CARPATHIAN JOURNAL OF FOOD SCIENCE AND TECHNOLOGY

journal homepage: **http://chimie-biologie.ubm.ro/carpathian_journal/index.html**

INNOVATIVE TECHNOLOGICAL PROCESS FOR EMULGATED PATE PRODUCTION OUT OF FISH PROCESSING BY-PRODUCTS

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Article history:
Received
03 March 2018
Accepted
5 December 2018

Keywords:
Fish Processing;
By-products;
Fish head pate;
Smoked Sprats.

ABSTRACT

The rise in consumption of fish and fish products has led to the generation of high amounts fish processing by-products and there is an urgent need to convert this nutritious by-product into a value-added product that is suitable for human consumption. In this investigation, an innovative technological process has been developed to produce a pate out of fish processing by-products. An emulsifier, containing 59% water, 33% vegetable oil and 8% Tari Combi Pate emulsifying mix, was added to the homogenized smoked sprat heads along with salt, onion, phosphate blend, vegetable oil, vinegar, wheat fibre, and spices and thoroughly mixed to form a pate. The pate was packaged in tin cans or mason jars and sterilized in an industrial autoclave. This process proved to be successful based on microbial and organoleptic testing of the pate. This implies that this process of manufacturing fish waste pate has a potential to provide an alternative economic solution and expand the product assortment offered by fish processing companies.

1. Introduction

Fish wastes contribute to a significantly large percentage of the production volumes in the fish processing industries and hence it becomes vital to either dispose it safely or convert it into a value-added product. The former option is not encouraged due to its undesirable impact on the environment, moreover, it should not be wasted given its nutritional potential (Saranya et al., 2016). Value addition to fish wastes is an attractive alternative as it creates additional economic incentives to the manufacturer and ensures sustainability. Fish wastes have found several applications in the food and feed industry. Fish protein and protein concentrates, fish gelatine, nutraceutical ingredients, fish oils, natural pigments, collagen and chitosan are few of the compounds that are being extracted from fish waste. Research has shown that fish wastes are a source of such valuable biomolecules as enzymes, anti-microbial and antitumor compounds (Jayathilakan, et al., 2012). Utilizing the fish waste to fortify other food products is another option. Recently, a flaxseed and cinnamon cookie was enriched with cooked Nile tilapia fish bones was developed. This product was rich source of Calcium, Potassium, Iron and Omega 3 fatty acids (Abdel-Moemin, 2015).

Sprats, *Sprattus sprattus*, is a small herring-like, marine fish found in European waters especially in Irish Sea, Black Sea, Baltic Sea and the Sea of the Hebrides. Sprats can be canned, salted, grilled or fried. The canned sprats (usually smoked) or “Sprats in oil” are consumed in many North European countries and Latvia is one of the biggest producers and exporters of this commodity. Currently, the production of this sector is exported to 60 countries. Latvian fishing industry companies are successfully

penetrating new markets and have begun to export canned fish to such exotic markets as, for instance, Japan (Can you give a reference here).

Sprats are rich in long chain polyunsaturated fatty acids, both eicosapentaenoic acid C20:5 n-3 (EPA) and docosahexaenoic acid C22:6 n-3 (DHA), which are known as healthy fats because of their health benefits (Stołyhwo, et al., 2006). Like other fish, Sprats are also rich in protein, vitamins and minerals. The utilization of the wastes (usually smoked heads) generated by the canned Sprats industry should be promoted in order to reduce waste disposal issues, increase profitability of the industry and develop novel and nutritious food products.

Several fish pates are sold across the globe today, most of them are made from fresh or smoked fish flesh. Few attempts were made to utilise fish wastes for the production of fish pate. In one such study, Cachapinta pulp, a waste product of the filleting industry, was used to produce an edible pate (Lobo et al., 2015). The objective of the present study is to develop an innovative pate formulation and process using the heads of smoked sprats as raw material and access the final product for its sensory acceptability.

2. Materials and methods

2.1. Materials

The fish processing waste, i.e. the heads of Sprats (from in-house laboratory, Piejūra Ltd., Nīca, Latvia) were used to make the pate. Apple cider vinegar (Bajoriškių), Semolina (Valdo, Voldemārs, Latvia), Pea flour (Fasma, Latvia), Soy Isolate (Sojavit, Olimp, Poland), salt, black pepper and vegetable oil (sunflower oil) was procured from the convenience store. The phosphate blend and emulsifier used were TARI® P 22 and TARI COMBI Pate, respectively. The filler for the pate was VITACEL® Wheat Fiber WF 400 supplied by J. Rettenmaier & Söhne GmbH & Co. KG, Germany. The spice blend used was Fischburger by Frutarom Savory Solutions Austria GmbH.

2.2. Pre-processing of the fish heads

Washed and sorted fish were impaled on spikes through the gills and smoked, after which the fish were decapitated. As a result, the fish carcasses fell off while the heads remained on the spikes. These heads were the raw materials used to make the pate. To reduce the heterogeneous matter in the final product, two methods were employed, namely, boiling and acid treatment. In the boiling method, fish heads were boiled in water (fish:water ratio 1:2) for 5 min. The water was drained off and the fish heads were then used to make the pate. The acid treatment method involved adding 6% apple cider vinegar to fish heads at vinegar:fish ratio 7:100 during the pate preparation, along with the other additives.

2.3. Making of the oil emulsion/emulsifier

The oil emulsion is made according to the following ingredient proportions (%w/w): vegetable oil – 33%, water – 59% and emulsifier TARI COMBI Pate – 8%. Initially, water was poured in Bowl Chopper (Talsa - K15e) with chopping speed of 2840 RPM, followed by the emulsifier (TARI COMBI Pate). Vegetable oil was gradually added and allowed to mix (via the cutting action of blade rotation) until a homogenous texture was achieved.

2.4. Making of the pate

After pre-processing, the fish heads were ground to a paste like texture in the Bowl Chopper (Talsa - K15e) with chopping speed of 2840 RPM. Initial trials were carried out by combining the fish head paste with various concentrations of water, salt, onion, phosphate blend, vegetable oil, vinegar, wheat fibre, oil emulsion, soy isolate, pea

flour, semolina, spice blend and black pepper. The mixtures were thoroughly mixed in the same cutter to form a pate.

2.5. Packaging and thermal processing of the pates

The pate was poured into tin cans or mason jars and sterilized in industrial autoclave (Zirbus Technology HST-Series Chamber volume 200l). The sterilization program was set to product temperature of 121.1°C for 2 hrs 12 min.

2.6. Microbial Analysis

Microbial testing was conducted 2 weeks after autoclaving the pate in order to determine the presence of coliforms, lactobacillus and sulphite-reducing clostridia. The pate was also tested for yeast and moulds.

2.7. Nutritional analysis

The energy value and macro nutrient content of pate was calculated using a tabular method, in which, protein, fat and carbohydrates contents of the individual components of the product were used to calculate the nutritional value based on their percentage content in the formulation.

2.8. Organoleptic analysis

Pate samples were evaluated for organoleptic attributes like colour, aroma, texture, taste, aftertaste, and appearance. A set of 19 individuals, within the age group of 22 to 42 years, were asked to evaluate the above attributes on a 5-point hedonic scale (1 implies not good at all while 5 implies excellent). The results were analysed, and a spider chart was drawn. A multi-variate analysis of variance (MANOVA) was conducted to evaluate the null hypothesis that there are no differences in respondents' opinions regarding organoleptic parameters of 4 pate samples (N=19).

3. Results and discussions

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Pate, traditionally made from foie gras (or duck liver) and consumed mainly by the French and Danes (Huda, et al., 2011), is now available in many parts of the world. With palates accepting new tastes, there is immense potential for development of novel food products in the pate format, with nutritional and economic benefits to consumers and manufacturers, respectively. Fish, as such, is highly nutritious commodity and much of the waste from the fish processing industry is converted to animal feed or discarded. Fish wastes, especially from smoked fish, are not utilised to its full potential owing to the smoky flavour and dry texture. In this study, a process was developed to convert the fish heads of smoked sprats into edible pate.

3.1. Pre-processing and pate preparation

The heads of smoked sprats are considerably different from heads of fresh or frozen sprats. Due to the smoking process, the fish heads become dry, get saturated with smoke, lose elasticity, and the eyes harden. Unlike the heads of fresh or frozen sprats which can be easily cut in the cutter until the mass is homogeneous, if smoked heads are continuously cut in the laboratory cutter, the heterogeneous matter, i.e. eyes, jaw and gill particles, may not undergo size reduction. If the pate is made from heterogeneous matter, presence of the solid matter will considerably worsen the organoleptic parameters of the pate. The heterogeneous matter in the pate would be present in any cutting process since small particles (eyes, gills) of smoked fish heads are not crushed by the cutter blades since they are light and move freely between the blades and the bottom portion of the cutter tank.

There are several approaches available to homogenize the difficult to cut food

materials. Studies (Shimosaka, et al., 1998) indicated changes in physical properties and composition of fish bones (raw and steamed) when cured in acetic acid. Fish bones quickly softened due to elution of bone minerals and the effect was accelerated if the bones were steamed. In this study, two methods were implemented. First, boiling softened the fish heads as well as reduced the smell and smoky flavour. This pre-treatment considerably improved both, the organoleptic properties of the final product and the degree of homogenization of fish heads by the cutter. The other treatment was a chemical one in which the fish heads were treated with 6% apple cider vinegar. The acetic acid in vinegar helps to decalcify the bone tissue and solubilize collagen (Nagai & Suzuki, 2000) thus softening the fish heads as well as hydrating them. According to the results of further degustation of the finished pates, such amount of acetic acid did not cause excessive product acidity. Moreover, under the canned pate technology, canned pates, prior to being put on the market, are held in the finished product storage area for two weeks during which the process of decalcification continues.

Smoked heads contain high amounts of dry matter; therefore, a finely cut mixture cannot serve as the only ingredient. In the meat processing industry, pates are made from raw materials with high levels of fats and connective tissue, i.e. meat scraps, cheeks, fatty pig skin, etc., since meat processing enterprises do not usually suffer from the lack of such raw materials. Production of healthier pates by replacing pork backfat by oil combinations of olive oil, linseed oil and fish oil as well as konjac gel are reported (Delgado-Pando et al., 2011). At the fish processing plants, raw flesh materials rich in fats are not available and purchasing thereof is economically and technologically useless. Therefore, to make the pate, oil emulsion based on vegetable oil, water and emulsifiers was used. Vegetable oil is always used in the production of sprats, mayonnaise and making of the sauce for laminaria, and enterprises can buy it at low wholesale prices. Vegetable oil can easily be stored in usual storage areas and used in pate production. The proportion of said ingredients may be changed within a relatively wide range depending on the desirable emulsion texture, economic indicators (the emulsion is more expensive than the heads and forms a considerable part of the pate's production cost) and further use of the emulsifiers (for instance, isolated soy proteins). A considerable reduction in the dosage of the emulsifier may cause separation of the pate in cans or jars during sterilisation and storage as well as cause separation of the stock fatty substances which will worsen the organoleptic properties of the product. While making the emulsion it is extremely important to add the oil slowly to the water-emulsifier mix. If the oil is added quickly it may possibly cause emulsion spoilage and separation thereof right in the cutter tank or soon after cutting is finished.

To make the pate, a number of peculiarities were taken into account. From times immemorial, a pate has been regarded as a cheap product due to the low costs; therefore, this study aimed to avoid using expensive ingredients. Since smoked heads have a distinct flavour and smoke aroma, ingredients having a distinct and spicy flavour (onion, garlic, black pepper, etc.) were used rather than mild spices. A ready to use spice blend was also used in the initial trials but was considered uneconomical and to eliminate the dependency on supplier it was replaced with salt and pepper. Phosphate blends and salt were used to increase the water-binding capacity of fish raw materials and moisture retention. Filler were used to get intended texture of the pate. It was taken into account that collagen would gelatinise in the can/jars during sterilisation of the pate

and viscosity of the mass would increase; therefore, this factor was kept in mind to prevent the pate from becoming too thick. The finished product temperature was maintained between 12°C and 15°C before packaging to avoid microbial or biochemical degradation. It was observed that only a carefully configured and adapted high-speed cutter with sharp blades could be used for all stages of the pate production and nothing else was required. Four pate samples with good characteristics were identified after numerous initial trials and their composition is listed in the Table 1.

3.2. Packaging and thermal processing of the pates

The mode of sterilisation depends largely on the autoclaves available at the enterprise, and the duration of sterilisation depends on the initial microbial contamination of the fish heads, storage time and conditions, product acidity (mainly because of the vinegar added), the initial temperature of the pate prior to pre-packaging (making of the mass should be finished at the temperature not higher than +15°C), volume and shape of the can (the more its volume, the longer sterilisation time), container material (glass jars heat up slower than tin cans). Can/jar rotation during thermal processing and sterilisation may also have an impact. The sterilization program of product temperature of 121.1C for 2hrs12min was calculated based on the above parameters and was found sufficient for sterilizing the pates to make them microbiologically safe for consumption. The price of tin cans and jars being approximately the same, glass jars were considered as a better choice as it is more attractive to the consumer (since the product can be seen).

3.3. Microbiological analysis

After 2 weeks of packaging and sterilization, the pate samples were analysed for microorganisms responsible for spoilage of packaged foods. Sulphite-reducing clostridia, lactobacillus nor coliforms were detected in 25g of pate. The sample also tested negative for yeasts and moulds. This confirms that the sterilization process is adequate to make the food microbiologically safe to consume. Smoking and canning are, historically, the best methods to preserve fish and fish products and increase its shelf-life (Ghaly et al., 2010).

3.4. Nutritional analysis

Knowing the content of protein, fat, and carbohydrates in the components of the product, their energy value and percentage in the recipe, nutritional value of the final product (sample 1) was calculated. Other food additives (flavours and blends) did not have food or energy value and hence their contribution to the proximate values was ignored.

Energy value was calculated as follows (From Table 1 and Table 2):
E = 11.32*9+45.3*1.37+11.32*0.41 = 101.88 + 62.061 + 4.5 = 168.45 kcal/100 g of product

Protein, fat and carbohydrates were calculated as follows (From Table 1 and Table 2):
Protein = 0.453*12.1 + 0.11*1.4 = 5.48 + 0.154 = 5.634 g/100g of product
Fat = 0.453*12.6 + 0.11*9 = 5.7+0.99 = 6.69 g/100g of product
Carbohydrates = 0.7*3.4 + 0.82*11.32 = 2.38 + 0.902 = 3.3 g/100g of product

The nutritional value of the smoked sprat heads pate (per 100 g) was: Proteins – 5.634 g, fats – 6.69 g, carbohydrates – 3.3 g (including ballast carbohydrates – 2.38 g) and

energy value – 168.45 kcal/100 g. Ballast substances are indigestible carbohydrates, which have zero caloric value, but play a huge role in proper digestion. In the present formulations, wheat fibre is used as ballast substances.

3.5. Organoleptic analysis

Sensory analysis is vital not only for developing new products but also for process optimisation and improvement (Sidel & Stone, 1993). Fig. 1 shows the organoleptic evaluation results of the 4 pate samples (composition given in Table 1). In the sensory evaluation participated nineteen independent evaluators, fully trained before carrying out the tasting. It can be observed that all the pate samples have scored between "average" to "good" during the evaluation process for all the attributes: colour, aroma, texture, taste, aftertaste, and appearance. Overall, samples 1 and 2 were better compared to samples 3 and 4 in almost all respects. Sample 1 was chosen for subsequent studies over sample 2 as it scored higher with respect to very important attributes like appearance, texture, taste and aftertaste. Although the scores other attributes such as colour and aroma were slightly better for sample 2, it suffered a serious drawback of have more number of ingredients, especially the fillers. The higher fish head content and presence of vinegar in Sample 1 may be responsible for imparting better taste and texture to the final product.

The result of the MANOVA indicated a significant difference, Wilk's Lambda = .51, $F(15,188) = 3.42$, $p < .05$, $\eta 2 = .20$. Follow up comparisons indicated that opinion difference across all organoleptic factors was significant, $p < .05$, except Texture, $p > .05$, suggesting that texture got similar evaluation across all pate samples. Further paired comparisons (using LSD correction) as shown in Table 3, revealed that colour, aroma and taste of Sample 1 and Sample 2 were scored higher than Sample 3 and Sample 4. Aftertaste of Sample 1 was better that of Sample 2, therefore Sample 1 has been chosen for further experiments.

3.6. Flavoured pates

Future studies are aimed at product improvement in terms of making the product cheaper by using cheaper ingredients. For example, by replacing the TARI blends by considerably cheaper mono-ingredient blends. On the basis of the neutrally flavoured pate, it is possible to produce a wide range of products with more complicated flavours. In terms of the organoleptic criteria, the below pates have been qualified and are being currently tested:

- "Borodinsky" – with cumin and cardamom, and "Caramel – burnt sugar" colouring;
- "Chilly" – with red hot chilli pepper flakes and grains. This pate is coloured using the liquid paprika extract;
- "Mediterranean Herbs" – with dried rosemary and thyme;
- "Tomato" pate containing 80 % of pate and 20 % of tomato paste;
- "Classical" – it is the base pate coloured using the "Caramel – burnt sugar" colour.

Table 1. Formulations of four pate samples that yielded the best results based on taste and texture

Ingredients	% (w/w)			
	Pate Sample 1	**Pate Sample 2**	**Pate Sample 3**	**Pate Sample 4**
Water	19.7	30.6	50	0
Vegetable oil	11.3	11.2	0	29.6
Tari Combi Pate	3	2.5	8	0
Salt	1.4	1	1.1	0
Fish heads	45.3	20.3	33.7	50
Apple cider vinegar	3.4	0	0	0
Soy isolate	0	4	7.2	14.3
Wheat fiber (filler)	3.4	3.5	0	0
Pea flour (filler)	0	2.7	0	0
Semolina (filler)	0	12.8	0	0
TARI P 22	0.9	0.9	0	0
Black pepper	0.3	1	0	0
Onion	11.3	9.5	0	6.1
Total	**100**	**100**	**100**	**100**

Table 2. Ingredient list (which contribute to food value) and their composition in pate sample 1

Ingredient	**Protein %**	**Fat %**	**Carbohydrates %**	**Ballast carbohydrates %**	**Energy value kcal/g**
Sprat (head)	12.1	12.6	0	0	1.37
Wheat fibre (Cellulose)	0	0	70	70	0
Onion	1.4	0	8.2	0	0.41
Vegetable oil	0	100	0	0	9

Table 3. Results of MANOVA analysis comparing different pate samples and organoleptic parameters

Colour	**Aroma**	**Taste**	**Aftertaste**
#1 better than #3 #2 better than #3 #4 #1=#2 #4 #2= #1	#1 better than #3 #4 #2 better than #3 #1=#2 #2=#1 #4	#1 better than #3 #4 #2 better than #3#4 #1=#2	#1 better than #2 #3 #2 = #3 #4

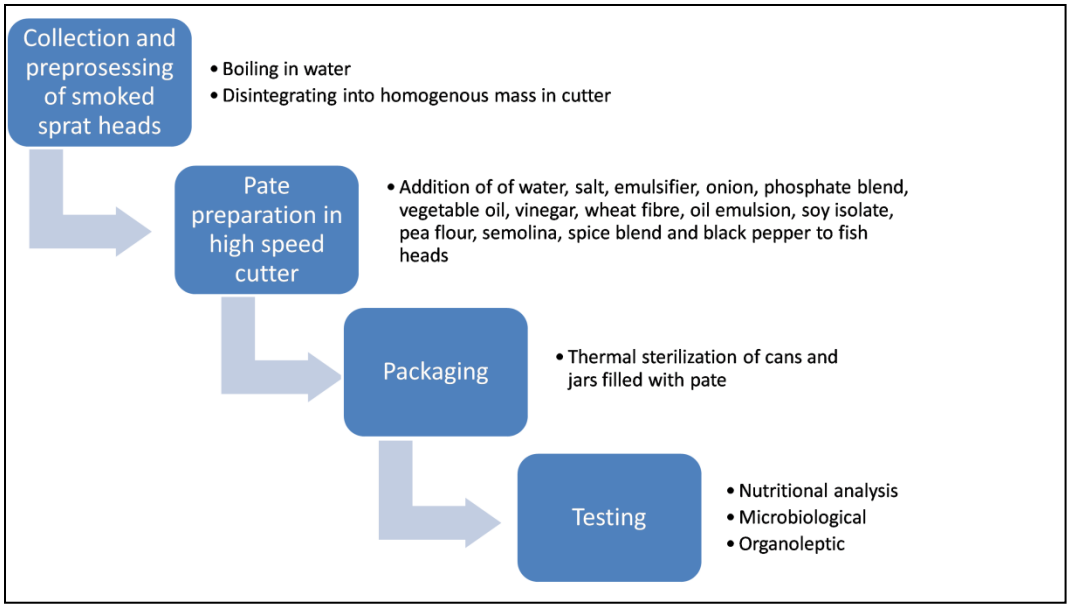

Figure 1. Process chart for preparation of fish head pate

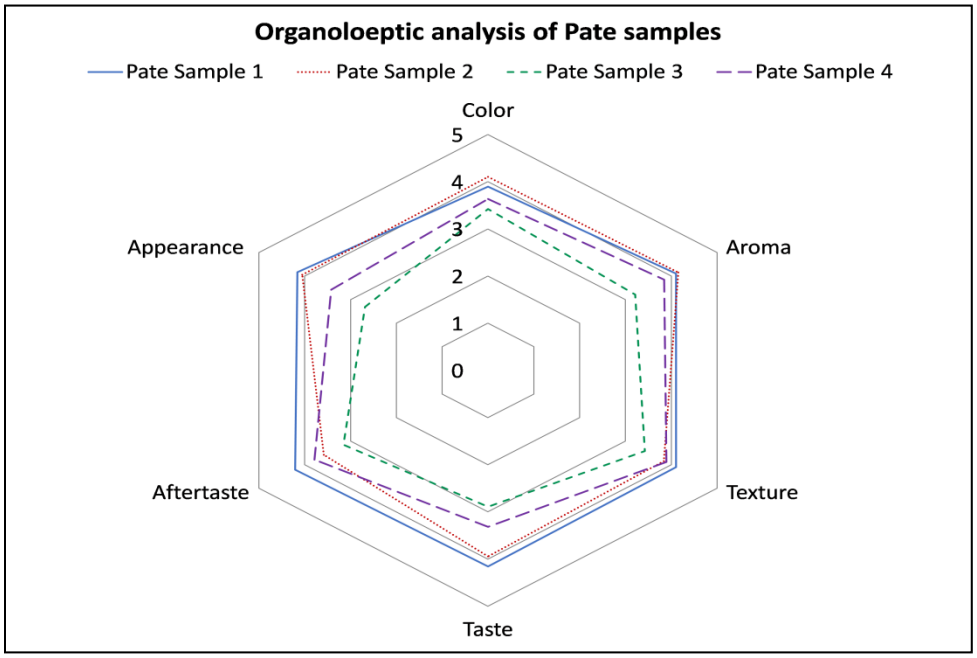

Figure 2. Organoleptic analysis of smoked Sprat heads pates

4. Conclusions

This study indicated a viable possibility to produce an edible pate out of heads of smoked sprats with minimal processing and low-cost ingredients. A simple high-speed cutter was used in conjunction with the emulsifying agent for the preparation of pate rather than using expensive sophisticated machinery. A neutral flavoured pate with good organoleptic properties has been successfully produced. Flavoured fish pates such as Borodinsky, Chili, Mediterranean herbs, Tomato and Classical flavours are being evaluated. This process has the

potential to convert the underutilized smoked fish waste into edible product, providing an environmental as well as economic solution to fish processing companies who are looking to expand their product range.

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Acknowledgment

In accordance with the contract No. 1.2.1.1/16/A/004 between "Latvian Food Competence Centre" Ltd. and the Central Finance and Contracting Agency, signed on 11th of October, 2016, the study is conducted by “Piejūra” with support from the European Regional Development Fund (ERDF) within the framework of the project "Latvian Food Industry Competence Centre”.