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Research article

PREPARATION OF HIGH QUALITY "KETO" NOODLES BY USING SODIUM ALGINATE, CALCIUM LACTATE AND RED DRAGON FRUIT PEEL

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Abstract:
Recently, research on healthy food products has received increasing attention. Research on optimizing the use of agricultural by-products has attracted more attention from researchers and nutritionists. The study was conducted to utilize red dragon fruit peel to prepare noodles from sodium alginate and calcium lactate. The effect of the ratio of red dragon fruit, sodium alginate and calcium lactate on the structure, color, betacyanin content and sensory properties was studied. When dragon fruit is added at different proportions, the viscosity and betacyanin content of the product change. With a dragon fruit peel ratio of 24%, the product is balanced in structure, taste and color through analysis of product structure and sensory value. In addition, with sodium alginate and calcium lactate content of 7% sodium alginate, 1% calcium lactate, the product has sensory value and maintains high betacyanin content in the product. This is the first study using sodium alginate, calcium lactate and red dragon fruit peel in the processing of noodle products. The study creates a premise for processing more diverse products, especially taking advantage of available agricultural by-products to process into value-added products and improve economic efficiency.

1. Introduction

Noodles serve as an important diet in numerous Asian nations and are gaining popularity among customers globally (Fu, 2008; Luangsakul et al., 2026a). Nevertheless, noodles possess a high glycemic index (GI), signifying their vulnerability to hydrolysis. Consequently, it is essential to endeavor to lower the glycemic index of noodles (Luangsakul et al., 2026b). By combining two different hydrocolloids, sodium alginate and calcium lactate, you create a firm gel that has a texture that is remarkably close to spaghetti or ramen noodles. It could be served for keto diet, which is known as is a low-carbohydrate, high-fat eating plan that forces the body to burn fat

for fuel instead of carbohydrates, leading to a metabolic state called ketosis (Alharbi & Al-Sowayan, 2020; O'Neill & Raggi, 2020). Moreover, Yuasa et al. (2019) latest research has facilitated the creation of "mentsuyu caviar (Japanese noodle soup base)" utilizing sodium alginate and calcium lactate. Sodium alginate is a natural polymer derived from brown algae. It is a linear polymer composed of (1→4)-linked β-D-mannuronic acid and α-L-guluronic acid pyranose units (Fenoradosoa et al., 2010). Sodium alginate, characterized by its high hydrophilicity, exhibits excellent hygroscopic qualities and dissolves easily in both hot and cold water, swiftly producing a thick colloidal solution with significant efficacy. It can also interact with divalent metal ions (except mercury and magnesium) to create alginate gels with significant tensile strength in food products (Wang et al., 2023). Lubowa et al. (2020) manufactured rice noodles with pregelatinized high-amylose maize starch in conjunction with Ca^{2+}-induced sodium alginate, which hardened the alginate, enhanced the tensile strength of the noodles, and increased their thickness. Yuasa et al. (2019) employed a plastic syringe to gradually inject mentsuyu containing 1% (w/w) sodium alginate into a 5% (w/w) calcium lactate solution. The solution promptly solidified into mentsuyu caviar, so augmenting the visual appeal of both mentsuyu and caviar. Gelation is a molecular gastronomy technique that employs sodium alginate and calcium salts to create diverse gel forms, including spherical gels (spherification). Sodium alginate is a polysaccharide formed by the association of sodium ions (Na^+) with the carboxyl group of alginates. While alginate is insoluble, sodium alginate is soluble in water and exhibits viscosity in aqueous solution. The monomeric constituents of alginate-β-D-mannuronate and α-L-guluronate are interconnected to form poly β-D-mannuronate, poly α-L-guluronate, and a heteropolymer (Martínez-Gómez et al., 2018). Nonetheless, no research has been conducted utilizing sodium alginate and calcium lactate to produce noodle products. Moreover, in Vietnam, by-products from the agricultural and food processing industries, which are the residuals following the harvesting and processing of agricultural and food goods, are frequently regarded as trash, however they can also be perceived as a valuable resource (Van Tai et al., 2023). The red dragon fruit has been scientifically demonstrated to possess significant nutritional content and natural antioxidant properties. Nevertheless, the peel is deemed waste and discarded (Chumroenvidhayakul et al., 2023a). The peel of red dragon fruit is rich in vitamins, minerals, and natural antioxidants, which may inhibit cancer, cardiovascular disease, and lower blood pressure (Nishikito et al., 2023). The flesh and peel of red dragon fruit are rich in betacyanin, a class of nitrogen-containing natural colors that are water-soluble. This chemical has numerous biological activities that promote health, including antioxidant capability, free radical scavenging, and the inhibition of cancer cells (Lim et al., 2025). Free radicals are the agents that expedite the aging process, induce sickness, and contribute to the formation of cancer cells. Utilizing discarded dragon fruit peel waste to mitigate environmental contamination and enhance the value of Vietnamese fruits. The study on the production of starch-free noodles from sodium alginate, calcium lactate, and dragon fruit peel initially established several parameters of the technical processing to ensure food hygiene and safety, enhance the economic value of raw materials, and promote environmental protection.

2. Materials and methods

2.1 Sample preparation

The dragon fruit is soaked in salt water with a concentration of 1.5% (w/v) for 15 minutes, then washed for further peeling process. The peel was blanched at temperature of 80°C with the ratio of 100:36 for water and material and keep for 1 minute. The blanched dragon fruit peel at was put into a blender with 300 ml of water and 0.9% defoamer XPJ-747 to form a homogeneous mixture. The ratio of dragon fruit peel was varied from 20% to 26% (Factor A), compared with water. Blending time was set up at 3 min. The mixture was

sonication for de-bubble in solution. Then, add 0.7% xanthan gum, 0.7% iodized salt, 4.5% konjac powder and 7% sodium alginate and continue grinding to create a thick, smooth and homogeneous mixture. The mixture was stand for 30 min to stabilize the structure. Prepare a soaking solution (1% sodium alginate, 700 ml water) with 0.5% ascorbic acid to soak the noodles immediately after shaping. Put the ground mixture into a hand-held noodle press and start pressing so that the noodles fall directly into the soaking solution. The collected noodle was further analyzed the characteristics and sensory evaluation

For the second experiment, the concentration of sodium alginate (5-9%, Factor B) and calcium lactate (0.8-1.2%, Factor C) were considered as the factor effect on quality of noodle. The production procedure was following as previous mentioned with the various concentration of sodium alginate and calcium lactate. The product characteristics as betacyanin content, structure properties, color and sensory properties were evaluated and compared.

2.2. Color and structure evaluation

Color properties of noodles samples were analyzed by colorimeter (CR – 400 Konica Minolta, Japan). The structure properties of noodles also were evaluated through the structure analyzer (Brookfield- CT3, USA).

2.3. Betacyanin content

The betacyanin content of fraction was quantified using a previously established spectrophotometric method (Wybraniec & Mizrahi, 2002) and represented as betanin equivalents (mg/100 g) by the following formulas

2.4. Sensory evaluation

Sensory evaluation by scoring method. Establish a sensory panel of 50 people, who are students at Tien Giang University, non-allergic and healthy. Each sensory panelist will be informed and sign an agreement that they are not allergic to the product. The sensory evaluation table describes the product for each criterion according to the scale of Vietnamese standards (TCVN 3215-79), with a preference from 0 (dislike) to 5 (very much like) for each criterion including: color, taste and structure.

2.5. Data analysis

All experimental results were presented as mean ± standard deviation (SD) from three determinations. A one-way ANOVA was conducted to assess the significance of differences among the means. P values less than 0.05 were considered significant.

3. Results and discussions

3.1. Quality of raw dragon fruit peel

The quality of raw materials plays an important role, directly affecting the quality of the final product. The selection and analysis of raw materials not only help to maximize the nutritional potential but also ensures economic efficiency in production. For the food processing industry, agricultural by-products such as dragon fruit peel, which used to be considered waste, are gradually being focused on as a potential source of raw materials (Van Tai et al., 2023). Dragon fruit peel is a source of secondary raw materials that are often discarded but contain many valuable nutritional components such as vitamin C, betacyanin and outstanding physicochemical properties. In the context of the global food waste and environmental protection, the use of agricultural by-products such as dragon fruit peel is becoming a popular trend. Previous studies have shown that dragon fruit peel not only contains important nutritional components but can also be widely applied in the food, cosmetic and pharmaceutical industries (Chumroenvidhayakul et al., 2023b; Van Tai et al., 2023). This not only minimizes the environmental impact but also brings added value to the product. Although red-fleshed dragon fruit peel has many potential benefits, the utilization of this raw material is still limited, mainly due to the lack of detailed studies on its physicochemical composition and practical applications. Therefore, research on red-fleshed dragon fruit peel not only contributes to solving the problem of resource

waste but also opens opportunities to develop products with high economic value. Therefore, analyzing and evaluating the physicochemical composition of the raw materials is a necessary step to establish a scientific basis for the research and product development process. The analysis results are shown in Table 1. Dragon fruit peel is a water-rich material (90.63%), which means that the material is easily damaged if not properly preserved, creating a favorable environment for microorganisms to grow. The relative content of vitamin C in the peel (0.034 mg/100 g) has the potential to be a source of natural antioxidants that help improve health, support the immune system and reduce oxidation (Traber & Stevens, 2011). Red-fleshed dragon fruit peel contains a high betacyanin content of 32.16 mg/100 g of fresh peel, which can be used as a natural colorant to replace synthetic colors. The indicators such as total acid 0.23%, total sugar 1.82%, reducing sugar 0.93 g/100g, ash 0.1%, pH of 5.06 and total soluble solid content of 5.28% show that this material has a slightly sour, slightly sweet and slightly acidic taste, which is convenient for processing food products. Therefore, red-fleshed dragon fruit peel is a natural raw material with great potential thanks to its high-water content, nutritional components such as vitamin C, sugar, minerals and natural pigments, and is also suitable for research on healthy food development.

Table 1. Physicochemical properties of dragon fruit peel

Parameter	Content
Moisture	90.63%
Vitamin C	0.034 mg/100 g
Total acid content	0.23%
Total sugar content	1.82%
Total reducing sugar content	0.93 g/100 g
Ash content	0.1%
pH	5.06
Total soluble solid content	5.28%
Total betacyanin content	32.16 mg/100 g

3.2. Effect the ratio of dragon fruit peel added to color, structure, betacyanin content, sensory value of the product and viscosity of the solution

The proportion of dragon fruit peel added not only affected the texture but also significantly influenced other important parameters such as hardness, viscosity, betacyanin content and sensory value of the product. Adjusting the appropriate proportion of dragon fruit peel is necessary to optimize the physical and chemical properties of the product, while ensuring its sensory appeal. In this experiment, the proportion of dragon fruit peel was investigated in detail to determine its effects on the quality of the product and find the best addition proportion.

Color

Color is one of the important criteria for evaluating a food product, especially in the food industry (Wu & Sun, 2013). Color not only affects the direct appeal but is also the first factor affecting the consumer's choice. In this experiment, determining the effect of the ratio of dragon fruit peel on product color helps to evaluate the ability to optimize the production process, thereby improving the sensory value and quality of the product. The results of the effect of the ratio of dragon fruit peel on product color as well as the appearance are shown in Table 2.

The dragon fruit peel ratio increases from 20% (A1) to 26% (A4), the values of L, a*, b* change significantly, showing that the dragon fruit peel ratio affects the color of the product. The L value increased steadily from A1 (43.34) to A3 (46.19) but increased slightly at A4 (46.83). This shows that the product with an increasing L value has an increasing brightness when the proportion of dragon fruit peel

increases. The a* value fluctuates from A1 (14.64) to A3 (19.71), then decreases slightly at A4 (16.35). This indicates that the red color increases sharply when the proportion of peel increases to 24% (A3) and decreases at higher levels (A4). The b* value fluctuates continuously from A1 (-1.74) to A4 (-1.83). This fluctuation indicates that the green color tends to decrease when the proportion of dragon fruit peel increases but is not stable. The proportion of dragon fruit peel clearly affects the color of the product. Increasing the proportion of dragon fruit peel increases the brightness (L) and red pigment (a*) up to a certain level of A3, but may decrease when the proportion of peel is too high. Evidently, the color of red dragon fruit is due to the pigment inside of fruit peel matrix as known as betalain, which mainly red-pink color (Lim et al., 2025). The greenness (b*) tends to decrease, indicating that the color balance needs to be optimized based on the proportion of peel. Optimizing the proportion of dragon fruit peel is essential to achieve balanced color, especially red and green.

Table 2. Results of the influence of dragon fruit peel ratio (%) on product color

Sample	Ratio of dragon peel (%)	Appearance	L	a*	b*
A1	20		43.34^{a}	14.64^{a}	-1.74^{b}
A2	22		45.19^{b}	14.99^{a}	-1.97^{a}
A3	24		46.19^{c}	19.71^{c}	-1.53^{c}
A4	26		46.83^{c}	16.35^{b}	-1.83^{b}
F			**	**	**
CV (%)			2,56	12,67	10,19

Note: Values in the same column with different lowercase letters (a, b, c,…) show statistically significant differences; (ns): no difference; (**): shows significant differences at the 1% level; (*): shows differences at the 5% level.

3.3.Structure properties

Texture is an important factor affecting the sensory quality and acceptability of food products. Dragon fruit peel has high viscosity and water content (Du et al., 2024), so the proportion of dragon fruit peel added not only affects the elasticity but also affects the tensile strength, which determines the stability and firmness of the product. The results of the effect of the proportion of dragon fruit peel on the structure of the product are shown in Table 3.

The results of Table 3 show that the effect of the ratio of dragon fruit peel addition on the elasticity and tensile strength of the product is different. When the ratio of dragon fruit peel increased from 20% (A1) to 24% (A3), the elasticity increased significantly from 6.75 mm (A1) to 11.25 mm (A3). However, when the ratio increased to 26% (A4), the elasticity decreased slightly to 8.25 mm. The high content of insoluble fiber in dragon fruit peel can hinder the formation of a structural network, creating small voids, making the product porous and less elastic (Chumroenvidhayakul et al., 2023b). This shows that the ratio of dragon fruit peel addition at too high a level reduced the elasticity of the product. Moreover, as the proportion of dragon fruit peel increased from 20% (A1) to 26% (A4), the viscosity of the mixture gradually increased from 16298 cps to 22320 cps. In general, the higher the proportion of dragon fruit peel, the greater the viscosity of the product, which can contribute to improving the structural stability of the product, but too high viscosity affects the uniform dispersion of the ingredients in the product, reducing the quality of the product.

Table 3. Results of the influence of dragon fruit peel ratio (%) on product structure

Sample	Ratio of dragon peel (%)	Elasticity (mm)	Tensile strength (gxmm)
A1	20	6.75^{a}	10.44^{a}
A2	22	7.50^{ab}	129.60^{b}
A3	24	11.25^{c}	180.03^{c}
A4	26	8.25^{b}	134.25^{b}
F		**	**
CV(%)		11.62	10.18

Note: Values in the same column with different lowercase letters (a, b, c,…) show statistically significant differences; (ns): no difference; (**): shows significant differences at the 1% level; (*): shows differences at the 5% level.

Table 4. Results of the influence of dragon fruit peel ratio (%) on the sensory score of the product

Sample	Ratio of dragon peel (%)	Sensory value		
		Color	Taste	Structure
A1	20	3.14^{a}	3.00^{a}	3.57^{ab}
A2	22	3.86^{b}	3.57^{ab}	4.28^{bc}
A3	24	4.57^{c}	4.43^{c}	4.57^{c}
A4	26	4.42^{bc}	4.00^{bc}	3.43^{a}
F		**	**	**
CV (%)		9.41	10.04	9.99

Note: Values in the same column with different lowercase letters (a, b, c,…) show statistically significant differences; (ns): no difference; (**): shows significant differences at the 1% level; (*): shows differences at the 5% level.

Similar to elasticity, the tensile strength also increased from 107.44 gxmm (A1) to the highest level of 180.03 gxmm (A3). When the addition ratio increased to 26% (A4), the tensile strength decreased to 134.25 gxmm. This shows that the addition ratio of dragon fruit peel beyond the optimal level can reduce the tensile strength of the product. Because dragon fruit peel contains cellulose and hemicellulose that are not able to bind tightly (Corimayhua-Silva et al., 2024). When adding a high ratio of dragon fruit peel, the fibers will be interrupted and break the bonding structure, making the product less durable. In addition, the uneven distribution of fibers also creates weaknesses in the structure, reducing the ability to withstand tensile strength (Chumroenvidhayakul et al., 2022). In summary, the addition ratio of dragon fruit peel at 24% (A3) is good, helping the product

achieve the highest value of elasticity and tensile strength, ensuring a solid and stable structure. If the addition ratio of peel is too high or too low, it will also affect the quality of the product's structure.

3.4.Sensory properties

Sensory evaluation not only reflects the satisfaction of the evaluator but also serves as a basis for optimizing the ratio of raw materials used, thereby enhancing the commercial value of the product. In this section, the survey of the ratio of added dragon fruit peel helps determine their impact on sensory criteria to select the most suitable ratio to create a quality product that is attractive to consumers. The results of the impact of the ratio of dragon fruit peel on the sensory value of the product are shown in Table 4.

The color assessment score increased from (A1) 3.14 points to the highest at (A3) 4.57 points and decreased slightly to (A4) 4.42 points, indicating that the dragon fruit peel ratio of 24% is good for creating the most beautiful color. While lower or higher ratios both reduce the level of color preference of the sensory panel. The flavor score also tends to increase with the dragon fruit peel ratio, the highest at sample (A3) 4.43 points, then decreased to 4.00 points (A4). This result shows that the dragon fruit peel ratio of 24% helps the product achieve the most preferred flavor. The texture score increased from 3.57 (A1) to 4.57 (A3) but decreased to 3.43 (A4), indicating that the dragon fruit peel ratio of 24% creates a product with good structure according to the sensory panel's evaluation standards. The dragon fruit peel ratio of 24% is highly appreciated by sensory experts in terms of color, flavor, and structure suitable for creating good products.

3.5.Betacyanin content

Betacyanin content is an indicator of the quality and nutritional value of the product. Betacyanin determines the characteristic color of the product and contributes to increasing its attractiveness to consumers (Nabi et al., 2023). The proportion of dragon fruit peel added directly affects the betacyanin content of the product, thereby affecting the sensory value and nutritional value. The results of the influence of the proportion of dragon fruit peel on the betacyanin content of the product are shown in Table 5. When the ratio of added dragon fruit peel increases from 20% (A1) to 26% (A4), the betacyanin content also increases from 21.21 mg to 27.04 mg. This shows that increasing the ratio of added dragon fruit peel has a direct relationship with the betacyanin content, thereby improving the color and nutritional value of the product.

Table 5. Results of the effect of dragon fruit peel ratio on betacyanin content of the product

Sample	Ratio of dragon peel (%)	Betacyanin content (mg/100g)
A1	20	21.21[a]
A2	22	22.72[a]
A3	24	24.33[b]
A4	26	27.04[c]
F		**
CV (%)		10.13

Note: Values in the same column with different lowercase letters (a, b, c,…) show statistically significant differences; (ns): no difference; (**): shows significant differences at the 1% level; (*): shows differences at the 5% level.

The ratio of dragon fruit peel: the ratio of dragon fruit peel has a clear influence on the quality of the product, the higher the ratio, the better the color, structure, betacyanin content and viscosity of the product. However, too high a ratio will affect the structure of the product, specifically elasticity and tension, which are also two characteristic factors that determine the quality of the product. Sample A1 has good color, betacyanin content and viscosity but the

worst structure. Sample A2 has an improvement in structure compared to sample A1 but still does not achieve good results. In sample A4, although the nutritional value increases, the mechanical stability and color decrease. Sample A3 (24% red dragon fruit peel) is considered the best due to its stable balance of color, structure, viscosity and high betacyanin content.

3.6. Effect of formula development (sodium alginate, calcium lactate) on color, structure, betacyanin content, sensory value of the product

Color is a decisive factor in the sensory quality of the product. In particular, the combination of structural components such as sodium alginate and calcium lactate not only affect the structure but also significantly affects the color, viscosity and betacyanin content. The results of the influence of the ratio between sodium alginate and calcium lactate on the color of the product are shown in Table 6. The L value tends to decrease when the calcium lactate ratio increases from 0.8% to 1.2% and sodium alginate increases. The sample with the ratio of sodium alginate (9%) combined with calcium lactate (1.2%) (B3C3) has the lowest L value (36.70), indicating a darker product. On the contrary, the sample with the ratio of sodium alginate (5%) and calcium lactate at (1.2%) (B1C3) has the highest L value (42.65) and the product has a lighter color. This shows that the higher the addition ratio, the lower the color of the product. The a* value ranges from 9.65 to 11.97, indicating a color difference between the samples. As the sodium alginate ratio increases from 5% to 9% and calcium lactate increases, the a value also decreases, indicating that the color gradually becomes redder. Sample B1C3 (5% sodium alginate, 1.2% calcium lactate) has the highest a* value (11.97), indicating that the product has the most distinct red color. The b* value ranges from -0.92 to -0.67, indicating that the product is more inclined to blue tones. Sample B1C1 (5% sodium alginate, 0.8% calcium lactate) has the lowest b value (-0.92), indicating that the blue tone is strongest.

Table 6. Effect of the ratio between sodium alginate and calcium lactate on product color

Sample	Sodium alginate (%)	Calcium lactate (%)	L	a*	b*
B1C1		0.8	40.72^{e}	11.46^{bc}	-0.92^{a}
B1C2	5	1.0	41.83^{f}	10.97^{b}	-0.74^{def}
B1C3		1.2	42.65^{g}	11.97^{c}	-0.72^{ef}
B2C1		0.8	40.34^{de}	10.67^{b}	-0.97^{a}
B2C2	7	1.0	39.61^{cd}	10.80^{b}	-0.81^{cd}
B2C3		1.2	39.20^{c}	11.49^{bc}	-0.67^{f}
B3C1		0.8	38.95^{c}	9.76^{a}	-0.92^{ab}
B3C2	9	1.0	37.82^{b}	9.77^{a}	-0.87^{bc}
B3C3		1.2	36.70^{a}	9.65^{a}	-0.77^{de}
F			**	**	**
CV (%)			4.69	8.57	13.00

Note: Values in the same column with different lowercase letters (a, b, c,…) show statistically significant differences; (ns): no difference; (**): shows significant differences at the 1% level; (*): shows differences at the 5% level.

For brightness L, different ratios of sodium alginate and calcium lactate will change the brightness of the product, with changes in calcium ions affecting the transparency or opacity of the gel. Redness a, chemical reactions during the gelation process can slightly reduce or increase the red color of the product. Finally, the blue b, when the calcium lactate ratio is higher, can reduce the color fastness of the natural pigment, affecting the blue value. As report of Islam et al. (2024), a higher calcium lactate ratio may decrease the

color fastness of natural pigments, especially affecting blue values, as calcium ions can disrupt the binding of dyes to fibers, resulting in accelerated fading and color loss. In summary, the change in the ratio between sodium alginate and calcium lactate significantly affects the color of the product, especially the brightness L and the red a

Texture is a factor that directly affects the consumer acceptability of the product, especially in products that require a certain elasticity and tensile strength. The combination of sodium alginate and calcium lactate plays an important role in gel formation, thereby determining the mechanical properties such as elasticity and tensile strength of the product. The results of the influence of the ratio of sodium alginate and calcium lactate on the structure of the product are shown in Table 7.

Table 7. Effect of the ratio between sodium alginate and calcium lactate on the structure and sensory properties of the product

Sample	Elasticity (mm)	Tensile strength (gxmm)	Sensory value			Betacyanin (mg/100g)
			Color	Taste	Structure	
B1C1	14.00^{a}	316.38^{a}	2.57^{a}	2.71^{a}	2.86^{a}	17.73^{d}
B1C2	17.33^{b}	480.97^{cd}	3.29^{ab}	3.43^{bc}	3.57^{bc}	15.54^{ab}
B1C3	21.67^{d}	712.607^{e}	4.14^{cd}	4.00^{de}	4.29^{de}	13.77^{a}
B2C1	16.67^{b}	467.59^{bcd}	3.14^{ab}	3.14^{abc}	3.29^{abc}	18.33^{de}
B2C2	26.00^{e}	963.58^{f}	4.71^{d}	4.57^{e}	4.71^{f}	18.27^{de}
B2C3	22.67^{d}	635.49^{de}	4.29^{cd}	4.14^{de}	4.29^{de}	14.49^{a}
B3C1	17.00^{b}	336.04^{ab}	2.86^{a}	3.00^{ab}	3.00^{ab}	19.95^{e}
B3C2	22.67^{d}	520.17^{d}	4.43^{cd}	4.29^{de}	4.43^{ef}	15.58^{c}
B3C3	20.00^{c}	373.28^{abc}	3.71^{bc}	3.71^{cd}	3.86^{cd}	16.21^{c}
F	**	**	**	**	**	**
CV (%)	8.83	12.80	9.73	12.45	10.04	7.04

Note: Values in the same column with different lowercase letters (a, b, c,…) show statistically significant differences; (ns): no difference; (**): shows significant differences at the 1% level; (*): shows differences at the 5% level.

Sodium alginate acts as a gelling agent when interacting with calcium ions from calcium lactate to increase the hardness and structural strength of the product (Pournaki et al., 2024). When the ratio of calcium lactate is higher, it will increase the ionic bond (Nielsen et al., 2022), thereby enhancing the hardness but can also make the product too firm or brittle if not properly controlled. The elasticity value ranges from 14.00 mm (B1C1) to 26.00 mm (B2C2). The sample with the ratio of sodium alginate (5%) and calcium lactate (0.8%) (B1C1) has the lowest elasticity, indicating a weak gel structure and poor elasticity. Increasing the ratio of sodium alginate (7%) and calcium lactate (1%) (B2C2) significantly increases the elasticity, the highest value of 26.00 mm shows a strong structure and good elasticity. At a high ratio of sodium alginate (9%), the elasticity tends to decrease slightly. This may be due to the sodium alginate content being too high, the gel structure becomes too dense and hard, losing the elasticity and toughness of the product. The tensile strength values ranged from 316.38 gxmm (B1C1) to 963.58 gxmm (B2C2). Sample B2C2 (7% sodium alginate, 1% calcium lactate) not only had the highest elasticity but also achieved the highest tensile strength of 963.58 gxmm, demonstrating that the structure was both elastic and resistant. At the sodium alginate ratio (9%), the tensile strength tended to decrease, indicating that a higher sodium alginate content does not necessarily mean better tensile strength. Samples with a calcium lactate ratio (1.2%) generally had better tensile strength than the sample used (0.8%), demonstrating the important role of calcium

lactate in increasing the strength of the gel bond. The ratio of sodium alginate and calcium lactate has an important influence on the mechanical properties of the product. The ratio in sample B2C2 (7% sodium alginate, 1.0% calcium lactate) gives the most stable elasticity and tensile strength. Therefore, the ratio of sodium alginate and calcium lactate needs to be controlled at an appropriate threshold. If the control level is exceeded, the product will be affected by excessive gelation, interaction imbalance and change in mechanical properties.

Sensory evaluation is an important step in the product research and development process. Especially for food products with high applicability. The goal of sensory evaluation is to determine the level of consumer satisfaction through criteria such as color, taste, texture - factors that directly affect the acceptance and commercial value of the product. In this study, product samples were mixed with different ratios of sodium alginate and calcium lactate. These two components not only play a decisive role in the physical and chemical properties of the product but also affect the sensory properties of the product. The results of the influence of the ratio between sodium alginate and calcium lactate on the sensory value of the product are also shown in Table 7. Samples with high sodium alginate ratio (7% or 9%) have the highest color sensory score of 4.71 points of sample B2C2 (7% sodium alginate, 1.0% calcium lactate), showing that this ratio is well evaluated by sensory experts. Sample B1C1 has a low color sensory score of 2.57 points (5% sodium alginate, 0.8% calcium lactate) which is not enough to create an attractive product color. The highest taste score was in sample B2C2 (7% sodium alginate and 1% calcium lactate) 4.57 points showing a good balance between these two ingredients in creating a harmonious taste. The sample with the lowest taste was B1C1 (5% sodium alginate, 0.8% calcium lactate) 2.71 points, which had a too strong taste and was not highly appreciated by the sensory panel. Sample B2C2 (7% sodium alginate and 1% calcium lactate) achieved the highest texture score of 4.71 points, showing the most preference of the sensory panel for the texture of this product. Sample B1C1 had the lowest sensory score of 2.86 points, showing that the product had a poor structure and did not meet the elasticity standards. In summary, sample B2C2 (7% sodium alginate 1% calcium lactate) achieved the highest overall sensory score in all three criteria, demonstrating that this blending ratio is most suitable for producing a product with high sensory quality.

Betacyanin content is an important indicator that affects the color and nutritional value of the product. Betacyanin is a natural compound with strong antioxidant properties, but its content can be affected by many factors during processing, including the ratio of ingredients such as sodium alginate and calcium lactate. The results of the influence of the ratio of sodium alginate and calcium lactate on the betacyanin content of the product are also shown in Table 7. Samples with higher sodium alginate ratio tend to maintain betacyanin content better than samples with lower ratio. Sample B2C1 (7% sodium alginate 0.8% calcium lactate) has a high betacyanin content, indicating that sodium alginate plays a role in protecting betacyanin from degradation during production. Betacyanin content tends to increase and then decrease as the calcium lactate ratio increases from 0.8% to 1.2%. However, when the calcium lactate ratio increases to 1.2%, the betacyanin content decreases slightly. This may be due to higher calcium lactate concentrations leading to chemical interactions that reduce the stability of betacyanin.

4. Conclusions

The changes in physical properties, betacyanin content and sensory value of "keto" noodles were studied. The study also showed that red dragon fruit peel can be effectively applied in the processing of noodles from sodium alginate and calcium lactate. The change in the ratio of raw ingredients changes the quality of the product. With the ratio of red dragon fruit 24%, sodium alginate 7% and calcium lactate 1%, the product has sensory

quality, maintaining a high betacyanin content. The study has opened a direction in the processing of nutritional products in the new era, especially taking advantage of by-products to process beneficial food products and reduce the burden on the environment.

Author Contributions

Conceptualization, L.T.K.L.; Methodology, L.T.K.L., N.T.N.U., N.T.T.T.; Formal Analysis, N.T.N.U; Investigation, N.T.N.U; Writing – Original Draft Preparation, L.T.K.L. N.T.N.U., N.T.T.T.; Writing – Review & Editing, L.T.K.L., N.T.T.T.; Supervision, L.T.K.L; Project administration, L.T.K.L.; Funding Acquisition, L.T.K.L.

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