Indonesian Food Science and Technology Journal
IFSTJ : Vol 4 no 1 December 2020
ISSN : 2615-367X

EFFECTS OF SAGO STARCH TYPES ON CRACKERS FROM EDIBLE LARVAE OF SAGO PALM WEEVILS

Helen C. D. Tuhumury*[1], Agustina Souripet[1], Sandriana J. Nendissa[1]

[#] *Department of Agricultural Product Technology, Faculty of Agriculture, Pattimura University Jl Ir. M. Putuhena, Kampus Poka Ambon 972233, Indonesia*

E-mail: hcdtuhumury@gmail.com helen.tuhumury@faperta.unpatti.ac.id

Submission date : 22 August 2020   Published date : 31 December 2020

Abstract— **Sago starch and palm weevil larvae can be utilized as ingredients in crackers making to replace tapioca and prawn or fish. This research aimed to study the physicochemical and sensory properties of crackers made from three different sago starch, i.e., Molat, Ihur, and Tuni mixed with sago palm weevil larvae and to determine the best sago starch in making palm weevil larvae crackers. Results showed that Molat sago starch was the best option in making palm weevil larvae crackers. It resulted in crackers with better physicochemical and sensory properties than other sago starch. This cracker had the moisture, ash, protein, fat, fiber, and carbohydrate contents of 9.74, 1.17, 6.94, 0.45, 1.22, and 80.50%, respectively. The hardness of the un-fried crackers (17.19 N) was higher than that of others, while the fried crackers were lower (5.00 N). The crackers from Molat sago starch were liked by panelists in their taste and perceived to have a standard aroma. Whereas panelists extremely desired color, crispiness, and overall likeness. Crackers developed from Molat sago starch, and palm weevil larvae can fulfill the demands of nutritional security.**
.

Keywords— **sago starch, palm weevil larvae, physicochemical properties, crackers, sensory,**

I. INTRODUCTION

The sago palm has been widely known to be indigenous to Maluku and has been an essential source of carbohydrate and serves as the staple food. Sago palms are economically acceptable, environmentally friendly, and promote a socially stable agroforestry system. Sago starch can convey significant contributions to the community if processed into various value-added products besides staple food such as crackers. Crackers are a popular local snack food made of pregelatinized starch in various Southeast Asian countries. They are usually produced by mixing tapioca starch with water, different kinds of flesh, e.g., fish, prawn or shrimp, and spices. The resulting dough is then shaped into various shapes and gelatinized by boiling or steaming. The gelatinized dough is cooled and dried until the moisture content reaches 10 percent. The sliced, dried product is fried in cooking oil before eaten [1, 2, 3].

Starch flour is one of the essential ingredients for making crackers. Tapioca starch is the most common starch being utilized, although there are various flours available for making crackers, including wheat, corn, rice, and sago. The process of making crackers can be modified using other starch than the tapioca starch. Sago starch is one of the potential alternative products as it has adequate nutrient content and is the staple food of most people in Maluku, Indonesia. Also, The Agency for the Assessment and Application Technology in Indonesia has applied the technology for making prawn crackers using sago starch [4].

Some important sago species are widely grown and used in the production of sago starch in Maluku. Three popular ones are locally known as molat (M. *sagus* Rottb)., ihur (M. *sylvestre* Mart.), and tuni (M. *rumphii* Mart.) [5]. Research has shown that there are significant differences in physicochemical and functional properties of these specific sago starches, i.e., the amylose content, swelling power, and solubility [6].

The larvae of sago palm weevil, locally called "Ulat sagu," have high protein and fat contents and are usually consumed by people in Maluku. On average, the larvae which belong to *Rhyncophorus* have high unsaturated fatty acids, palmitoleic acid (38%), and linoleic acid (45%), respectively [7]. This Rhyncophorus is an edible insect that can be used as meat products in the daily diet and hence may have the potential prospect to be incorporated into crackers as flesh ingredients alternatively to other flesh ingredients such as chicken, beef, prawn, or fish in making crackers.

Therefore, starch from sago of different varieties and meat ingredients, including larvae of sago palm weevil, can be utilized in making crackers. Sago starch has also been used in making fish crackers. Those prepared with sago starch yielded the highest resistant starch content compared to tapioca and wheat starch [8]. A new cracker product developed should be accepted by consumers according to its characteristics, which will determine its quality. Hence, this study's objective was to develop from sago starch of different types a variety of crackers with larvae of sago palm weevil as flesh ingredients and to determine their physicochemical and sensory properties.

II. Material and Methods

A. Material and Equipment

Sago starch Molat, Ihur, and Tuni, as well as the larvae of sago palm weevil, were collected from local farmers in Hutumuri Village, Ambon, Indonesia. The preliminary analysis of moisture and amylose content of sago starch is shown in Table 1.

TABLE 1.

MOISTURE AND AMYLOSE CONTENT OF SAGO STARCH

Sago starch	Moisture (%)	Amylose (%)
Molat	12,45	19,43
Ihur	12,70	18,85
Tuni	12,86	20,11

B. Methods

Preparation of crackers

Larvae of sago palm weevils were cleaned, and each flesh was blended using a blender. The blended flesh was then weighed for 100 g (10% of total 1000 g starch). Garlic (0.02 % w/w), salt (0.01% w/w), and MSG was ground and added into each blended flesh. 1000 g sago starch for each formulation was divided into two parts. First, 1/3 part was mixed with 1000 mL of water and blended flesh. The mixture was stirred and cooked until it became a thick paste. The second 2/3 part of starch was added gradually into the thick paste, stirred and kneaded to produce a homogenous dough. The dough was stuffed into cylinder plastic wrap with a diameter of 5 cm and length 25 cm, and both ends were tied. The stuffed dough was boiled in water for 60 minutes until cooked. Then it was cooled for 24 hours at room temperature and another 24 hours in the refrigerator until it became hardened. The stiff dough was sliced using a meat slicer to a thickness of 2 mm and dried overnight in an oven with a temperature at 60ºC. The dried slices were deep-fried in palm cooking oil at 180ºC for 30 seconds following the frying method by Neiva *et al*. [9].

Proximate composition

The chemical composition of fried crackers was determined according to the AOAC method [10]. Moisture content was determined by drying the samples overnight at 105°C, and the carbohydrate content was calculated by difference. The ash content was determined by ashing the samples overnight at 550°C. The crude protein content was determined by the Kjeldahl method, and the crude lipid content was determined by the soxhlet method.

Color

The color of the cracker sample before and after frying was measured using a colorimeter (Minolta CR 300, Japan). The color reading includes lightness (L^*), redness (a^*), and yellowness (b^*). The equipment was standardized with a white color standard.

Hardness

The hardness of dried and fried crackers was measured using a compression test with the Instron Universal Testing Machine. (Model TM-M) under the conditions: preload 1 N, preload speed 300 mm/min, test load 10 mm/min. Hardness was measured as Fmax values.

Linear expansion

The percentage linear expansion was obtained on deep frying the dried crackers in oil at 180-200ºC. The un-puffed cracker was ruled with three lines across using a fine oil pen. Each line was measured before and after puffing. The percentage linear expansion was calculated according to the method used by Yu (1991) [11] as follows:

$$LE(\%) = \frac{\text{length after puffing - length before puffing}}{\text{length before puffing}} \times 100$$

Sensory evaluation

Sensory evaluation was performed using 30 untrained panelists comprising of undergraduate students and staff members of the Faculty of Agriculture, Pattimura University. The panelists were asked to evaluate color, taste, aroma, crispiness, and overall acceptability. A 5-point hedonic scale was used where 1= dislike extremely to 5 = like extremely.

Statistical analysis

The data collected were analyzed using ANOVA for a completely randomized experimental design. The means of treatment showing significant differences ($p < 0.05$) were subjected to the Tukey test. These analyses were performed using a statistical software MINITAB version 17.

III. Result and Discussion

A. Chemical composition of crackers

The chemical composition of crackers made from starch from different varieties is shown in Table 2. Most of the chemical characteristics of the crackers were statistically different, except for protein content.

The moisture content of the crackers ranged between 9.74-11.83%. The highest moisture content was observed in crackers made from Tuni sago starch (11.83%) and was significantly different from crackers from Ihur and Molat. The lowest moisture content was found in crackers from Molat (9.74%). Indonesian national standards for prawn and fish crackers have set the quality value for these crackers to have a moisture content of 12 and 14%, respectively. The moisture content of crackers may be influenced by sago starch's characteristics, which can bind water. Since Molat sago starch has the lowest moisture content, i.e., 12.45% (Table 1), then the crackers form this starch also resulted in having the lowest moisture content. Other molecules such as protein and fat in the mixed ingredients were bound to the starch [12,13]. When these ingredients were added into the formulation, there was a tendency to increase moisture due to the network formation between proteins from the mixed ingredients bound to starch to trap water molecules into the protein matrix in the crackers dough [3].

TABLE 1.

CHEMICAL COMPOSITION OF CRACKERS

Crackers	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Fiber (%)	Carbohydrate (%)
Molat + Palm weevil larvae	9.74 c	1.17 b	6.94 a	0.45 b	1.22 b	80.50 a
Ihur + Palm weevil larvae	10.95 b	2.50 a	6.89 a	1.00 a	2.33 a	76.34 b
Tuni + Palm weevil larvae	11.83 a	2.11 ab	7.00 a	1.10 a	1.85 ab	76.13 b

Means within a column with the same letter are not significantly different ($p < 0.05$)

Ash contents of the crackers were in the range of 1.17% to 2.5%. For crackers made from Ihur and Tuni starch, there were no significant differences in their ash contents. The protein content of crackers from these three sago starch mixed with palm weevil larvae was found to be 6.94-7.00%. There were no significant differences between the protein content of these crackers. It was suggested to have resulted from the processing condition such as cooking and steaming to produce crackers. However, most were still considered as first grade quality of crackers (min 7% protein content).

The fat content of the crackers were about 0.45-1.10%, values which were substantially lower than the fat content of the mixed ingredients reported in previous studies. This lower value was because fat or lipid, in general, are bound by amylose fraction of the starch when processed into crackers [13]. Moreover, considerable amounts of value t were reduced when the ingredients were washed during the making of the crackers dough. Lipids tend to float at the surface after washing and are thrown away with the washed water [2].

Ihur sago starch contributed to the highest fiber content 2.33% and appeared to have similar values with crackers from Tuni sago starch. The carbohydrate contents of the crackers were 76.13-80.50%, with the crackers from Molat sago starch being the highest and significantly different from the other two starch types. The higher and lower content of carbohydrates is one of the reasons for the vital addition of starch flour with flesh ingredients [1], more importantly, palm weevil larvae to provide a more nutritional food product.

B. Physical Properties of Crackers

The color of the crackers that were physically measured by observing the L, a, and b Hunter scale on raw, unfried, and fried crackers can be seen in Table 3. Generally, the decrease in the Hunter color value of both raw, un-fried, and fried crackers was probably due to the difference in mixed ingredients, types of starch, and the washing procedure applied in the making of crackers.

The color characteristics of un-fried and fried fish crackers are shown in Table 3. All the color values showed significant differences ($p<0.05$) between each un-fried and fried cracker. Both of the un-fried and fried samples showed similar trends: Molat sago starch had higher L* value, which contributes to lighter product color. Though the larvae flesh contains some pigments that contribute to the darker color, i.e., lower L* value than average fish and prawn crackers (approx L value of 80), the Molat sago starch is a white product which made it lighter than other types of sago starch.

TABLE 2.

PHYSICAL CHARACTERISTICS OF UN-FRIED AND FRIED CRACKERS

Un-fried crackers	L	a	b	Hardness (N)
Molat + Palm weevil larvae	33.00 ab	9.45 a	10.04 a	17.19 a
Ihur + Palm weevil larvae	34.39 a	7.68 a	9.83 a	12.58 b
Tuni + Palm weevil larvae	28.20 b	7.77 a	8.03 b	10.99 c
Fried Crackers				
Molat + Palm weevil larvae	52.34 a	6.44 a	8.43 a	5.00 c
Ihur + Palm weevil larvae	47.78 b	6.16 a	8.17 ab	10.67 a
Tuni + Palm weevil larvae	47.29 b	5.44 b	7.85 b	7.35 b

Means within a column with the same letter are not significantly different ($p < 0.05$)

The frying process would result in the loss of the lighter color of the fried product. The lightness of the raw un-fried crackers increased when they were fried. Fried crackers have undergone linear expansion, which made them lighter in color than raw crackers [11]. Ngadi et al. [14] stated the decrease in the L* value in the fried food sample may be attributed to

Maillard browning and caramelizing at high frying temperature. The rate of Maillard reaction depends on its chemical environments, such as the chemical composition of food, water activity, pH, and reaction temperature.

Types of sago starch did not affect the redness of un-fried crackers; instead, these values in fried crackers were considerably influenced by different sago starch. Types of starch determined the yellowness of both un-fried and fried crackers.

TABLE 2 also shows the hardness of the crackers. Types of starch determined the hardness of the un-fried and fried crackers. Molat had the highest value of hardness in un-fried crackers, followed by Tuni and Ihur, respectively. On the contrary, when crackers were fried, Molat had the lowest hardness value. Low hardness usually perceived as great crispiness by consumers, and consumers prefer crackers with high crispiness scores [1].

C. Linear Expansion

Linear expansion of crackers can be seen in Figure 1. Linear expansion is a critical quality determinant of crackers. Crackers with high linear expansion are mostly preferred by consumers and are correlated with the sensory characteristics of crispiness [1]. Linear expansion is directly related to crispness, the most important sensory attribute of crackers. An acceptable level of crispiness of crackers is obtained if the linear expansion is higher than 77% [15, 16].

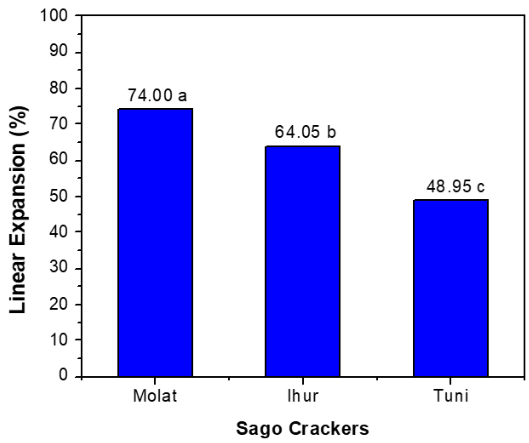

FIGURE 1.

LINEAR EXPANSION OF SAGO CRACKERS

Molat, Ihur, and Tuni starch contributed to the linear expansion of crackers with Molat, the highest (74.00%), and Tuni being the lowest (48.95%). Yu [11] has reported that the linear expansion of the fried fish crackers decreased with the increased ratio of fish to starch. The linear expansion is also inversely proportional to the protein content but linearly correlated with the carbohydrate [17]. The types and amount of starch are the essential factors that influence linear expansion. Moreover, amylopectin is suggested to be the main component of the starch that contributes to linear expansion. Tuni had the highest amylose content (Table 1) followed by Ihur and Molat, which reversely made Molat have higher amylopectin content hence the highest linear expansion. Linear expansion of crackers correlated with total amylopectin content in flour [1]. Kyaw et al. [3] have found out that the highest linear expansion of crackers was achieved when the starch granule has swollen to the maximum. Incomplete gelatinization during the steaming process may result in a decrease in the linear expansion of crackers. Therefore, instead of the type of starch and amylose/amylopectin ratio, steaming time and thickness of the cut crackers also determine their linear expansion. Longer steaming time and a thickness of more than 2 mm caused lower linear expansion [3, 1].

D. Sensory Characteristics of Crackers

A hedonic test to determine the panelists' preference on the crackers was applied on color, taste, aroma, crispiness, and overall likeness and summarized in Figure 2.

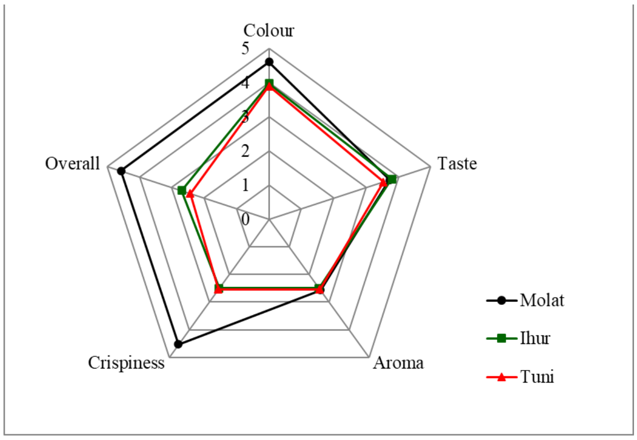

FIGURE 2.

SENSORY CHARACTERISTICS OF FRIED CRACKERS

Panelists were found to extremely like the color, crispiness, and overall likeness of crackers made from Molat sago starch compared to Tuni and Ihur which were liked, and normal in color and crispiness, subsequently. However, there was no difference in the preference on the crackers from these three starch types based on its taste and aroma, i.e., liked by panelists in its taste and perceived to have a normal aroma. Besides, the crispiness perceived by panelists was mostly determined by the types of starch and seemed that the crispiness score went in line with the degree of linear expansion. The higher the linear expansion value of the crackers, the crispier was the cracker perceived by panelists.

IV. Conclusion

Molat sago starch was the best option in making palm weevil larvae crackers. This cracker had the moisture, ash, protein, fat, fiber, and carbohydrate contents of 9.74, 1.17, 6.94, 0.45, 1.22, and 80.50%, respectively. The hardness of the un-fried crackers (17.19 N) was higher than others, while the fried crackers were lower (5.00 N). The crackers from Molat sago starch were liked by panelists in their taste and perceived to have a normal aroma. Whereas panelists extremely liked the color, crispiness, and overall likeness.

References

[1] Huda N., I. Boni., I. Noryati. 2009. The Effect of Different Ratios of Dory Fish to Tapioca Flour On The Linear Expansion, Oil Absorption, Colour, and Hardness of Fish Crackers. International Food Research Journal 16:159-165.

[2] Huda N, N. Ismail, AL Leng, CX Yee. 2007. Chemical Composition, Colour, And Linear Expansion Properties Of Commercial Fish Cracker. 12th Asian Chemical Congress, Kuala Lumpur 23-25 August 2007.

[3] Kyaw ZY, SY Yu, CS Cheow, MH Dzulkifly, NK Howell. 2001. Effect Of Fish To Starch Ratio On Viscoelastic Properties And Microstructure Of Fish Cracker (Keropok) Dough. International Journal of Food Science and Technology 36: 741-747.

[4] BPPT. 2006. Sago With The Potency To Enrich Food Diversity. Sagu, Potensial Perkaya Keragaman Pangan (in Indonesian) BPPT. Accessed 19-01-2020 dari http://www.bppt.go.id/

[5] Alfons JB, S Bustaman. 2005. The Prospect And Development Of Sago In Maluku. Prospek dan Arah Pengembangan Sagu di Maluku (in Indonesian) BPTP Maluku, Ambon. 45 p

[6] Taniwel ND. 2006. Charcteristic Of Physicochemical Properties Of Several Sago (Metroxylon sp.) starch. Karakteristik Sifat Fisikokimia Beberapa Jenis Pati Sagu (Metroxylon sp) (in Indonesian). Skripsi. Fakultas Pertanian Universitas Pattimura. Ambon.

[7] Van Huis A., J Van Itterbeeck, H Klunder, E Mertens, A Halloran, G Muir, P Vantomme. 2013. Edible Insects Future Prospects For Food And Feed Security. FAO Forestry Paper 17.

[8] Nor M.ZM., RA Talib, MA Noranizan, NI Chin, K Hashim. 2014. Increasing Resistant Starch Content In Fish Crackers Through Repetitive Cooking-Chilling Cycles. International Journal of Food Properties 17:966-977.

[9] Nieva CRP, TM Machado, RY Tomita, EF Furlan, MJ Lemos Neto, DHM Bastos. 2011. Fish Crackers Development From Minced Fish And Starch: An Innovative Approach To A Traditional Product. Ciencia e Tecnologia de Alimentos 31(4): 973-979.

[10] AOAC 2000. Official Methods of Analysis. 17th eds. Washington, DC: Association of Official Analytical Chemist

[11] Yu SY. 1991. Acceptability Of Fish Crackers (Keropok) Made From Different Types Of Flour. ASEAN Food Journal 6: 114-116.

[12] Ahmad FB, PA Williams, JL Doublier, S Durand, A Buleon. 1999. Physicochemical Characterization Of Sago Starch. Carbohydrate Polymers 38: 361-370.

[13] Luallen, TE. 1985. Starch As A Functional Ingredient. Food Technology 59-63.

[14] Ngadi MO, Y Li, L Oluka. 2007. Quality Changes In Chicken Nuggets Fried In Oil With Different Degree Of Hydrogenation. LWT-Food Science and Technol0gy 40:1784-1791.

[15] Siaw CI, AZ Idrus, SY Yu. 1985. Intermediate Technology For Fish Crackers (Keropok) Production. Journal of Food Technology 20: 17-21.

[16] King MA. 2002. Development And Sensory Acceptability Of Crackers Made From Big-Eye Fish (*Brachydeuterus auritus*). Food and Nutrition Bulletin 23(3): 317-320.

[17] Huda N, L Angli, Y Chungxian, Herpandi. 2010. Chemical Composition, Color, And Linear Expansión Properties Of Malaysian Commercial Fish Cracker (Keropok). Asian Journal of Food and Agro-Industry 3(5): 473-482.