Physicochemical Properties of Sago Flour Food Bars Fortified with White Sweet Potato Flour and Sidat Fish Flour

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Abstract. Food bars are alternative fast foods with high calorific value because they are enriched with various nutrients available in natural ingredients. While the benefits that can be obtained from food bars made from various flour are the nutritional value in food bars such as calories, carbohydrates, reducing sugars, protein fats, water, ash, and fibre. Sweet potato (Ipomoea batatas) is a type of plant whose roots are edible. All sweet potato varieties can be used in making flour, sweet potato flour is a crushed sweet potato which is partially removed from its water content. The use of protein fortification of eel fish will enrich the nutrition of food products. The purpose of this study is expected to provide information about sweet potato plants as a source of carbohydrates that can be processed in making white sweet potato flour and eel fortification sago flour as an alternative food. So the researchers used a Completely Randomized Design, which consisted of one factor with the type of sweet potato flour, sago flour, fortification of eel fish meal. Morphological results of starch granules morphology in food bar products using Scanning Electron Microscopy (SEM). Starch granules micrographs in food bars in all treatments show that starch granules are not compact and still have quite large fibre between starch granules, and have non-uniform starch granule density due to fibre. In addition, the nutritional content of food bars shows that the use of sweet potato flour and sago flour, as well as the fortification of 5% eel fish meal (T2), provides the best value of formulation treatments that are recommended for development as food bar products. However, it is necessary to add other nutrients such as vitamins, minerals to enrich the nutritional value of food bars as energy and nutritious fast food.

1. Introduction

Food is a very important factor in human life, especially to meet human food needs which are estimated to reach 9 billion in 2050. Food problems occur because of social, political, economic and environmental factors, especially the impact of disasters so that they can consider food handling strategies [1]. Innovation and production techniques, as well as attention to aspects of food safety, are needed to meet the elements of food security and nutritional value of each product [2,3].

In Indonesia, the main food needs are rice, corn, cassava, and sweet potatoes. One effort that can increase food availability is the use of existing agricultural products even though they have not been used economically and intensify the excavation of new food sources. Efforts to provide greater food through food technology can be done with two approaches. First, utilizing agricultural products which until now their use is still limited. Second, it examines characterizations to underlie the use of these materials and processes or enhance existing traditional processes. The total calories recommended as an emergency food bar is 2100 kcal, in one food bar containing 233 kcal then you need to consume 9 food bars per day [4].
Sweet potato or yam (*Ipomea batatas*) is an agricultural commodity that has a bright prospect in the future and has high economic value because besides being used as the food it can also be projected as an industrial material. As well as research the character of the nutritional value of sweet potato varieties has greatly developed, especially in white, purple and orange sweet potatoes [5]. As a high carbohydrate ingredient, these tubers can be used as tuber flour, composite flour, and starch. However, the utilization of starch from tubers is still limited due to a lack of information about the physicochemical and technological processes, especially about the use of cassava flour in making bread [6].

The need for eels in Indonesia is quite high [7]. Besides eels are also a source of vitamins. Vitamin A and important mineral sources such as iron, iodine, zinc, selenium, and calcium are all closely related to micronutrient deficiencies. In addition, many uses of fish meal from various types of fish as a substitute for soy flour [8].

Food bars are alternative fast food with high calorific value because they are enriched with various nutrients available in natural ingredients [9]. While the benefits that can be obtained from food stems made from various starches are the nutritional value of food stems such as calories, carbohydrates, reducing sugar, protein fat, water, ash, and fibre. Likewise, the colour produced in this product are quite attractive, namely brownish-white and the resulting texture is solid and not brittle so that it makes the food bar/snack bar resistant to friction during packaging and storage [10].

Sweet potatoes can be processed into flour which can be processed into various food products that have high added value. The process of making flour can turn local food into value-added, value-added, and nutritious-flavoured food products according to people's tastes, and the price is affordable by the wider community [11]. White sweet potato flour has a high protein content so it is good for producing various food products that have nutritional value, such as in making noodles in reducing the digestibility of starch and its glycemic index value [12]. The raw materials for making food bars are white sweet potato flour and enriched sago flour, sago flour which is a source of protein, and a source of carbohydrates. Through this research in making food bars using white sweet potato flour and sago eel flour which is enriched in the results of the analysis of the physicochemical and organoleptic properties of the food stems produced.

2. Materials and Method

2.1. Material
The materials used in this study were white sweet potato flour (WSPF), sago flour (SF), and eel fish meal (EFF), water, eggs, milk powder, family, and materials for chemical analysis. The tools used in this study are seals, containers, trays, blenders, chopper tools, sieves, and analytical scales.

2.2. Research Method
This study uses CRD (Completely Randomized Design) consisting of one factor with the type of white sweet potato flour (WSPF), sago flour (SF), eel meal fortification (EFF). WSPF proportion: 70%, 65%, 60%, 55%, 50%. SF: 30%, 30%, 30%, 30%, 30%. EFF: 0%, 5%, 10%, 15%, 20%. Additional ingredients. Mixing is done until the dough is completely mixed and even, or not sticky, then the dough is ready to be printed. Factors studied were the physicochemical nature of food bar products.

3. Result and Discussion
One of the processed sweet potato products that can be developed is food bars. It can be consumed as prepared food that meets the daily energy needs of humans and in emergencies (disasters) can be used as an emergency food (emergency food) for the people of Indonesia in the disaster area. Food bars are solid food products that are rod or round in shape and are a mixture of various dry ingredients such as cereals, nuts, dried fruits which are combined together with the help of binders. In this study, the binder was a sweet potato flour.

3.1. Morphology Food Bars
Observation of starch granule microstructure in food bar products using Scanning Electron Microscopy (SEM). Starch granule micrographs in food bar products in all treatments (Figure 1) show that starch
granules are not compact and still have large fibres that are between the starch granules, and have non-uniform starch granule density due to fibre. The use of tubers as a material for making solid food (sago plates) with certain formulas will give a difference in the morphological shape of each starch granule in each product [13].

![Fig 1. Scanning Electron Microscopy Food Bars (FB) with Proportion of Treatment T1 = WSPF 70%, SF 30%, EFF 0%; T2 = WSPF 65%, SF 30%, EFF 5%; T3 = WSPF 60%, SF 30%, EFF 10%; T4 = WSPF 55%, SF 30%, EFF 15%; T5 = WSPF 50%, SF 30%, EFF 20%.

3.2. Moisture

The moisture is the amount of water contained in a material expressed in percent. The moisture is also a very important characteristic of food because water can affect the appearance, texture, and taste of food. Water content in food also determines the freshness and durability of these foodstuffs, which has high moisture resulting in easy bakery, mold, and yeast to breed, so that changes in food will occur. The low water content of food is one of the factors that can make durable foodstuffs [14]. Analysis of the average moisture of Food bar with wheat flour, and sago flour fortification of eel fish meal can be seen in Figure 2:

![Fig 2. Average Value of Food Bars Water Level (FB) with Proportion of Treatment T1 = WSPF 70%, SF 30%, EFF 0%; T2 = WSPF 65%, SF 30%, EFF 5%; T3 = WSPF 60%, SF 30%, EFF 10%; T4 = WSPF 55%, SF 30%, EFF 15%; T5 = WSPF 50%, SF 30%, EFF 20%.

Based on Figure 2, it appears that the food bar water content ranges from 3.47% - 5.98%. This shows that the lowest food bar water content is (3.47%), the treatment (T1) using white sweet potato flour 70%, sago flour 30%, and fortification of eel fish meal 0%, while the highest is (5, 98%) in the treatment (T5).
The T5 treatment has a higher water content compared to the T1, T2, T3, and T4 treatments. This food bar water content is in accordance with SNI 01-2886-2000 namely the maximum food bar water content is 4% (Indonesian National Standardization, 2000). Water content has a close relationship with the crunchiness and crispness of food bar products [15]. The results of the analysis of the variety showed that the food bar with white sweet potato flour and fortified sago flour gave no significant difference.

3.3. Fat
Fat or oil is the most effective source of energy compared to carbohydrates and protein. Almost all foodstuffs contain a lot of fats and oils, especially ingredients derived from animals. Analysis of fat content contained in food can be done by extracting fat. However, extracting fat in a pure manner is very difficult, because when extracting fat, it will also be extracted substances that are found in the fat such as sterols, phospholipids, free fatty acids, essential oils, and pigments.

![Graph of Average Values of Food Bar Fat (FB) with Proportion of Treatment T1 = WSPF 70%, SF 30%, EFF 0%; T2 = WSPF 65%, SF 30%, EFF 5%; T3 = WSPF 60%, SF 30%, EFF 10%; T4 = WSPF 55%, SF 30%, EFF 15%; T5 = WSPF 50%, SF 30%, EFF 20%.

Based on Figure 3, it can be seen that the fat content of food bars ranges from 17.36% - 18.10%. the highest fat content is (18.10%), which is in the treatment (T1), while the lowest is (17.36%), which is in the treatment (T5). This is because at the time of the process of making food bars the fat is still a lot of sticking because using the mixer tool is not so dissolved so that the fat content is very high. While the food bar fat content based on SN1 01-2973-1992 ranged from 10.49%. The results of the various analysis showed that the fat content of food bar with the substitution of white sweet potato flour, and sago flour, the fortification of eel fish flour had a significant different effect.

3.4. Protein
Protein is a heterogeneous polymer of amino acid molecules. In globular proteins, hydrophilic, polar side chains are on the outside and hydrophobic side chains, non-polar, arranged on the inner surface so that these proteins have relatively high solubility in water or in aqueous salt solutions at pH values below or in its isoelectric point [15]. Analysis of average protein content of food bar with wheat flour and sago flour fortification of eel fish meal can be seen in Figure 4.

Based on Figure 4, the average food bar protein content ranged from 0.37 to 3.64, the highest protein content was (3.64), that is in the treatment (T4) while the lowest was (0.37) in the treatment (T1). In Figure 4, a food bar with 70% white sweet potato flour is seen, and 30% sago flour, without the addition of fortified eel flour ingredients in the treatment (T1), 0%, while food bars with 50% white sweet potato flour, 30% sago flour %, and 20% eel fish fortification ingredients in the treatment (T5), the value of the protein content was a little low. The more white sweet potato flour is added the less protein content in food bars. Food bar protein levels according to SNI 01-2886-2000 range between 8.04%. The results of the analysis of the variety show that the food bars with white sweet potato flour, and sago flour, photographed eel fish meal had a very different effect.
3.5. Ash
Ash is an inorganic combustion substance from organic compounds. In food, besides ash, there are also other components, namely mineral. Ash content in food is very influential in the nature of food. Ash content is the total amount of mineral elements or inorganic substances that are needed by the body or those that are not needed by the body. Ash content of food bar based on SNI 01-2886-2000 is 1.5%. The average value of food bar ash content with white sweet potato flour substitution, and sago flour, eel fortification can be seen in Figure 5.

Based on Figure 5, an ash content of food bars with white sweet potato flour, and sago flour, fortification of eel fish meal ranged from 2.35% - 2.48%. The highest ash content in food bars with 70% white sweet potato flour, 30% sago flour, 0% eel fish fortification is 2.48%, which is in the treatment (T1), while the lowest is 2.35%, in the treatment (T5). Ash is residual inorganic residue from combustion. Inorganic residues are usually present in ingredients, in the form of compounds such as sodium, potassium, calcium, and silica. Food bar ash content in white sweet potato flour, and sago flour, fortified eel fish flour does not meet the standard quality requirements in Indonesia. The results of the analysis of the variables showed that the food bar with white sweet potato flour, and sago flour, fortified eel fish flour gives a significantly different effect on food bar ash levels [15].

Fig 4. Graph of Average Values of Protein Food Bar (FB) with Proportion of Treatment T1 = WSPF 70%, SF 30%, EFF 0%; T2 = WSPF 65%, SF 30%, EFF 5%; T3 = WSPF 60%, SF 30%, EFF 10%; T4 = WSPF 55%, SF 30%, EFF 15%; T5 = WSPF 50%, SF 30%, EFF 20%.

Fig 5. Graph of Average Value of Food Bar Ash Level (FB) with Proportion of Treatment T1 = WSPF 70%, SF 30%, EFF 0%; T2 = WSPF 65%, SF 30%, EFF 5%; T3 = WSPF 60%, SF 30%, EFF 10%; T4 = WSPF 55%, SF 30%, EFF 15%; T5 = WSPF 50%, SF 30%, EFF 20%.
3.5.1. Carbohydrate

Carbohydrates are compounds that can be interpreted as polysaccharide ketones which have the formula CH2O and its derivatives. Carbohydrate compounds in the form of glucose and glycogen are important for energy sources. Some carbohydrates have specific functions that are important are ribose in cell nucleic proteins, galactose in lipids, certain lipids and lactose in milk. Carbohydrates are found in cereals (rice, wheat, corn, potatoes, etc.), as well as in grains that are widely experienced. Graph of the average value of carbohydrate food bar with wheat flour, and sago flour fortification of eel fish meal seen in Figure 6.

![Graph of Average Value of Carbohydrate Food Bar (FB) with Proportion of Treatment T1 = WSPF 70%, SF 30%, EFF 0%; T2 = WSPF 65%, SF 30%, EFF 5%; T3 = WSPF 60%, SF 30%, EFF 10%; T4 = WSPF 55%, SF 30%, EFF 15%; T5 = WSPF 50%, SF 30%, EFF 20%.

Based on Figure 6, it can be seen that carbohydrate food bars range between 70.91 - 75.58%. The highest carbohydrate content is 75.58%, which is in the treatment (T1), while the lowest is 70.91% in the treatment (T5). The addition of white sweet potato flour to the food bar gave a significantly different effect on carbohydrate content for each treatment. The more amount of white sweet potato flour is added, the higher the amount of carbohydrate. This is because white sweet potato flour is a greater carbohydrate content than eel flour. The results of the various analysis showed that the food bar with white sweet potato flour, and sago flour, eel fortification, gave a significantly different effect on the carbohydrate content of the food bar. The data shows that T1 treatment meets the SNI 01-2886-2000 standards, which is a maximum of 70%. Based on the analysis of carbohydrate levels of food bars with different treatments it can be concluded that food bars with T1 treatment are different from treatments (T2, T3, T4, and T5). This is due to a decrease in water content, and protein content, then estimated so that the calculation with carbohydrate differences increases. The use of tubers in making sago plates has an average carbohydrate value of 86.9% [16].

4. Conclusion

Based on the results of research conducted, it can be concluded that by the use of white sweet potato flour and sago flour addition by doing fortification of eel fish flour in the manufacture of solid food (food bars), the characteristics of chemical properties in the form of water content ranged from 3.47 to 5.98 %, Fat content 17.36-18, 10%, protein content 0.37 - 3.64%, ash content 2.35 - 2.48%, carbohydrates 70.91 - 75.58%. The best-ranking treatment of all treatments, the determination of the best ranking is at T2.

References

[1] Cretella, A., 2019. Alternative food and the urban institutional agenda: Challenges and insights from Pisa. Journal of Rural Studies, 69, pp.117-129.
[2] Augustin, M.A., Riley, M., Stockmann, R., Bennett, L., Kahl, A., Lockett, T., Osmond, M., Sanguansri, P., Stonehouse, W., Zajac, I. and Cobiai, L., 2016. Role of food processing in food and nutrition security. Trends in Food Science & Technology, 56, pp.115-125

[3] Hoisington, A., Manore, M.M. and Raab, C., 2011. Nutritional quality of emergency foods. Journal of the American Dietetic Association, 111(4), pp.573-576.

[4] Zoumas, B.L., Armstrong, L.E., Backstrand, J.R., Chinachoti, P., Klein, B.P., Lane, H.W., Marsh, K.S. and Tolvanen, M., 2002. High-energy, nutrient-dense emergency relief product. Food and Nutrition Board: Institute of Medicine. National Academy Press, Washington, DC.

[5] Zhang, L., Zhao, L., Bian, X., Guo, K., Zhou, L. and Wei, C., 2018. Characterization and comparative study of starches from seven purple sweet potatoes. Food hydrocolloids, 80, pp.168-176.

[6] Etong, D.I., Mustapha, A.O., Lawrence, I.G., Jacob, A.G. and Oladimeji, M.O., 2014. Nutritional and physicochemical properties of wheat (Triticum vulgare), cassava (Manihot esculenta) and sweet Potato (Ipomoea batatas) flours. Pakistan Journal of Nutrition, 13(8), p.439.

[7] Ratucoreh, C.Y. and Retnoaji, B., 2018, August. The growth and histology structure of Indonesian eel (Anguilla bicolor bicolor McClelland, 1844) fed with microalgae. In AIP Conference Proceedings (Vol. 2002, No. 1, p. 020009). AIP Publishing.

[8] Ngandzali, B.O., Zhou, F., Xiong, W., Shao, Q.J. and Xu, J.Z., 2011. Effect of dietary replacement of fish meal by soybean protein concentrate on growth performance and phosphorus discharging of juvenile black sea bream, Acanthopagrus schlegelii. Aquaculture nutrition, 17(5), pp.526-535.

[9] Jariyah, J.J., Basuki, E.K. and Pertwi, Y.A., 2017. Evaluasi sifat fisikokimia food bar dari tepung komposit (pedada, talas dan kedelai) sebagai alternatif pangan darurat. Jurnal Teknologi Pangan, 11(1).

[10] Adiandri, R.S., Darniadi, S. and Hidayah, N., 2012. Identifikasi Komponen Flavor pada Tepung Ubijalar, Kacang Hijau, dan Kedelai sebagai Bahan Baku Produk Snack Bars. In Prosiding Seminar Hasil Penelitian Tanaman Aneka Kacang dan Umbi (pp. 340-349).

[11] Anandito, R.B.K., Siswanti, S., Nurhartadi, E. and Hapsari, R., 2016. Formulasi Pangan Darurat Berbentuk Food Bars Berbasis Tepung Millet Putih (Panicum milliaceum L.) dan Tepung Kacang Merah (Phaseolus vulgaris L.). agriTECH, 36(1), pp.23-29.

[12] Winarno. F. G. 1997. Pemanfaatan dan pengolahan beras non nasi. Makalah dalam Konsultasi Tekni Pengembang Industri Pengolahan Beras Non Nasi. Departemen Perindustrian dan Pusbangtepa-IPB. Jakarta. P. 39-69.

[13] Rasulu, H., Yuwono, S.S. and Kusnadi, J., 2012. Karakteris-tik tepung ubi kayu terfermentasi sebagai ba-han pembuatan sagukasi. J Teknol Pertanian, 13, pp.1-7.

[14] Gandaningarum, L., 2018. Sensory and Chemical Characteristics of Bar Cookies Made from Mung Bean Flour and Ripe Plantain var Raja as Emergency Food. Pertanika Journal of Tropical Agricultural Science, 41(3).

[15] Rasulu, H., 2014. Quality Improvement of Cassava Flour of Local Variety of Ternate Through Fermentation Method (Application on Traditional Food of North Maluku “Sagu lempeng”). International Journal on Advanced Science, Engineering and Information Technology, 4(6), pp.423-425.

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