Global Scientific JOURNALS

GSJ: Volume 9, Issue 5, May 2021, Online: ISSN 2320-9186
www.globalscientificjournal.com

REVIEW ARTICLE : FISH PROTEIN CONCENTRATE (FPC) FOR FOOD FORTIFICATION INGREDIENT

Junianto[1], Nabila Syifa Nurrahmah[2], Widia Rusyani[2], Rcakasiwi Adiarsa[2]

[1] *Lecture, Faculty of Fisheries and Marine Science, Padjadjaran University, Indonesia*
[2]*Studemt, Facultry of Fisheries and Marine Science, Padjadjaran University, Indonesia*

KeyWords
biscuits, bread, fish protein concentrate, fortification, traditional, crackers, nanotechnology

ABSTRACT

The purpose of this review article is to examine the use of fish protein concentrate as a protein fortification ingredient in biscuits, bread, and traditional food products. Based on the various articles and other literature reviewed, it can be concluded that the use of fish protein concentrate in biscuits, bread, and traditional products can increase the protein content of these products. The maximum acceptance of the panellists for the product occurs when the additions of fish protein concentrate less than 10%. The application of nanotechnology in fish protein concentrate is an alternative to the development of fish protein concentrate as fortification ingredients.

Introduction

Inadequate protein intake is one of the causes of many cases of nutritional deficiencies [1][2]. Protein intake is very important for the body, because the function of protein, which is to build new cells and replacing the damaged cells, cannot be replaced by other nutrients [3]. Protein deficiency can inhibit the formation of antibodies, causing the immune system to decline, and as a result, the body will be susceptible to disease [4]. Recurrent chronic infections are sign that the body is experiencing a lack of protein energy [2]. The impact of protein deficiency on children had a 3.46 times greater risk of becoming stunted compared to children with adequate protein intake [5].

Foods that are loved by children, such as biscuits, bread, and snacks usually have low protein content. Therefore in order to prevent nutritional deficiencies, protein enrichment for these foods is very important. The ingredients that can be used for protein enrichment are fish protein concentrate.

Fish protein concentrate (FPC) is a product obtained from the extraction using organic solvents and drying process to remove fat and water from the fish body [6][7]. This separation product which is a 'stable protein' has a higher protein content than before and is intended as human food ingredients [8]. The commonly used organic solvents are ethanol and isopropyl alcohol. These organic solvent can also remove the fishy smell in the concentrate. The use of fish protein concentrate as fortification ingredients in food products with low protein content is an alternative to increase protein consumption and product nutritional quality [9]. Therefore, it is very important to study the use of fish protein concentrate as a protein fortification ingredient in biscuits, bread and traditional food products.

Fortification of Fish Protein Concentrate in Biscuit

Fish protein concentrate can be applied to daily consumed foods. The addition of fish protein concentrate as fortification ingredients for food products is one of the promising alternative uses, for example, the fortification of biscuits. A research on fortification

of fish protein concentrate in biscuits has been conducted by Afriani et al. in 2016 to determine the effect of tilapia fish protein additions on the biscuit's chemical and organoleptic characteristic [10]. The treatment used in the research was the addition of 0%, 5%, 10%, 15%, and 20% tilapia fish protein concentrate with the formulation shown in Table 1.

Table 1. Formulation of Tilapia FPC Fortification in Biscuit

Ingredients	Tilapia FPC Biscuit Formulation				
	0%	5%	10%	15%	20%
Flour	170	170	170	170	170
FPC	0	8,5	17	25,5	34
Butter	100	100	100	100	100
Sugar	50	50	50	50	50
Egg Yolk	36	36	36	36	36
Milk	50	50	50	50	50
Baking Powder	2	2	2	2	2
Vanilla	2	2	2	2	2
Total	410	410	410	410	410

Source : Afriani et al. [10]

In the application of food quality, organoleptic testing is very important to determine indication of spoilage, deterioration of quality and other damage to a product [11]. The appearance of a product is very important, because appearance is the first thing that consumers perceive, appearance also tends to give the impression that the food product is of good quality [12]. As shown in Table 2. the tilapia fish protein concentrate addition in biscuits did not make a significant difference to the appearance. Treatments 0%, 5%, and 10% have median values of 7 which mean the product is favored by the panelists. Tilapia fish protein concentrate addition in biscuits also did not make a significant difference to the other organoleptic properties such as aroma, taste, and texture. For aroma and taste, the best results were obtained from the addition of 5% FPC with a value of 7,8 and 7,7, respectively. This is due to the specific aroma of the fish that has not yet been smelled in 5% treatment. In terms of texture properties, the best result was also produced by the 5% treatment with a value of 7.3 and in general the addition of tilapia fish protein concentrate to the texture of the biscuits resulted in values from the median range of 6-7. Along with the addition of tilapia fish protein concentrate, the value of the texture properties decreased. The decreased value was caused by the interaction between protein and starch granules which inhibited the release of water when baked [13].

Biscuit hardness values ranged from 1201,91 to 1383,53 gf/cm2, with the highest value resulting from treatment 20%, by 1383,53 gf/cm2. The increased hardness of these biscuits can be caused by the density of the biscuit dough in the formulation. The denser the dough, the harder the biscuits will be. Biscuits hardness can also be caused by the baking temperature and time. High temperature can cause the denaturation of myofibril protein and binding tissue [14][15]. Denaturation of protein will result in the disruption of water and fat binding capacity, which will affect the hardness of the product [10][16].

In chemical characteristics testing, as shown in Table 2, the value of water and protein content increased with the addition of tilapia fish protein concentrate. The water content value range from 2,88 to 4,22%. This resulted still considered good quality biscuits by the BSN (National Standardization Agency of Indonesia), as the maximum limit of water content allowed in Indonesia is 5% [17].The protein content value range from 9,12 to 17,41%. This result also considered good quality biscuits since the minimum value allowed in Indonesia is 5%. Overall, the addition of tilapia FPC by 5% resulted in the biscuit product with the best acceptance rate.

Table 2. Biscuit Chemical and Organoleptic Characteristic with Tilapia FPC Addition

Variable	Tilapia FPC Addition				
	0%	5%	10%	15%	20%
Appearance	7,1	7,0	6,2	6,7	6,0
Aroma	7,0	7,8	6,5	6,0	6,1
Taste	7,1	7,7	6,7	6,4	5,6
Texture	7,1	7,3	6,3	6,2	6,0
Hardness (gf/cm^2)	1201,91	1207,89	1252,76	1331,77	1383,53
Water content (%)	2,88	3,22	4,22	4,15	4,22
Protein content (%)	9,12	11,09	13,47	15,23	17,41

Source : Afriani et al. [10]

Another study was conducted by Anugrahati et al. by using sutchi catfish protein concentrate as biscuit fortification ingredients [18]. Sutchi catfish is widely consumed in Indonesia as the cultivation productivity rate is high. Sutchi catfish is known as freshwater fish which has high protein content and low fat content. Sutchi catfish has nutritional content value as follows : water content 74,4%, protein 17%, fat 6,6%, and ash 0,9% per 100 grams [19]. The treatments used in this study are the addition of sutchi catfish protein concentrate by 0%, 10%, 15%, 20%, and 25% with the formulation shown in Table 3.

Table 3. Formulation of Sutchi Catfish FPC Fortification in Biscuit

Ingredients	Sutchi Catfish FPC Biscuit Formulation				
	0 %	10 %	15 %	20 %	25 %
Wheat	100	100	100	100	100
FPC	0	10	15	20	25
Shortening	27	27	27	27	27
Sugar	32	32	32	32	32
Salt	1.5	1.5	1.5	1.5	1.5
Milk	6	6	6	6	6
Baking powder	0.5	0.5	0.5	0.5	0.5
Vanilla	0.05	0.05	0.05	0.05	0.05
Lecithin	0.4	0.4	0.4	0.4	0.4
Water	8	8	8	8	8
Chicken eggs	2	2	2	2	2

Source : Anugrahati et al. [18]

The organoleptic test results, as shown in Table 4. showed that the addition of Sutchi catfish protein concentrate did not cause a significant change to the color. And in the addition of 25% sutchi catfish protein concentrate, the biscuit show a slight discoloration to a darker color. This phenomenon is caused by a reaction between reducing sugars and amino acids during the heating process. This reaction has a big impact on the food industry because this reaction not only affects the color of the product, but also affects the aroma and taste [20]. The discoloration in biscuits also affect the brightness property value, the darker the color the lower the brightness. The organoleptic test also showed that the addition of sutchi catfish protein concentrate addition affect the aroma and taste of biscuits. The aroma and taste score decreased along the protein concentrate addition, namely 4,10 to 3,23 and 4,20 to 3,10, respectively. This is due to the significant aroma of sutchi catfish is more clear along the addition of the fish protein concentrate. The score decreased also occurred in the crunchiness property. The crunchiness score decreased from 4,00 to 2,83 along with the protein concentrate addition. The decreased score is caused by the increasing density of the dough. Inversely proportional to crunchiness, the hardness property increases with the increasing of the dough density. Other factors that can be affect the hardness properties are the baking temperature and time [10].

Table 4. Biscuit Physical and Organoleptic Characteristic with Catfish FPC Addition

Variable	Sutchi Catfish FPC Addition				
	0%	10%	15%	20%	25%
Color	3,43	3,53	3,53	3,57	3,93
Aroma	4,10	4,07	3,80	3,67	3,23
Taste	4,20	3,83	3,70	3,33	3,10
Crunchiness	4,00	3,80	3,60	3,10	2,83
Brightness	74,57	72,12	70,13	68,13	65,65
Hardness (gf)	1739,56	1757,55	1778,44	1805,22	1804,44

Source : Anugrahati et al. [18]

In this research, the addition of 15% catfish protein concentrate resulted in the best chemical characteristic values. This is because of the protein content in the addition of fish protein concentrate by 15% increased significantly compared to the control treatment, while other chemical properties such as water content, fat content, ash content, and carbohydrates did not experience significant changes as shown in Table 5. The in vitro protein digestibility of biscuits for the 15% treatment was significantly different from the control treatment, but not significantly different from commercial biscuits. The increased value of protein content in biscuit with 15% protein concentrate addition treatment causing the increase in protein digestibility as the protease activity in breaking down the pro-

tein also increased. But the increased number of protein content does not necessarily increase the digestibility [21][22]. There are other factors that can affect the protein digestibility, such as interaction between protein and polyphenols, phytates, carbohydrates, fats, and protease inhibitors, and there is also factors related to the characterization of protein structures such as tertiary, quarternary, and structure that can be damaged by heat and the reduction treatment [23][24][25][26].

Table 5. Chemical Properties of Difference Treatments in Biscuits

Variabel (%)	Control Treatment Biscuits	Addition of 15% FPC Biscuits	Commercial Biscuits
Water content	4,49	4,38	3,29
Protein content	8,59	18,72	9,37
Fat content	18,00	18,15	16,20
Ash content	2,29	2,32	1,74
Carbohydrate	66,63	56,43	69,42
Protein digestibility in vitro	87,82	91,71	90,35

Source : Anugrahati et al. [18]

Fortification of Fish Protein Concentrate in Bread

Apart from being used as an ingredient in biscuits, fish protein concentrate can also be used as a fortification ingredient in bread. Like any other Southeast Asian countries, bread is not the main staple food in Indonesia. But in Indonesia, breads with sweet filling are loved by children. As a source of carbohydrate, bread has a little protein content but high in fat content. Considering that sweet stuffing breads are loved by both children and adults, bread has the potential to be fortified with fish protein concentrate to increase its protein content and to support the increase of protein intake in Indonesia. The increase in protein content is expected to increase the product value.

Research on the addition of fish protein concentrate in bread has been conducted by Defira et al. in 2019 [27]. The fish protein concentrate used in this research is tilapia fish protein concentrate, the addition treatments used were 0%, 5%, 10%, and 15% and the formulation as shown in Table 6. The solvent used in the making of tilapia fish protein concentrate is isopropyl alcohol. The

Table 6. Formulations of ingredients in breads fortified with tilapia FPC

Ingredients	Treatments			
	0%	5%	10%	15%
Flour (g)	750	750	750	750
FPC (g)	0	37.5	75	112.5
Margarine (g)	75	75	75	75
Sugar (g)	100	100	100	100
Salt (g)	2	2	2	2
Milk (g)	30	30	30	30
Yeast (g)	11	11	11	11
Vanilla (tsp)	3	3	3	3
Water (ml)	300	300	300	300
Chicken Eggs (grain)	3	3	3	3

Source : Defira et al. in 2019 [27]

Tilapia fish protein concentrate addition in biscuits gave changes to the biscuit organoleptic characteristics. As in the appearance, the more the fish protein concentrate addition, the browner the color. The fish protein addition also affects the number of brown spots on the bread surface. The browning and the spots formation was due to the increase number of protein [28]. The brown color and spots on the surface of the bread are caused by the reaction between amino acids and peptides contained in the fish protein concentrate with reducing sugars from other bread ingredients [29]. Based on the sensory analysis result by 80 panelists, bread without the addition of tilapia fish concentrate has the best appearance with light brownish yellow color, as shown in Table 7. The brown spots on bread seemed to decrease the panelist interest on the bread appearance.

As for the texture, aroma, and taste, the highest analysis results came from bread with 5% tilapia fish addition. The tilapia fish protein concentrate addition of 5% bread has a soft and elastic texture. The percentage of tilapia fish addition in bread affect the bread

water content, as fish protein is water absorbent [30]. Increasing the tilapia fish protein concentrate in dough will decrease the gluten number, so it will affect the rise ability of the bread and causes the bread to dense [31]. The 5% treatment did not give a significant change in the original aroma and taste of the bread, meaning that this much addition is likeable by the panelists.

Table 7. Average Sensory Analysis Score

Characteristics	Treatments			
	0%	5%	10%	15%
Appearance	7,01±0,06^{b}	6,99± 0,05^{b}	6,97±0,03^{bb}	6,86±0,04^{a}
Texture	7,15±0,09^{bc}	7,23±0,05^{c}	7,07±0,05^{b}	6,87±0,03^{a}
Aroma	7,11±0,15^{bc}	7,23±0,05^{c}	6,95±0,03^{ab}	6,87±0,06^{a}
Taste	7,11±0,05^{ab}	7,29±0,07^{b}	7,03±0,10^{a}	6,97±0,04^{a}

Source : Defira et al. in 2019 [27]

The addition of tilapia fish protein concentrate has been shown to increase the protein content in bread. The protein content value range from 8,37-17,37%, with the lowest value came from the control treatment and the highest content came from the 15% treatment. Thus, the best treatment for the tilapia fish concentrate fortification in biscuits came from the 5% treatment, which have the best results in organoleptic analysis and higher protein content.

Fortification of Fish Protein Concentrate in Traditional Food

In addition to the products previously described, food products that can be fortified with fish protein concentrate are traditional snack products. For example, mlarat cracker, the Indonesian traditional cracker originating from Cirebon region. This product is known for its unique frying process. Usually cracker products are fried using vegetable oil, but the frying process of mlarat crackers using sand. This frying process with sand is what makes this product called mlarat craker (poor cracker). The ingredients used in making mlarat crackers include tapioca flour and spices consisting of onions, salt and other spices. The ingredients used in the production of mlarat crackers does not contain protein, therefore to improve the nutritional value of the product, fortification can be done with fish protein concentrate. The study on fortification of fish protein concentrate in mlarat cracker has been conducted by Listyarini et al. in 2018 [32].

The fish protein concentrate used in the research was from African catfish afkir dissolved in two different solvents, ethanol and isopropyl alcohol (IPA), and underwent four extraction stages. The fish protein concentrate addition treatment consisted of six different treatments; the control treatment with fish protein concentrate addition of 0%, and the African catfish afkir protein concentrate addition of 6%, 8%, 10%, 12%, and 14%. The use of African catfish as a source of fish protein concentrate is based on its high protein content, which is 17.09% and its moderate fat content, which is 2.75%.

Based on the research, the addition of African catfish protein concentrate to mlarat crackers was proven to increase protein content, with the highest protein content obtained from the addition of 14% fish protein content treatment is 14.80%. The analysis of the florescence level was carried out by comparing the volume of crackers before and after the frying process. As shown in Table 8. the addition of fish protein concentrate tend to reduce the fluorescence level. The decrease in the fluorescence level was a result of the starch usage reduced and replaced by fish protein concentrate [13]. The fish protein concentrate then fill the cavities formed during the heating process so that the cavities being formed getting smaller, so the level of florescence will decreases. In addition to the decreasing of fluorescence level, the crunchiness and the flavor values of the crackers also decreased. This is because of the high protein content in food product tends to reduce the level of crunchiness and flavors [33]. The protein from fish protein concentrate will have an interaction with starch granules which causes water excretion to be inhibited, so that when the frying process is done, only a little of water evaporated from the crackers and decrease the cracker's florescence level and crunchiness value [13]. As for the taste and color analysis, the assessment carried out is subjective with hedonic testing.

Table 8. Results of Mlarat Crackers Analysis with the Addition of African Catfish FPC

Variable	Treatments					
	0%	6%	8%	10%	12%	14%
Protein (%)	1.24	9,10	11.38	12.41	14.10	14.80
Affinity Rate (%)	406.00	344.00	334.00	285.00	209.00	183.00
Crunchiness (Score)	4.93	4.70	4.07	3.60	2.93	2.10

Taste (Score)	1.90	2.40	2.06	2.36	2.26	2.26
Color (Score)	4.80	4.36	4.26	4.06	4.13	4.13

Source : Listyarini et al. in 2018 [32].

Another Indonesian traditional product that can be fortified with fish protein concentrate is semprong roll cookies. Semprong is an Indonesian traditional roll cookies made from rice flour which has a crunchy texture, cylindrical in shape, and has a sweet taste. Research on the addition of fish protein concentrate in semprong has been conducted by Wijaya et al., in 2017 using snakehead fish (Channa striata) protein concentrate [34]. The addition of snakehead fish protein concentrate aims to increase the animal protein content of semprong. The snakehead fish protein concentrate addition treatments used in the research was 0%, 5%, 10%, and 15%. The parameters tested in this study included organoleptic parameters (taste, texture, appearance, aroma) and proximate values (moisture, protein, and fat content).

Based on the results of the study, the addition of snakehead fish protein concentrate in semprong had a significant effect on the organoleptic assessment and nutritional content, as shown in Table 9. In organoleptic testing with moderately trained panelists, it was found that semprong with the addition of fish protein concentrate treatment by 15% gave the best assessment results. As for the proximate test, it was found that the addition of snakehead fish protein concentrate affected the protein content, water content, and fat of semprong. The greater the fpc additions treatments, the greater the protein content and water content. As for fat content, the addition of FPCs is inversely proportional to the fat content result [34].

Table 9. Results of the Analysis of Addition of FPC in Semprong

Variable	Treatments			
	0%	5%	10%	15%
Taste	2.33	2.81	3.35	3.67
Texture	2.03	2.61	2.86	3.49
Fine	2.47	2.68	3.12	3.56
Aroma	2.44	2.81	3.17	3.68
Water content	3.09	3.10	3.16	4.57
Protein	8.90	11.41	13.06	21.62
Fat	13.37	11.80	8.00	5.31

Source : Wijaya et al. [34]

Fish Protein Concentrate Development

As a processed fish product, fish protein concentrate has features in the form of high nutritional value and has non-lost protein functional properties [34]. Therefore, this product has been developed in various forms of food processing to increase the nutritional value of a food product. The benefits provided by fish protein concentrate in food products are expected to be a solution to the global problems regarding hunger and malnutrition (especially protein deficiency). Initially the fish protein concentrate product considered less attractive, because generally the concentrate product was in the form of flour that has a strong fishy aroma like fish meal for animal feed. This strong aroma could be a problem when the fish protein concentrate fortified in other product, because it can affect the taste. The food product taste is influenced by chemical compounds, concentrate, and the interaction with othe component [35]. The greater the amount of tilapia protein concentrates addition, the stronger the fish taste [36][37].

However, along with the times, fish concentrate products also began to develop. Various studies have been conducted to determine the best chemical, physical and biological processing techniques to produce concentrates that can be used in the manufacture of food products. One example of the newest fish protein concentrate product is marine beef, which can be used as a substitute for beef products in various food preparations. Dehydrated marine beef has excellent emulsion, coagulation and gel formation power [38]. Because marine beef has similar taste as beef, this fish proteins concentrate can be a solution for alternative animal protein source for people who cannot eat beef products.

Processed fish protein concentrate products have a great potential in the future. This is due to the growing number of people who understand the importance of consuming high nutritious and balanced food products and the large opportunity for innovation in processed fish protein concentrate products. Even so, the big opportunity for developing fish protein concentrate products in the future is not without challenges. In its development, fish protein concentrate product development must be accompanied by adequate resources, meaning that it did not disturb the resource requirements for other fields. Apart from resource challenges, another challenge that may arise in the development of future fish protein concentrate products is the appropriate market. The challenges in developing fish protein concentrate largely depend on dietary habits, customs or culture, as well as consumer preferences. Although

many people have begun to understand the importance of nutritional content in improving the quality of life, many people also choose food based on their eating habits, economic capacity, and other reasons. Another challenge in developing its development as an ingredient or supplement to food product formulations, fish protein concentrate must be able to mix well without reducing the appearance, texture, taste and aroma of the food product. The application of nanotechnology in fish protein concentrate is to answer these challenges. the texture, taste and aroma of the food product. The application of nanotechnology in fish protein concentrate is to answer these challenges. the texture, taste and aroma of the food product. The application of nanotechnology in fish protein concentrate is to answer these challenges.

Conclusion

The results of the review show that the use of fish protein concentrate in biscuits, bread and traditional products can increase the protein content of these products. The maximum acceptance of the panelists for the product occurs when the fish protein content increases not more than 10%. The application of nanotechnology in FPCs is an alternative to the development of fish protein content product as fortification ingredients.

References

[1] S.R. Rolfes, K. Pinna, E. Whitney, "Understanding Normal and Clincial Nutrition". Boston : Cengage Learning, 2014.
[2] H. Haslina, S.F. Muis, S. Suyatno, "Nilai Gizi, Daya Cerna Protein dan Daya Terima Patilo sebagai Makanan Jajanan yang Diperkaya dengan Hidrolisat Protein Ikan Mujair" Jurnal Gizi Indonesia, vol. 1, no. 2, pp. 34-40, 2006.
[3] S. Almatsier, "Prinsip Dasar Ilmu Gizi" Jakarta : PT Gramedia Pustaka Utama, 2009.
[4] H. Susanto, S.I. Maslikah. "Efek Nutrisional Tepung Daun Kelor (Moringa oleifera) Varietas NTT terhadap Kadar Albumin Tikus Wistar Kurang Energi Protein" Publikasi Ilmiah Seminar Nasional MIFA, 2011.
[5] L. Hidayati, H. Hadi, A. Kumara. "Kekurangan Energi dan Zat Gizi Merupakan Faktor Resiko Kejadian Stunting Pada Anak Usia 1-3 Tahun yang Tinggal di Wilayah Kumuh Perkotaan Surakarta" Jurnal Kesehatan, vol. 3, no. 1, pp. 89-104, 2010.
[6] S.M Ibrahim, "Evaluation of Production and Quality of Salt-Biscuits Supplemented with Fish Protein Concentrate", World Journal Dairy Food Science, vol. 4, no. 1, pp. 28-31, 2009.
[7] F.J Rieuwpassa, J. Santoso, W. Trilaksani, "Karakterisasi Sifat Fungsional Konsentrat Protein Telur Ikan Cakalang (Katsuwonus pelamis)". Jurnal Ilmu dan Teknologi Kelautan, vol. 5, no. 2, pp. 299-309, 2013.
[8] D. Dewita, S. Syahrul, S. Isnaini. "Fortifikasi Konsentrat Protein Ikan Patin Siam pada Produk Snack Amplang dan Mi Sagu Instan Sebagai Produk Unggulan Daerah Riau", Jurnal Pengolahan Hasil Perikanan Indonesia, vol. 17, no. 2, pp. 156-164, 2014.
[9] N. Perbowo, R.H.S Ibrahim, R. Andriyani, E. Mindrawati, N.P. Setiawati, K. Kurnia, et al., "Inovasi Teknologi Pengolahan Kerjasama Penelitian/Riset Perguruan Tinggi dan Litbang (Hidrolisat Protein Ikan)" Jakarta : Direktorat Jendral Penguatan Daya Saing Produk Kelautan dan Perikanan, 2016.
[10] R.R. Afriani, N. Kurniawati, I. Rostini. "Penambahan Konsentrat Protein Ikan Nila terhadap Karakteristik Kimia dan Organoleptik Biskuit", Jurnal Perikanan Kelautan, vol.7, no. 1, pp. 6-13, 2016.
[11] D. Wahyuningtyas, "Uji Organoleptik Hasil Jadi Kue Menggunakan Bahan Non Instan dan Instan", Binus Business Review, vol. 1, no.1, pp. 116-125, 2010.
[12] I.P. Tarwendah, "Jurnal Review: Studi Komparasi Atribut Sensoris dan Kesadaran Merek Produk Pangan", Jurnal Pangan dan Agroindustri, vol. 5, no.2, pp. 66-73, 2017.
[13] L. Lavlinensia, "Kajian Beberapa Faktor Pengembangan Volumetrik Dan Kerenyahan Kerupuk Ikan", thesis, IPB University, Bogor.
[14] Y.H. Hui, "Encyclopedia of Food Science and Technology", New York : John Wiley and Sons, 1992.
[15] E. Tornberg. "Effect of Heat on Meat Proteins Implications on Structure and Quality of Meat Prodcts." Meat Science, vol. 70, no. 3, pp. 493-508, 2005.
[16] G. Sumnu, S. Sahin. "Recent Develompments in Microwave Heating", Technologies for Food Processing, vol. 53, pp. 419-444, 2005.
[17] Badan Standardisasi Nasional, "SNI 2973:2011 Biskuit" Jakarta : Badan Standardisasi Nasional, 2011.
[18] N.A. Anugrahati, J. Santoso, I. Pratama. "Pemanfaatan Konsentrat Protein Ikan (KPI) Patin dalam Pembuatan Biskuit", Jurnal Pengolahan Hasil Perikanan Indonesia, vol. 15, no. 1, pp. 45-51, 2012.
[19] Departement of Health of Republic Indonesia, "Komposisi Zat Gizi Makanan Indonesia" Bogor : Pusat Penelitian dan Pengembangan Gizi, 2001.
[20] R. Hustiany. "Reaksi Maillard Pembentuk Citarasa dan Warna pada Produk Pangan". Banjarmasin : Lambung Mangkurat University Press, 2016.
[21] G.S. Gilani, E. Sepehr. "Protein Digestibility and Quality in Products Containing Antinutritional Factors are Adversely Affected by Old Age in Rats", Journal of Nutrition, vol. 113, no. 1, pp. 220-225, 2003.
[22] I.S. Schmidt, C.M. Nyachoti, B.A. Slominski, "Nutritional Evaluation of Egg by-products in Diets Foe Early-Weaned Pigs" Journal of Animal Science, vol. 81, no. 9, pp. 2270-2278, 2003.
[23] K.G. Duodu, J.R.N Taylor, P.S Belton, B.R. Hamaker. "Factors Affecting Sorgum Protein Digestibility", Journal of Cereal Science, vol. 38, no. 2, pp. 117-131, 2003.
[24] K. Ikeda, M. Oku, T. Kusano, K. Yasumoto. "Inhibitory Potency of Plant Antinutrients Towards the in vitro Digestibility of Buckwheat Protein", Journal of Food Science, vol. 51, no. 6, pp. 1527-1530, 1986.
[25] S.S. Deshpande, S. Damodaran. "Heat Induced Conformational Changes in Phaseolin and Its Relation to Proteolysis.", Biochimica et Biopysica Acta (BBA) Protein Structure and Molecular Enzymology, vol. 998, no. 2, pp. 179-188, 1989.
[26] I.A. Vaintraub, P. Seliger, A.D. Shutov. "Action of Pepsin on The Reverse Proteins of Some Leguminous Seed", Nahrung, vol. 23, no. 1, pp. 15-21, 1979.
[27] R. Defira, D. Desmelati, D. Dahlia. "Pengaruh Fortifikasi Konsentrat Protein Ikan Nila (Oreochromis niloticus) pada Roti Manis", Agroindustri Halal, vol. 5, no. 2, pp. 122-131, 2019.
[28] W.S. Siahaan, N.S. Ira, L. Suardi. "Pengaruh Penambahan Konsentrat Protein Ikan Gabus (Channa striatus) terhadap Mutu Kwetiau" JOM UNRI, vol. 1, no. 1, pp. 1-13, 2015.

[29] L.S. Nuraeni, "Pengaruh Suhu dan Lama Pengeringan terhadap Karakteristik Tepung Terubuk (Saccharum edule Hasskarl)", thesis, Pasundan University, Bandung, 2018.
[30] Y. Yenni, "Pengaruh Penambahan Konsentrat Protein Ikan Patin (Pangasius hypopthalmus) terhadap Mutu Mie Sagu Instant selama Penyimpanan pada Suhu Kamar" thesis, University of Riau, Pekanbaru, 2013.
[31] D.A. Pusuma, Y. Praptiningsih, M. Choiron, "Karakteristik Roti Tawar Kaya Serat yang Disubstitusi Menggunakan Tepung Ampas Kelapa", Jurnal Agroteknologi, vol. 12, no. 1, pp. 29-42, 2018.
[32] S. Listyarini, A. Asriani, J. Santoso, "Konsentrat Protein Ikan Lele Dumbo (Clarias Gariepenus) Afkir dalam Kerupuk Melarat untuk Mencapai Sustainable Development Goals" Jurnal Matematika, Sains, dan Teknologi, vol. 19, no. 2, pp. 106-113, 2018.
[33] A. H. Purnomo, A. Chalid, S. Bustaman, "Prelimary Study on Preparation of Fish Cracker", Laporan Penelitian Teknologi Perikanan, vol 38, pp. 17–21, 19
[34] A. Wijaya, S. Mus, S. Suparmi. "Pengaruh Penambahan Kosentrat Protein Ikan Gabus (Channa Striata) terhadap Mutu Kue Semprong", thesis, University of Riau, Pekanbaru, 2017.
[35] T. Leksono, S. Syahrul, "Studi Mutu dan Penerimaan Konsumen terhadap Abon Ikan", Jurnal Natur Indonesia, vol. 3, no. 2, pp. 178-184, 2001.
[36] W.S. Siahaan, N.S Ira, L. Suardi, "Pengaruh Penambahan Konsentrat Protein Ikan Gabus (Channa striatus) terhadap Mutu Kwetiau", Jurnal Online Mahasiswa Universitas Riau, vol. 2, no.2, pp. 1-13, 2015.
[37] R.P. Nando, S. Suparmi, D. Dewita, "Studi Pembuatan Biskuit dengan Penambahan Konsentrat Protein Ikan Gabus (Channa striata)" Jurnal Online Mahasiswa Universitas Riau, vol.2, no.2, pp. 14-22, 2015.
[38] R. Widodo, T.W.S. Panjaitan, I. Yuwono. "Karakterisasi Bakso Kering Kaya Protein dari Marine Beef dengan Substitusi Tepung Suweg", Jurnal Teknik Industri HEURISTIC, vol. 12, no.2, pp. 124-141, 2015.