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Developing pearl products from watermelon juice (*Citrullus lanatus*) in Long An, Vietnam

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Abstract

Watermelon juice, rich in bioactive compounds such as antioxidants, vitamins and amino acids, is gaining increasing attention for its health benefits and innovative applications in the food industry. In this study, pearl products from watermelon juice were successfully developed. The parameters surveyed included watermelon juice heating temperature (from 80-100°C), type of thickener (tapioca starch, kudzu powder, wheat flour, mixture of the above three powders), a ratio of thickener (55%, 60%, and 65% w/w), Results have shown that appropriate parameters for the process of creating watermelon pearl products have been determined, including watermelon juice heating temperature of 90°C, tapioca starch as the thickener ratio of 60% w/w, product cooking time of 20 min, the storage temperature of -18°C, storage packaging as biaxially oriented polypropylene/aluminum/ polyethylene. In addition, the resulting product has a firm structure, a pink color, and a typical watermelon aroma with high consumer sensory scores. Watermelon juice tapioca pearl products have significant potential in a variety of food applications. These products can take advantage of the rich bioactive compound content of watermelon juice, providing innovative options for the health-conscious consumer market.

1. Introduction

Watermelon (*Citrullus lanatus*) belongs to the Cucurbitaceae family and originates from Africa. *Citrullus lanatus* is an herbaceous plant that grows up to 3 meters long (Enemor *et al*., 2019). Watermelon is a member of the gourd family, with a hard shell containing a lot of water. Watermelon is popular with many people because of its sweetness and water content, and it also helps provide many vitamins and trace elements to the body (Sangeeta *et al*., 2020). In Vietnam, watermelon is widely grown in the Mekong Delta provinces and has high product quality. Long An watermelon has small seeds, is fragrant, has a delicate skin, is sweet, juicy, slightly crunchy and is not limited if stored for a long time like other strawberry varieties. Watermelon has high nutritional value, is beneficial for health, and provides many essential vitamins and minerals for the body, such as vitamin C, vitamin B5, and potassium (Hdider *et al*., 2020; Zamuz *et al*., 2021). In addition, watermelon is also a source of biological compounds such as carotenoids, lycopene, and polyphenols. These compounds are highly effective in inhibiting cancer-causing free radicals (Fatima *et al*., 2021).

Pearl tea, a product often added to milk tea, has a diameter of 0.6 - 1 cm and is made from tapioca flour with water and sugar to create elasticity (Pande *et al*., 2024). Pearls are considered the most essential ingredient in pearl milk tea. In the ingredients of pearl products, tapioca starch is the primary source of starch, while water and sugar are used to create elasticity. After cooking, pearls are chewy, shiny, transparent, and have a dense texture with good elasticity (like marshmallows) (Zhu *et al*., 2024). Pearls are made by moist-heat

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treatment of a mixture of gelatinized and non-gelatinized starch to a moisture content as 50% (wb) and then mechanically shaken to form spheres with a 0.6 - 1 cm diameter. Nowadays, utilizing fruit juices to produce pearl products is an appropriate solution for diversifying products and improving the preservation time of fruit juice. Tapioca flour, derived from tapioca root, is a famous powder used to produce pearl products in milk tea. Therefore, these products are highly significant because they help reduce post-harvest losses and toxicity of tapioca root material and increase the efficiency of using this food crop (especially in tropical countries like Vietnam) (Fernando *et al*., 2022). Currently, the use of watermelon juice in Vietnam is limited because of its short storage time, and its sensory value decreases during storage. Therefore, developing a product from watermelon juice is a suitable application to solve the above problem.

Thus, this study aimed to evaluate the parameters affecting the development of pearl products from watermelon juice originating from Long An province (Vietnam). The product is expected to achieve good sensory value and retain the content of bioactive compounds with high antioxidant activity. These pearls, rich in bioactive compounds, could be used in functional foods and beverages, providing innovative solutions for health-conscious consumers and expanding the utility of watermelon-derived ingredients.

2. Materials and methods

The watermelons used for the study were red-fleshed watermelons provided by farms in Long An province, Vietnam. Ingredients used to make watermelon pearls include Meizan tapioca starch, 11 Meizan all-purpose flour, tapioca starch from Viet San food company, sugar and watermelon flavor provided by Me Nature company. The above ingredients were all purchased in Vietnam.

Chemicals used for digestion processes included 2,2-diphenyl-1-picrylhydrazyl (DPPH, 99% purity), methanol (99% purity), and sodium benzoate (99% purity). Chemicals were provided by Xilong, China.

2.1 Production process of watermelon pearls

After purchasing, watermelons were washed, peeled to get the flesh, and pressed into juice. Then, the watermelon juice was heated at temperatures of 80, 85, 90, 95, and 100°C for 15 min. Besides, thickeners, including tapioca starch, wheat flour, and kudzu powder, were mixed with watermelon juice above (with thickener ratios of 55, 60, and 65% w/w) and kneaded into a dough. 10 g of flour was divided into small pieces and formed into round pearls with a diameter of 0.8 - 1 cm. Once completed, the watermelon pearls were cooked in boiling water with a pearl: water weight ratio of 1:6 (w/w) for 15, 20, and 25 min. Finally, the pearls were taken out, rinsed with cold water, and drained.

2.2 Determination of moisture content

The moisture content of the sample was determined by drying the sample to constant weight at 105°C (Pu *et al*., 2018).

2.3 Determination of antioxidant activity

Antioxidant activity was determined based on research by Neglo *et al*. (2021). A sample of 0.5 mL was added to 3 mL of methanol and 0.5 mL of 0.6 mM DPPH. Next, the mixture was dark incubated for 30 min at room temperature and then spectrophotometrically measured at 517 nm. The control sample was also determined similarly with 3.5 mL methanol and 0.5 mL 0.6 mM DPPH. Antioxidant activity (% inhibition) of the sample was calculated (Neglo *et al*., 2021).

2.4 Sensory evaluation

Sensory perception was assessed according to a taste -scoring test by 60 people. 7-point satisfaction scale (1 – very hate, 2 – hate, 3 – slightly hate, 4 – normal, 5 – slightly like, 6 – like, 7 – very like). The final sensory score was the average sensory score of 60 people for each sample. Based on this sensory score, evaluate and compare the quality of samples with each other (Vietnamese standard (TCVN) 11183: 2015).

2.5 Statistical analysis

Statgraphics (version 20, Statpoint Technologies, Inc., Warrenton, VA, USA) was used for data analysis. Each experiment was repeated three times. Data is represented as mean±standard deviation (S.D.). Least Significant Difference (LSD) and analysis of variance (ANOVA) at a significance level of 0.05 ($p<0.05$) were performed to compare the mean values.

3. Results and discussions

3.1 Effect of juice heating temperature on the quality of watermelon pearls

The effect of juice boiling temperature on watermelon pearl quality was shown in Figure 1. The pearl samples heated at different temperatures (80°C, 85°C, 90°C, 95°C and 100°C) showed some changes in the best definition. In terms of shape and size, the pearls were all around and showed no signs of sharp changes as the temperature increased. The color of the samples also did not change much, still maintaining a fairly uniform light pink color, although at higher temperatures (95°C

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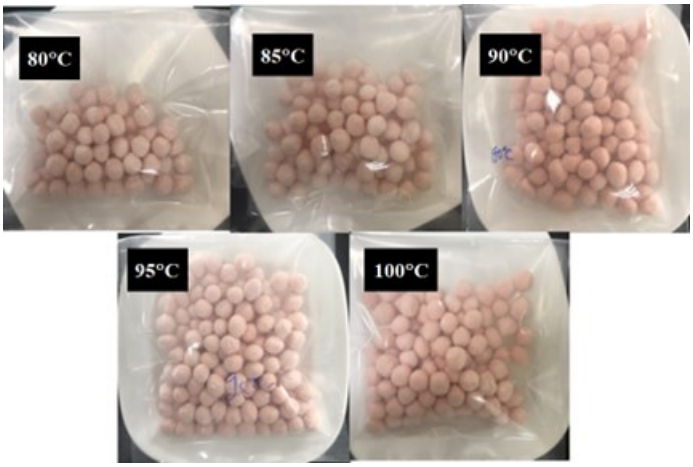

Figure 1. Watermelon pearl products at different juice heating temperatures.

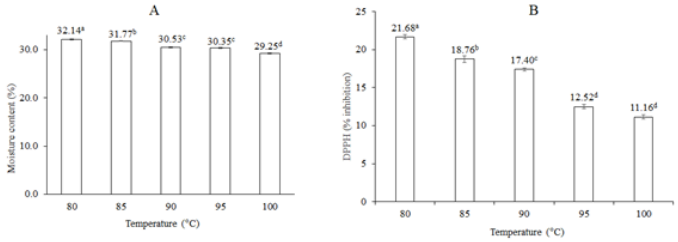

Figure 2. Effect of heating temperature on semi-finished watermelon pearls. A: Moisture content of products, B: Antioxidant ability. Values with different superscripts are statistically significantly different at the 95% confidence level.

and 100°C) it could be a pale color. However, in terms of configuration at higher temperatures, it affected the toughness or softness of the pearls. Figure 2 shows that the product's moisture content and antioxidant capacity were significantly affected by the watermelon juice heating temperature. With the heating temperature of watermelon juice at 80°C and 85°C, the semi-finished tapioca pearls had a soft structure, the round beads were easily deformed, and the bead surface had the phenomenon of hygroscopicity (with moisture content above 31.77%). It did not meet the required characteristics of packaged dried tapioca pearls. On the other hand, with the juice heating temperature at 90°C and 95°C, the product had a fairly solid grain structure and was dry, with moisture content surveys at two temperature levels showing no difference with the values respectively 30.53% and 30.35% (Figure 2). However, when heating the juice to 100°C, tapioca pearls had the lowest moisture content (29.25%), the ability to capture DPPH free radicals decreased sharply (Figure 2), and the color of watermelon tapioca pearls became less red than the other samples.

In addition, Figure 2 shows that the ability to scavenge free radicals by DPPH decreases when the heating temperature of watermelon juice has increased from 80°C to 100°C. Specifically, at 100°C, the DPPH free radical reduction value reached the lowest of 11.16%, and there was no significant difference with the sample heated at 95°C. With heat levels of 80, 85, and 90°C, the resulting product's ability to scavenge DPPH free radicals decreased by 17.40%, 18.76%, and 21.68%, respectively. The reason was that higher temperatures would decompose compounds capable of scavenging free radicals (DPPH) in watermelon, leading to a reduction in the product's antioxidant capacity (Bulathgama *et al*., 2020). Therefore, the product's ability to inhibit DPPH would decrease with increasing watermelon juice heating temperature. From the above survey results, the appropriate watermelon juice heating temperature for further research was 90°C.

3.2 Effects of different types of thickeners on the quality of watermelon pearls

According to the results in Figure 3 the difference in the quality of watermelon pearls when using different types of thickeners. Besides, Figure 4, changing the type of thickener had a clear effect on the sensory quality of watermelon pearls. Specifically, the product made from tapioca starch gave the highest average score (6.03±0.85 points) according to the taste scoring test: the product had the characteristic red color of watermelon, a chewy, soft texture, and the grain surface had the characteristic shine of pearls. The remaining thickeners (kudzu powder, wheat flour, and a mixture of 3 types of flour) all had low sensory scores (< 4 points). This was shown by the fact that tapioca pearls, after being cooked evenly, did not have the characteristic red color of watermelon and had a structure that was not flexible and tough compared to tapioca starch samples.

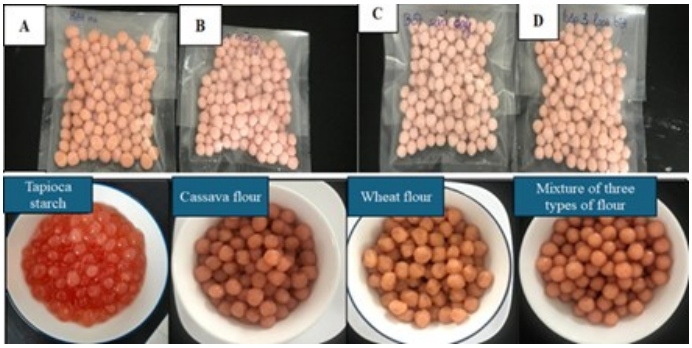

Figure 3. Watermelon pearls (semi-finished products) were produced from different thickeners.

This difference was due to the difference in chemical composition and properties of the powders. Tapioca starch differed from other starches because the fat, protein, and ash content in tapioca starch was very low (Oyeyinka *et al*., 2019). This was an important factor that helped distinguish tapioca starch from the starch of cereals. In addition, tapioca starch had a lower amylose content than other starches, and the molecular weight of amylose and amylopectin was high. A small amount of phosphorus in tapioca starch was not bound as phosphate ester (Wang *et al*., 2018). Tapioca starch typically contains about 17-20% amylose, and there has been no

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major change in amylose content (Yuan *et al*., 2022). Regarding molecular structure, the amylose of tapioca starch was not completely branched, and the branching rate was lower than that of wheat flour and rice flour. In addition, amylose in tapioca starch had a higher molecular weight than other starches. Amylopectin of tapioca starch was short primarily chains, with only less than 1% being highly long chains (Tappiban *et al*., 2020).

Starch undergoes an irreversible structural transformation called gelatinization when heated in excess water. It includes three main processes: During heating, water is absorbed into the amorphous space of the starch, leading to swelling. Water then entered the tightly bound regions of the double helical structure of amylopectin. At normal temperatures, these regions did not allow water to penetrate. However, as temperature caused these regions to become more diffuse, the amylose chains began to dissolve, separating into an amorphous form. Finally, the ingress of water caused swelling, the amylose molecules completely dissolved in water, and the granule structure was decomposed (Li, 2022).

The viscosity increased when the starch solution cooled due to the reverse degradation process. This process was the self-arrangement of the molecules and forms bonds such as amylose-amylose, amylose-amylopectin, and amylopectin-amylopectin and hydrogen bonds with water, making the amylose molecules longer and the amylopectin branched longer (Jiang *et al*., 2020). Starches high in amylose formed hard gels, while starches high in amylopectin formed more stable and softer gels. This property was common for starches, but less attention was paid to tapioca starch because of its low amylose content and higher molecular weight of amylose than other types. In addition, tapioca starch had the characteristic of a "hollow" flavor, which helped watermelon tapioca pearls highlight the taste of watermelon more than other types of flour (Feng *et al*., 2018).

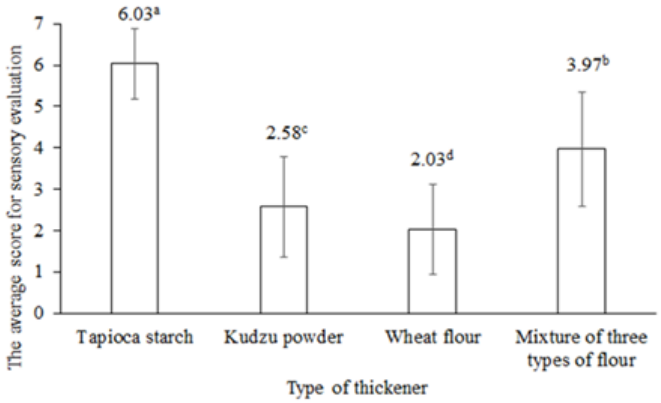

Figure 4. Sensory scores of products made with different thickeners. Values with different superscripts are statistically significantly different at the 95% confidence level.

According to the sensory evaluation results in Figure 4, the most preferred thickener was tapioca starch (6.03±0.85 points). Therefore, tapioca starch would produce watermelon pearls throughout the experiment.

3.3 Effect of thickener ratio on the quality of watermelon pearls

According to the results in Figures 5 and 6, changing the thickening ratio affected the sensory quality of watermelon pearls.

The product with a thickener ratio of 60% w/w had the highest average sensory score of 6.08±0.76 points. In this sample, the powder mass was relatively smooth after mixing and easy to shape, and the particles did not stick together. Samples with a thickener ratio of 55% w/w and 65% w/w gave low sensory scores of 3.02±0.92 points and 3.88±0.71 points, respectively (50% lower than the sensory score of the sample that had a thickener ratio of 60% w/w). Based on the results obtained, a thickener ratio of 60% w/w was appropriate in the production of watermelon pearl products.



Figure 5. Effect of thickener ratio on mixing ability.

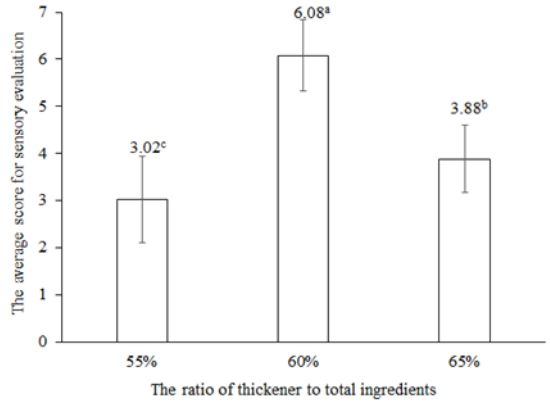

Figure 6. Average sensory score when changing the thickener ratio. Values with different superscripts are statistically significantly different at the 95% confidence level.

4. Conclusion

In this study, the production of pearl products from watermelon juice has been successfully carried out. Moreover, the optimal parameters that have been determined include a watermelon juice heating temperature of 90°C, the thickener as tapioca starch with

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the content of 60% w/w, a product cooking time of 20 min. The resulting product has the characteristic red color of watermelon, tough, flexible structure, and a shiny seed surface. Pearl products from watermelon juice open up great application potential in the beverage industry, contributing to diversifying and improving the preservation time of fruit juices from Vietnam.

Conflict of interest

The authors declare no conflict of interest.

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