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Effect of Proportion of Jack Bean Flour, Tapioca Flour, and Corn Starch on the Nutrition of Instant Milkfish Crabstick

Nadira Ismiyatul Finani[1], *Dedin Finatsiyatul Rosida*[1,2*], *Andre Yusuf Trisna P*[1].

[1] *Food Technology Department, Faculty of Engineering, Universitas Pembangunan Nasional "Veteran" Jawa Timur, Surabaya 60294, Indonesia*
[2]*Innovation Center of Appropriate Food Technology for Lowland and Coastal Area, Universitas Pembangunan Nasional "Veteran" Jawa Timur, Surabaya 60294, Indonesia*

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CORRESPONDING AUTHOR

*E-mail: dedin.tp@upnjatim.ac.id

A B S T R A C T

Jack bean (Canavalia ensiformis) is a local legume with a high protein content, offering potential as an alternative to wheat flour. The addition of tapioca starch and corn starch in fish jelly products aims to improve texture and enhance gel strength. This study aims to determine the optimal combination of jack bean flour, tapioca flour, and corn starch proportions, along with the appropriate carrageenan concentration, to produce high-quality instant crabsticks. A completely randomized design (CRD) was used with two factors: the proportion of jack bean flour, tapioca flour, and corn starch (10:70:20, 20:50:30, and 30:30:40) and the concentration of carrageenan (1.5%, 2.5%, and 3.5% w/b). Data were analyzed using Two-Way ANOVA at a 5% significance level, followed by DMRT at 5% if significant interactions were found. The best formulation was obtained using a proportion of 20% jack bean flour, 50% tapioca flour, and 30% corn starch, combined with 2.5% carrageenan. This formulation yielded a moisture content of 11.05%, ash content of 3.67%, fat content of 4.84%, protein content of 31.89%, and carbohydrate content of 48.47%. These findings highlight the potential of jack bean flour as a functional ingredient in the development of high-protein, wheat-free crabsticks.

Contribution to Sustainable Development Goals (SDGs)'
SDG 2: Zero Hunger – By utilizing jack bean flour as an alternative to wheat flour, this study promotes the development of high-protein, nutrient-dense food products that can support food security and nutritional improvement.
SDG 3: Good Health and Well-Being – The formulation of crabsticks using jack bean flour enhances protein intake, which is essential for health and well-being, particularly in addressing malnutrition and protein deficiencies.
SDG 9: Industry, Innovation, and Infrastructure – The research encourages food product innovation by integrating underutilized local legumes into seafood-based products, promoting the diversification of sustainable food sources.
SDG 12: Responsible Consumption and Production – By utilizing local, plant-based ingredients such as jack bean flour, tapioca starch, and corn starch, this study supports sustainable food production while reducing reliance on imported wheat flour.
SDG 13: Climate Action – The use of jack bean flour as a wheat alternative can contribute to reducing the environmental impact of food production by lowering the carbon footprint associated with wheat imports and large-scale monoculture farming.

1. INTRODUCTION

Crabstick or imitation crab meat is one of the processed seafood made from surimi, which is made from myofibril protein concentrate obtained from fish meat by adding fillers, flavors and colors [1]. One type of economical fish that has the largest production in Indonesia and has the potential to be utilized as raw material for surimi is milkfish (*Chanos chanos sp.*). In 2022, the value of milkfish aquaculture production in East Java Province reached 167 thousand tons [2]. Milkfish is known as milkfish because of its high nutritional content and savory taste, so it has a high level of consumption. Milkfish contains 20.496% protein, and 0.721% fat [3]. Milkfish has mineral content in the form of calcium (4.8%), phosphorus (16.9%), and iron (0.1%) [4].

In fish meat restructuring products, it is generally necessary to add ingredients to improve physical characteristics. Ingredients added include starch, flour, and hydrocolloids [5]. The addition of starch in fish jelly products aims to improve texture, increase gel strength, produce surimi gel matrix stability, and increase water holding capacity and sensory properties of the resulting product [6]. Tapioca starch is the most widely used filler used because it contains high amylopectin (83%) so that it can form a flexible and cohesive gel [7]. The use of tapioca starch as a binder causes the texture of crabstick to be sticky or less compact, so to improve the texture, different types of starch such as corn starch are needed. The content of corn starch consists of about 25% amylose which gives hard properties, while amylopectin causes stickiness [8]. High-amylose flour has a harder, more adhesive, and compact flour gel [9]. Drying starch with a high amylose ratio results in a porous structure caused by amylose with straight chains easily absorbs water [10].

The supporting factor for processed surimi products is the addition of wheat flour as a filling material. However, efforts to reduce dependence on wheat flour is the use of flour made from local commodities, one of which is flour derived from legumes. One of the local commodities that is underutilized in Indonesia is jack bean. Jack bean have a carbohydrate content (66.1%) and protein content (66.1%). (66.1%) and high protein (27.4%) and lower fat (2.9%) [11]. In addition, jack bean contain various nutrients that are hypocholesterolemic in nature, such as niacin, fiber, isoflavones, and isoflavones. such as niacin, fiber, isoflavones, phenols, and saponins [12].

The use of gluten free flour will result in unstable dough and the texture of the crabstick becomes broken and not chewy, so it is necessary to add other food additives such as hydrocolloids. To obtain a gel texture that has high elasticity, there are types of hydrocolloids that can be used, namely carrageenan as a stabilizer and gelling agent. Carrageenan can combine polymer chains to form a continuous three-dimensional mesh which is a matrix. This matrix causes the carrageenan gel to be strong, stable, rigid and elastic [13]. The addition of carrageenan resulted in increased stickiness, elasticity, and tensile strength in fish meat restructuring products [14].

Crabsticks are commercialized as frozen food, which requires freezing in the distribution process. Crabstick product innovation can be processed into instant products to minimize damage during distribution and long shelf life. Instant products are produced through an installation process, which includes the process of making dough, steaming, drying [15]. Some research on instant processed fish products include instant etong fish meatballs [16], instant cork fish meatballs [17], instant cork fish tekwan [18], dried crabstick [19], and instant pempek [20]. Instant crabsticks are an alternative to the usual processed crabsticks where instant crabsticks have not been widely reported. Based on the description above, the research aims to find out the best combination and the effect of proportion of jack bean flour, tapioca flour, and corn starch, as well as the addition of carraganen to the nutrition of instant crabstick.

2. MATERIALS AND METHODS

2.1 Materials

The materials used in this study were milkfish, jack beans obtained from Ponorogo, tapioca flour, corn starch, carrageenan, orange food coloring, ice cubes, NaCO3 (baking soda), salt, sugar, water, egg whites, oil, garlic powder, flavoring, and pepper. Materials for analysis is petroleum ether, sulfuric acid (H_2SO_4), sodium hydroxide (NaOH), aquades, alcohol, hydrochloric acid (HCl), ethanol, sodium chloride (NaCl).

2.2 Research Procedures

This research was conducted in a completely randomized design (CRD) with two treatment factors. The first factor used was the proportion of koro pedang flour, tapioca flour, and corn starch (10:70:20), (20:50:30), and (30:30:40). The second factor was the addition of carrageenan (1.5%, 2.5%, and 3.5%). The data obtained were processed using ANOVA (Analysis of Variance) at the 5% level. If there is a significant difference, further tests are carried out using the DMRT (Duncan't Multiple Range Test) method at the 5% level.

2.3 Making Instant Milkfish Crabstick

Carrageenan was added according to the treatment (1.5%, 2.5%, and 3.5%) to the surimi and stirred gently. Surimi was pulverized using a food processor with the addition of 22% ice cubes and 0.2% salt. Mixing all ingredients, namely egg whites, flour, seasonings, and oil. The smooth dough is then molded into thin sheets with the top surface given orange food coloring. The dough is steamed first at 95ºC with plastic covered so that it does not stick, After 1 minute the dough sheet is rolled into a crabstick shape. Second steaming at 95ºC for 4 minutes. After cooling, the crabstick is stored in the freezer for 12 hours. Crabsticks are dried using a cabinet dryer at 70ºC for 5 hours.

3. RESULT AND DISCUSSION

Instant milkfish crabstick products was analyzed chemically including water content, ash content, fat content, protein content, and starch content. The results of the chemical analysis of instant crabstick products are attached in **Table 1.**

Table 1. Analysis results of chemical characteristics of instant milkfish crabstick

Proportion of Koro Pedang : Tapioca : Corn Starch	Carrageenan	Moisture Content (%)	Ash (%)	Fat (%)	Protein (%)	Carbohydrate (%)
10 : 70 : 20	1.5	13.40 ± 0.12	2.76 ± 0.18	4.44 ± 0.01	29.67 ± 0.31	49.72 ± 0.44
	2.5	10.59 ± 0.06	3.28 ± 0.06	4.46 ± 0.03	30.79 ± 0.50	50.83 ± 0.44
	3.5	8.80 ± 0.04	4.37 ± 0.09	4.46 ± 0.06	30.75 ± 0.58	51.62 ± 0.54
20 : 50 :30	1.5	13.30 ± 0.02	2.84 ± 0.15	4.84 ± 0.04	30.03 ± 0.09	48.9 ± 0.24
	2.5	11.05 ± 0.20	3.67 ± 0.08	4.84 ± 0.02	31.89 ± 0.33	48.47 ± 0.65
	3.5	8.99 ± 0.14	4.52 ± 0.06	4.84 ± 0.03	31.62 ± 0.44	50.01 ± 0.53
30 : 30 : 40	1.5	13.48 ± 0.13	3.63 ± 0.11	5.17 ± 0.02	34.68 ± 0.17	42.92 ± 0.47
	2.5	11.09 ± 0.18	3.94 ± 0.03	5.17 ± 0.00	34.80 ± 0.16	45.09 ± 0.08
	3.5	9.26 ± 0.00	4.70 ± 0.01	5.19 ± 0.05	34.51 ± 0.37	46.33 ± 0.43

Moisture content

Table 1 shows that the greater the proportion of tapioca and the addition of carrageenan causes the water content of instant crabstick to decrease. This is due to the starch content, especially amylose, which plays a role in binding water in the product. However, the drying process causes the starch granules to be more porous, porous, and more surface area so that the bound water is easily evaporated faster. Amylose has a straight and tight structure so that it easily absorbs water and is easy to release it again [8].

The addition of carrageenan causes the product to release water so that the product is porous and drier. During freezing the process of aggregate formation continues to occur and the gel will shrink while releasing water [14]. At high temperatures, free water and water that binds to hydroxyl groups and sulfate esters in the matrix will be released because carrageenan forms a gel at temperatures between 45ºC-65ºC and will melt again at 70ºC-95ºC [21]. Carrageenan has the ability to form a gel where the polymer chains form a mesh that captures or mobilizes water within it.

Ash Content

The high proportion of jack bean flour and corn starch, with the low proportion of tapioca, and the higher addition of carrageenan caused the higher ash content of crabsticks. addition of carrageenan causes the ash content of crabstick to be higher. This is due to jack bean flour contains high ash content, which is 2.19%. Corn starch contains mineral salts such as 20 mg of calcium, 2 mg iron, and 30 mg phosphorus [22].

The addition of carrageenan also increased the ash content of the product as carrageenan is high in minerals. Mineral content in carrageenan consists of Mg with a value of 2.9 mg/g, Ca 2.8 mg/g, K 87.1 mg/g, and Na 11.9 mg/g [23]. The higher ash content obtained with increasing carrageenan concentration is probably due to the reaction between carrageenan flour and protein. High ash content is caused by the negatively charged hydroxyl group in carrageenan flour that binds to the amine group in protein [24]. In addition, the steaming and drying process in instant crabstick processing causes some water to be lost, thus increasing the mineral content of the ingredients.

Fat content

The higher the proportion of koro pedang flour used, the higher the fat content. fat content of milkfish instant crabstick. This is because koro pedang flour contains fat content which is quite high at 3.28%. The addition of carrageenan did not had no significant effect on fat content. This is because carrageenan has very little fat content. Carragennan has a small fat content of 0.13% [25].

Protein content

Table 1. shows that the higher the proportion of jack beans flour and corn starch, and the lower the proportion of tapioca, the more protein content of crabstick. Based on the results of the analysis, jack bean flour contains 27.18% protein, so the addition of jack bean flour increases the protein content of the product. jack bean has a high protein content (27.4%) so it is known as Protein Rich Flour (PRF) [11]. The use of carrageenan in high amounts can cause a reduction in protein levels due to its water-binding properties and change the interaction between proteins in the product. carrageenan can fill the space that should be filled by proteins, thus reducing the interaction between proteins and water which contributes to a decrease in protein levels. Carrageenan can bind with protein into proteo-carrageenan thus increasing the surface area that can absorb or bind water [26].

The reaction of carrageenan flour with protein is caused by the presence of sulfate ester groups that are negatively charged with carboxylic residues on amino acids that are positively charged, besides that it is also caused by negatively charged hydroxyl groups in carrageenan flour that bind to amine groups on proteins [24].

Carbohydrate content

The high proportion of tapioca and carrageenan and the low proportion of corn starch and jack bean flour resulted in high carbohydrate content of instant milkfish crabsticks. This is due to the high starch content in tapioca flour, which is 80.17%. Similarly, the addition of hydrocolloid materials such as carrageenan which can increase the carbohydrate content of the product. Carrageenan is a polysaccharide or carbohydrate polymer extracted from red seaweed which has 68.48% carbohydrates [14]. The increase in reducing sugar due to the addition of carrageenan is due to the structure of carrageenan which has due to the structure of carrageenan which has galactan molecules with the main unit of galactose, which contains groups of galactose groups. galactose, which contains hydroxyl (OH) groups that are reactive and reducing at the the end of its wake structure. Thus, the higher the concentration of carrageenan the higher the concentration of carrageenan added, the higher the reductive group so that the reduction sugar produced will increase [27].

4. CONCLUSION

The proportion of jack bean flour, tapioca, and corn starch showed a significant interaction ($p \leq 0.05$) on the treatment of moisture content, ash content, protein content, and carbohydrate content. However, it did not interact significantly with the parameters of fat content. The addition of jack bean flour can increase the protein content of the product to 34.80%.

The best treatment analysis results are in the treatment of the proportion of Jack bean flour, tapioca flour, and corn starch (20:50:30) and the addition of carrageenan 2.5% is the best treatment with 11.049% moisture content; 3.67% ash content; 4.84% fat content; 31.89% protein content: and 48.47% carbohydrate content.

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