeze of liquid nitrogen have certain protective effect on fibrillin of hairtail muscles. High level Ca2+-ArPase in hairtails leads to high chemical reaction rate and level of hairtail muscles, which results in easier metamorphosis of refrigerated procucts. Quick-freeze hairtails by using liquid nitrogen have high activity of Ca2+-ArPase and the reason may be that liquid quick freeze processed samples have smaller ice particles, thus produce small increase of ionic strength that head structures of myosin are more stable. Another reason may be that sharp freezing decreases oxidative levels of sulphydryl of myosin, thus head structures of myosin are integrated. Increase of total sulphydryl content is resulted from exposure of more sulfhydryl groups in protein molecules; decrease of total sulphydryl content is resulted from oxidation of SH1 and SH2 in head areas of myosin. Besides, formation of degenerated foldamers may cover certain amount of sulphydryl, which results in decrease of detected free sulphydryl. Changes of total sulphydryl content of hairtails are not in accordance with decrease of Ca2+-ArPase activity, which may be related to different qualities of hairtails.

In conclusion, through the analysis of protein characteristics of hairtails during refrigeration, the study discovered that salt-soluble protein content, Ca2+-ArPase activity and total sulphydryl content of sharp freezing samples using liquid nitrogen were significantly higher than flat group and freezer group. Changes of sulphydryl content and decline rules of Ca2+-ArPase activity have certain difference. SDS-PAGE atlas of hairtails myofibrils indicates that sharp freezing using liquid nitrogen can significantly reduce degradation levels of myofibril heavy chains, actin and other marker proteins and maintain protein level of hairtail meat, which keeps high level of economic values of hairtails and contributes greatly to aquatic product economy of China.

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