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PROXIMATE COMPOSITION, TEXTURE PERFORMANCE AND SENSORY EVALUATION OF LINDUR FRUIT-POTATO SIMULATION CHIPS ENRICHED WITH SHRIMP *(Penaeus vannamei)* SHELL POWDER

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Abstract

Study aimed to investigate the utilization of shrimp shell powder in the production of lindur fruit-potato simulation chips, which was assessed using proximate composition, texture performance and sensory evaluation parameters. Three different ratios of lindur fruit-potato flour (w/w) (30:70, 40:60 and 50:50), as well as different concentrations of shrimp shell powder (0, 1, 3 and 5%) were used in the formula. The results showed that lindur fruit-potato simulation chips enriched with shrimp shell powder had 3.22-4.42% moisture content, 3.33-4.94% ash content, 3.77-5.83% protein content, 14.59-19.04% fat content, 71.06-76.34% carbohydrate content and 341.4-530.9 g/cm^2 hardness. Ratio lindur fruit flour and potato flour of 40:60 as well as 3% of shrimp shell powder was chosen as the best treatment since the formula produced lower hardness, higher protein content and the most crispy and tasty chips preferred by panelists.

Keywords: shrimp shell powder, simulation chips, lindur fruit flour, potato flour

1. Introduction

Simulation chips is chips that involves flour formulation and kneading process during production (Kusbiantoro, Histifarina & Ahza, 2005). Recently, a lot of potential vegetation has been used as ingredient of simulation chips, including lindur fruit. Lindur fruit (*Bruguiera gymnorrhiza*) is one of mangrove species which is potential for food ingredient due to its high carbohydrate content and known as a source of energy. Therefore, lindur fruit has been widely used in snack formulation to replace wheat and other imported flours. Some studies have reported the utilization of lindur fruit into food formulations such as biscuit (Perkasa, 2013); cookies (Dewi, Sukerti & Ekayani, 2014); dodol (Seknun, 2012); and chips (Sarofa, Yulistiani & Mardiyah, 2011).

During its application, lindur fruit is processed into flour and generally used as substitute matter of other basic flours such as tapioca, wheat, rice or potato flour to minimize brittle texture of the product due to lack of amylose content which is responsible for elasticity and adhesiveness. It has been reported that lindur fruit flour only contains 22.67-28.18% amylopectine (Dhinendra, Dewi & Romadhon, 2015), while other starch sources such as rice, glutinous rice, wheat and cassava were identified to contain 88.22-99.11% amylopectine (Imanningsih, 2012). Substitution of lindur flour to wheat flour at ratio of 40:60 was reported to produce better characteristics of biscuit (Perkasa, 2013), while proportion of lindur: wheat flour 30:70 resulted in crackers with high nutritional content as well as product high acceptance (Sarofa et al., 2011).

Meanwhile, Indonesia also has a huge potency of fisheries commodities. One of primer commodities for export is shrimp. Shrimp production in Indonesia has been increasing yearly, i.e. from 457.600 tons in 2012 to 480.000 tons in 2013 (Auliani, 2013). *Litopenaeus vannamei* is one of species which assigned by the Minister of Marine Affairs and Fisheries to support shrimp farming industries (Budhiman, Paryanti & Sunaryanto, 2005). The exported shrimp is usually marketed as peeled and headless. Due to trimming process, some parts of shrimp body including leg, appendages, head, shell

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and tail are wasted, accounting for 40-50% of the total shrimp weight (Khan & Nowsad, 2012). This enormous potential waste has not been optimally utilized yet. However, shrimp shell contains 43.4-50.2% protein, 3.4-12.8% fat and 14.6-22.7% ash (Khan & Nowsad, 2012). Ibrahim, Salama, & El-Banna (1999) reported that dried shrimp shell rich in glutamic acid as well as minerals, especially Ca, P, Na and Zn. Therefore, shrimp shell is potential to be used as source of food ingredients. Khan and Nowsad (2012) has studied that the unutilized shrimp shell waste with high quality protein can be further fortified into crackers.

Potato chip is one of the most popular snack food consumed by all ages. Substitution of lindur fruit flour and addition of shrimp shell powder into potato chips products is expected to improve the characteristic of the product in terms of nutritional content and texture as well as to develop a new variant of potato chips with different taste and flavor. This study was aimed to reveal proximate composition, texture performance and sensory evaluation of lindur fruit-potato simulation chips enriched with shrimp shell powder. It is expected that this study can recommend the best proportion of lindur fruit flour to potato flour as well as concentration of shrimp shell powder used for the simulation chips.

2. Material and Methods

2.1. Material

Materials used in this study were lindur fruit flour and shrimp (*Litopenaeus vannam*ei) shell powder which were obtained from Research Center for Marine and Fisheries Product Processing and Biotechnology, Jakarta. The lindur fruit flour and shrimp shell powder were processed using method developed by Hastarini et al. (2014). Other materials used in the study were potato chips ingredients such as potato flour, rice flour, margarine, tapioca, corn flour, lecithin, salt and maltodextrin.

2.2. Methods

2.2.1. Lindur fruit-potato simulation chips formulation

The chips were made by mixing all ingredients at sufficient amount, namely potato flour, rice flour (5%), starch flour (5%), corn flour (10%), margarine, lecithine, maltodextrine, salt and water. Lindur fruit flour and shrimp shell powder were added into chips formulation, using various ratios, i.e. 30:70; 40:60 and 50:50 (Sarofa et al., 2011; Perkasa, 2013) and three concentration levels of shrimp shell powder, i.e. 0, 1, 3, and 5% of total flour amount. The dough was then manually sheeted into ±1 mm thick, molded and sun-dried. The chips were then deep fried at 140 ºC for 45 seconds and allowed to dry before packed (modification of Mursalina, Sinaga, & Silalahi, 2012). All treatments were done in triplicates.

2.2.2. Analysis of parameter

In this study, the characteristics of the lindur and shrimp shell materials referred to Hastarini et al. (2014), while the characteristics of chips products being analyzed were moisture, ash, protein and fat contents (AOAC, 2005). The carbohydrate content was calculated using by difference method. In addition, HCN content, tannin content, starch, amylose and amylopectine of lindur fruit flour were also compared to the results obtained by Seknun, (2012); Sulisyawati, Wignyanto, & Kumalaningsih (2012). Hardness of the chips was measured by TAXT-Stable Micro System Texture Analyzer using HDP/CFS probe (Tunick et al., 2013). The sensory evaluation was conducted by 15 semi-trained panelists using descriptive scoring and hedonic tests (MBRIO, 2010). The attributes observed in the descriptive scoring test were appearance, texture, odour and taste; while in the hedonic test panelist evaluated their preferences on the attribute of appearance, colour, odour, taste, texture as well as overall preferences. Descriptive scoring test was conducted with the scale of 1-5, the highest score showed the desirable characteristics while the lowest score representing the undesirable features (Table 1). The scoring attribute scheme was determined during pre-evaluation discussion carried out by 6 well-trained panelists. Hedonic test was described with 1 to 7 scales, i.e. 1 represents the most unpreferred sample and 7 represents the most preferred sample (Table 2). All parameters were analysed in triplicates. The data were then statistically analysed using PASW Statistics18 programme. Proximate values and hardness data were analysed using ANOVA test while sensory data were analysed using Kruskal-Wallis test.

3. Results and Discussion

3.1. Characteristics of Lindur Fruit Flour and Shrimp Shell Powder

Chemical composition of fresh lindur fruit as well as lindur fruit flour used in the study (Hastarini et al, 2014) compared to other studies (Seknun, 2012; Sulistyawati et al., 2012; Hidayat, Suptijah, & Nurjanah, 2013) are presented in Table 3.

Lindur fruit (*Bruguiera gymnorrhiza*) flour can be categorized as food materials from mangrove vegetation since it consists of nutrition compounds such as carbohydrates, protein, and fat. Other

Table 1. Descriptive scoring attribute scheme for lindur fruit-potato simulation chips enriched with shrimp powder

Attribute	Score				
	1	2	3	4	5
Appearance	Broken	Mostly broken and perforated	Less neat, partially broken	Less neat, slightly perforated, flat surface, intact	Neat, not perforated, flat surface, intact
Texture	Very hard	Hard, tough to chew	Slightly hard to chew	Less hard, easily to chew	Crispy, easily to chew
Odour	Very strong disturbing odour	Strong disturbing odour	Slightly disturbing odour	Savory smell, slightly strong desirable flavor	Savory smell, strong desirable flavor
Taste	Bitter	Slightly bitter	Less tasty, slightly, savory, bitter	Less tasty, less savory	Tasty, savory

Table 2. Hedonic scheme for lindur fruit-potato simulation chips enriched with shrimp powder

Score	Meaning
7	Very like
6	Like
5	Slightly like
4	Neutral
3	Rather dislike
2	Dislike
1	Very dislike

mangrove fruit species that also can be consumed are *Avicenia alba* and *Sonneratia alba*, in which those fruits are generally used to replace rice and corn during food crisis due to drought season in the east part of Indonesia such as Timor, Flores, Sumba, Sabu, and Alor (Hidayat et al., 2013). The carbohydrate content of lindur fruit used in the experiment was reported 92.52% and increased to 95.24% when it was converted into flour (Hastarini et al., 2014). The results were in accordance with study conducted by Seknun (2012) and Hidayat et al. (2013), in which lindur fruit flour had carbohydrate content of 91.6 and 97.66% respectively.

In addition, starch content of lindur flour used in the experiment was relatively high, i.e 68.32% (Hastarini et al., 2014), correspond with the result obtained by Seknun (2012) which reported that lindur flour contained 61.30% of starch. The proportion of amylose of lindur flour was higher compared to amylopectine, which is only 26.47% compared to 41.05% (Hastarini et al., 2014). Similar result was also obtained by Seknun (2012) revealed that lindur flour had 33.51% of amylose and only 27.79% of amylopectine. Amylose and amylopectine are the polysaccharide molecules contained in starch. Amylose is single strain polysaccharide part of starch; composed of glucose molecules -1,4-glycosidic, has smaller size and soluble fraction. Amylopectine is a branched polysaccharide part of starch, composed of glucose molecules that are bound to each other through 1,4-glycosidic branching via 1,6-glycosidic bond at 20-25 units per molecule of glucose. This molecule is bigger, insoluble fraction, and forming *double helix.* The total ratio of amylose-amylopectine

Table 3. Chemical composition of fresh lindur fruit and lindur fruit flour

Component	Fresh lindur fruit (Hastarini et al., 2014)	Lindur fruit flour (Hastarini et al., 2014)	Lindur fruit flour (Seknun, 2012)	Lindur fruit flour (Sulistyawati et al., 2012)	Lindur fruit flour (Hidayat et al., 2013)
Moisture content (% wet weight basis)	54.25	9.59	5.83	8.46	11.84
Ash content (% dry weight basis)	3.01	1.09	4.2	1.75	0.3
Protein content (% dry weight basis)	3.93	3.21	3.77	6.11	1.67
Fat content (% dry weight basis)	0.52	0.44	0.42	1.95	0.35
Carbohydrate content (% dry weight basis)	92.52	95.24	91.6	89.67	97.66
HCN content (ppm)	11.6	5.5	5.59	3.37	1.98
Tanin content (mg/100g)	0.81	0.74	-	0.19	0.21
Starch (% dry weight basis)	-	68.32	61.3	-	-
Amylose (% dry weight basis)	-	41.05	33.51	20.42	33.98
Amylopectine (% dry weight basis)	-	26.47	27.79	-	-

fraction greatly affects to starch gelatinization profile (Imanningsih, 2012). When starch is heated, some of the *double helix* amylopectin fraction stretched and released when no hydrogen bonds are severed. If a higher temperature is given, the more hydrogen bonds are broken, causing water to seep into the starch granules. In this process, amylose molecules released into the water phase that surrounds the granules, so that the structure of the starch granules become more open, and more water into the granule, causing the granules to swell and increase in volume. Then the water molecules form hydrogen bonds with hydroxyl groups of the amylose and amylopectin sugar molecules. On the outside of granules, the amount of free water is reduced, while the amount of amylose released increased. Amylose molecules tend to leave a granule because its structure is shorter and easier to dissolve. This mechanism explains that the starch solution is heated to be more viscous. However, when the ratio of amylose is higher compared to amylopectine, the materials considered to have lower capacity to absorb water, lower elasticity and higher adhesiveness. Therefore, combination of lindur flour with other materials containing higher amylopectine such as glutinous rice, corn or tapioca is required to form dough that can be molded.

Moreover, fresh lindur fruit often contains antinutritional compounds that might result in undesired effects when it is consumed i.e cyanides (HCN) and tannin. Tannin is an acid polyphenol compound with a stringent taste, found in many parts of plants such as stems, leaves and fruit (Hagerman, 2002). This compound has carcinogenic effect to human body when consumed continuously in excessive amount (Awika, Yang, Browning, & Faraj, 2009). Meanwhile, cyanides (HCN) also can be toxic when consumed in excessive doses because this compound interferes cytochrome-oxidase enzyme that stimulates respiration in aerobic organisms (Sulistyawati et al., 2012). Therefore, fresh lindur has to be processed further to reduce or remove cyanides and tannin concentration before being used as food ingredients. Method developed by Hastarini et al. (2014) revealed that reducing the cyanides and tannin concentration was conducted by soaking the fruit into the mixture of ash husk and water at concentration of 30% for 24 hours. Results of the study showed that HCN content of fresh lindur fruit decreased from 11.6

ppm to 5.5 ppm after being processed into flour. Similar trend also showed by tannin content, reduced from 0.81 in fresh fruit to 0.74 mg/100g after being process into lindur flour (Hastarini et al., 2014). According to FAO, HCN content of food should not be higher than 50 ppm, while permitted doses for tannin should not be higher than 560 mg/kg body weight per day. Both HCN and tannin content of lindur flour used in this study were categorized below the permitted level, thus it is safe to be consumed.

Meanwhile, chemical component of fresh shrimp shell and shrimp shell powder used in the study (Hastarini et al., 2014) compared to other study (Khan & Nowsad, 2012) are presented in Table 4.

Result of proximate composition of fresh shrimp shell and shrimp shell powder used in the experiment showed that the protein content decreased from 65.77% in fresh shrimp shell to 55.13% in shrimp shell powder (Hastarini et al., 2014). Meanwhile, ash content of shrimp shell increased from 18.32% in fresh shrimp shell to 21.17% in shrimp shell powder (Hastarini et al., 2014). The proximate values of shrimp shell powder in the experiment were almost similar to study conducted by Khan & Nowsad (2012), revealed that proximate composition of shrimp shell powder was 47.48% protein, 10.5% lipid and 19.6% ash content. A study has reported that shrimp shell contains higher level of lipid, fiber and ash content rather than shrimp flesh, while higher level of protein, carbohydrate and moisture content was noticed in the flesh tissue (Ravichandran, Rameshkumar, & Prince, 2009).

3.2. Proximate Value of Simulation Chips

Moisture contents of lindur fruit-potato simulation chips formulated with shrimp shell powder were 3.22-4.42% (Table 5). Higher proportion of lindur flour compared with potato flour in simulation chips formula did not significantly affect moisture content ($P>0.05$). This is allegedly related to protein content of materials. Protein plays a role in water absorption and holding capacity (Sarofa et al., 2011). Lindur flour has low protein content, i.e. only 3.21% (Table 3). Thus, the addition of higher proportion of lindur flour in the formulation did not influence the moisture content of simulation chips.

Moisture content of simulation chips decreased significantly due to addition of shrimp shell powder at higher concentration ($P<0.05$). Lower moisture content was obtained from addition of 3% shrimp shell powder. Shrimp shell powder rich in protein, ranging from 47 to 55% (Table 4), thus, its addition into formula might increase the moisture content due to water absorption and holding capacity of protein molecules. However, this phenomenon did not occur at low concentration (1 and 3%) and seemingly appeared at higher concentration. This was shown at addition of 5% shrimp shell powder where the moisture content of simulation chips increased slightly.

According to SNI 01-4301-1996, the moisture content of chips should not exceed 3%. This value was lower than moisture content of lindur fruit-potato simulation chips resulted in the experiment, i.e. 3.22-

Table 4. Proximate composition of fresh shrimp shell and shrimp shell powder

Component	Fresh shrimp shell (Hastarini etal., 2014)	Shrimp shell powder (Hastarini et al., 2014)	Shrimp shell powder (Khan & Nowsad, 2012)
	2014	2014	2012
Moisture content (%wet weight basis)	79.05	10.33	-
Ash content (%dry weight basis)	18.32	21.17	19.60
Protein content (%dry weight basis)	65.77	55.13	47.48
Fat content (%dry weight basis)	11.88	11.04	10.50

4.42%. This might be related with drying process during processing the chips. The study used traditional drying method during processing the chips (sun drying) in order to be easy applied by the household scale industries. However, this method was depending on weather condition which might cause unevenness in the level of dryness. In addition, the chips were sheeted using manual tools leading to the different thickness between batches. This treatment also affects the different level of dryness between pieces of chips. The use of machinery during molding and drying process can help product to meet the requirement as well as to provide a uniform end product.

Ash contents of lindur fruit-potato simulation chips formulated with shrimp shell powder were 3.33-4.94% (Table 5). Higher proportion of lindur fruit flour in the formula did not significantly affect ash content (P>0.05). Addition of 1-3% shrimp shell powder did not significantly affect ash content of the chips, but addition of 5% increased ash content significantly (P<0.05). As mentioned in Table 4, shrimp shell powder contained 18.9% of ash. Ash content reflects the total mineral content of the products (Pomeranz & Meloan, 1987; Haard, 1996). According to Ravichandran et al. (2009) the shell of *P.indicus,* has been identified to contain several minerals such as calcium, sodium, potassium, manganese, copper and chromium. The minerals composition was identified to be higher in the shell samples than flesh tissues. The calcium content (3000 mg/100 g) in the shrimp by product, including the shell, was higher than those of phosphorus (400 mg/100 g), sodium (270 mg/100 g) and magnesium (100 mg/100 g) while manganese and iron were present in trace amounts (Heu, Kim, & Shahidi, 2003).

Similar to moisture content, ash content of chips should not exceed 3% (SNI 01-4301-1996), while ash contents of lindur fruit-potato simulation chips produced in the experiment were higher than 3%. This means that the chips did not meet the quality requirements of potato chips described in SNI. Therefore, in order to meet the expected product, further study on the most suitable formulation is necessary.

Protein contents of lindur fruit-potato simulation chips formulated with shrimp shell powder were 3.77-5.83% (Table 5). Addition of higher concentration of lindur fruit flour to the potato chips formula did not significantly affect its protein content (P>0.05). However, addition of shrimp shell powder into the formula significantly increased the protein content (P<0.05). It revealed that the protein content of the chips is influenced by the addition of shrimp shell powder. Shrimp shell was reported to contain lower percentage of crude protein compared to flesh content; however, the level of protein content was considered as high, reached to 32.5% (Ravichandran et al., 2009). A study conducted by Heu et al. (2003), showed that aspartic acid, glutamic acid, phenylalanine, lysine and arginine were the predominant amino acids in the protein fraction of shrimp by product. The total content of free amino acids of the shrimp processing by-products (2000 mg/100 g) was 15% higher than that of the edible parts (1700 mg/100 g) with the dominant

Table 5. Proximate composition of lindur fruit-potato simulation chips enriched with shrimp shell powder (%)

Ratio of lindur fruit flour : potato flour	Concentration of shrimp shell powder (%, w/w)	Moisture content (% wet weight basis)	Ash content (% dry weight basis)	Protein content (% dry weight basis)	Fat content (% dry weight basis)	Carbohydrate content (% dry weight basis)
30 : 70	0	4.42±0.03^{a}	4.51±0.00^{a}	4.31±0.27^{a}	14.59±0.19^{a}	76.56±0.11^{a}
	1	4.22±0.02^{b}	4.61±0.04^{ab}	4.44±0.00^{b}	15.25±0.40^{a}	75.68±0.45^{a}
	3	3.22±0.05^{c}	3.33±0.67^{a}	4.42±0.05^{b}	16.28±0.62^{a}	75.95±0.04^{a}
	5	3.47±0.06^{ab}	4.94±0.09^{b}	5.83±0.03^{c}	15.59±0.73^{a}	73.63±0.74^{a}
40 : 60	0	4.15±0.28^{a}	4.25±0.01^{a}	3.93±0.35^{a}	15.46±0.39^{a}	76.34±0.47^{a}
	1	3.39±0.07^{b}	4.41±0.04^{ab}	4.28±0.11^{b}	16.10±0.11^{a}	75.18±0.04^{a}
	3	3.51±0.02^{c}	4.49±0.02^{a}	4.86±0.15^{b}	17.05±0.34^{a}	73.57±0.48^{a}
	5	4.01±0.12^{ab}	4.81±0.03^{b}	5.53±0.03^{c}	16.42±0.22^{a}	73.24±0.04^{a}
50:50:00	0	4.03±0.34^{a}	4.04±0.05^{a}	3.77±0.02^{a}	17.00±0.18^{b}	75.19±0.44^{a}
	1	3.75±0.05^{b}	4.61±0.03^{ab}	4.89±0.10^{b}	17.23±1.32^{b}	73.26±1.28^{a}
	3	3.62±0.04^{c}	4.44±0.04^{a}	4.90±0.03^{b}	18.59±2.33^{b}	72.06±2.22^{a}
	5	4.40±0.23^{ab}	4.43±0.07^{b}	5.44±0.08^{c}	19.04±1.77^{b}	71.06±2.00a

*Note: different alphabet indicates significantly differences (P<0.05)

free amino acids were taurine, threonine, leucine, tryrosine and phenylalanine (Heu, Kim & Shadidi, 2003).

Fat content of potato chips enriched with lindur fruit and shrimp shell powder were ranging from 14.59 to 19.04% (Table 5). These values considered to be high since other studies obtained that fat content of fried potato chips was about 9% (Gibson & Kurilich, 2013). Addition of lindur fruit flour increased the fat content ($P<0.05$). This result is in contrast with a study conducted by Khan & Nowsad (2012) which noted that addition of higher concentration of shrimp shell powder to crackers increased fat content, approaching to 30-34% dry weight. However, lindur fruit flour was identified to have low level of fat content, with only 0.44% dry weight (Table3). It was allegedly that the high level of fat content was probably attributed to the use of lipid rich ingredients (margarine). The presence of lipid in the formulation is aimed to improve the physical structure of the product including the expansion, softness, firmness and aroma (Perkasa, 2013).

In addition, carbohydrate content of simulation chips was calculated by difference of other compositions such as water, ash, and protein contents. Results showed that the carbohydrate contents of lindur fruit-potato simulation chips were generally high, ranging from 71.06 to 76.34% (Table 5). However, there were no significantly different between treatments in terms of carbohydrate content ($P>0.05$).

3.3. Hardness of Lindur Fruit-Potato Simulation Chips

The crispness of lindur fruit-potato simulation chips can be determined from the hardness. The highest hardness value means that the chips are hard and not crispy. In contrast, the more crispy the chips, the lower hardness value. Result showed that substitution lindur fruit flour to the simulation chips formulation produced the chips with significantly different hardness value ($P<0.05$). Simulation chips with the ratio of potato and lindur fruit flour of 40:60% produced lower hardness value compared to other (Figure 1). The lowest value was obtained from simulation chips with the ratio of lindur fruit flour and potato flour of 40:60 without addition of shrimp shell powder, i.e. 341.4 g/cm^2. Higher hardness value obtained from the ratio of lindur fruit flour and potato flour of 50:50, i.e. 403.2-462.9 g/cm^2. This result is in line with a study conducted by Sarofa et al. (2011) in which lower proportion of lindur fruit flour formulated in chips demonstrated lower cracking point, meaning that it has higher crispness. Based on the raw materials analysis, lindur fruit flour has lower amylopectin content i.e 23.93% (Table 3). Ratio of amylose-amylopectine contributes to the swelling capacity of product (Supriyadi, 2012). Higher amylopectin content plays role in the gelatinization process during heating, producing elastic structure, higher swelling capacity and lower hardness and vice versa (Anindita, Sukardi, & Santosa, 2013; Istanti, 2005; Supriyadi, 2012). Crackers with higher swelling capacity were also found

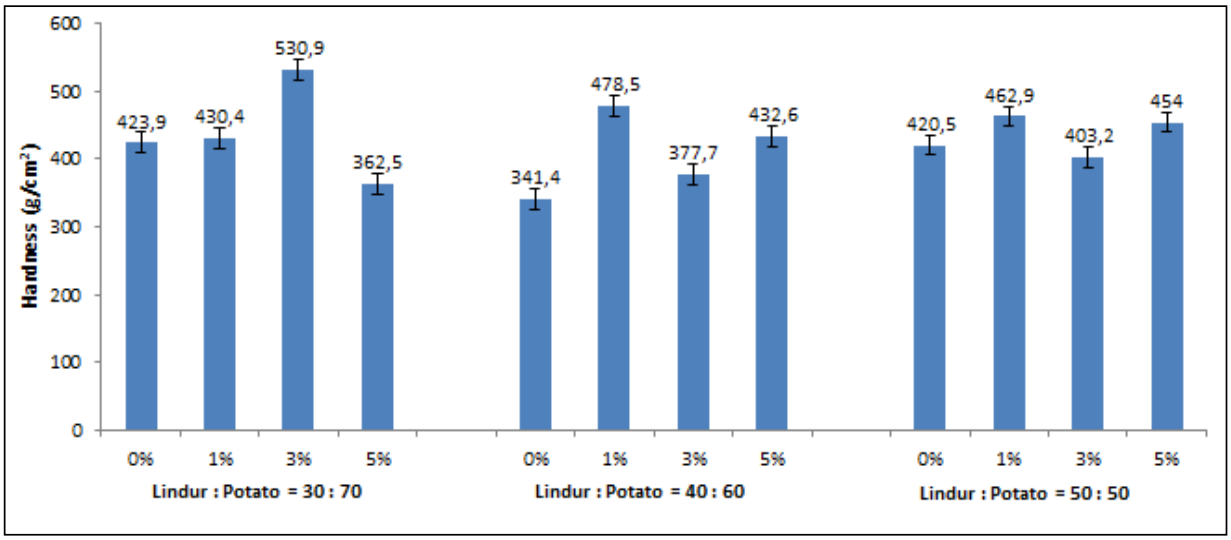

Figure 1. Hardness of lindur fruit-potato simulation chips enriched with shrimp shell powder.

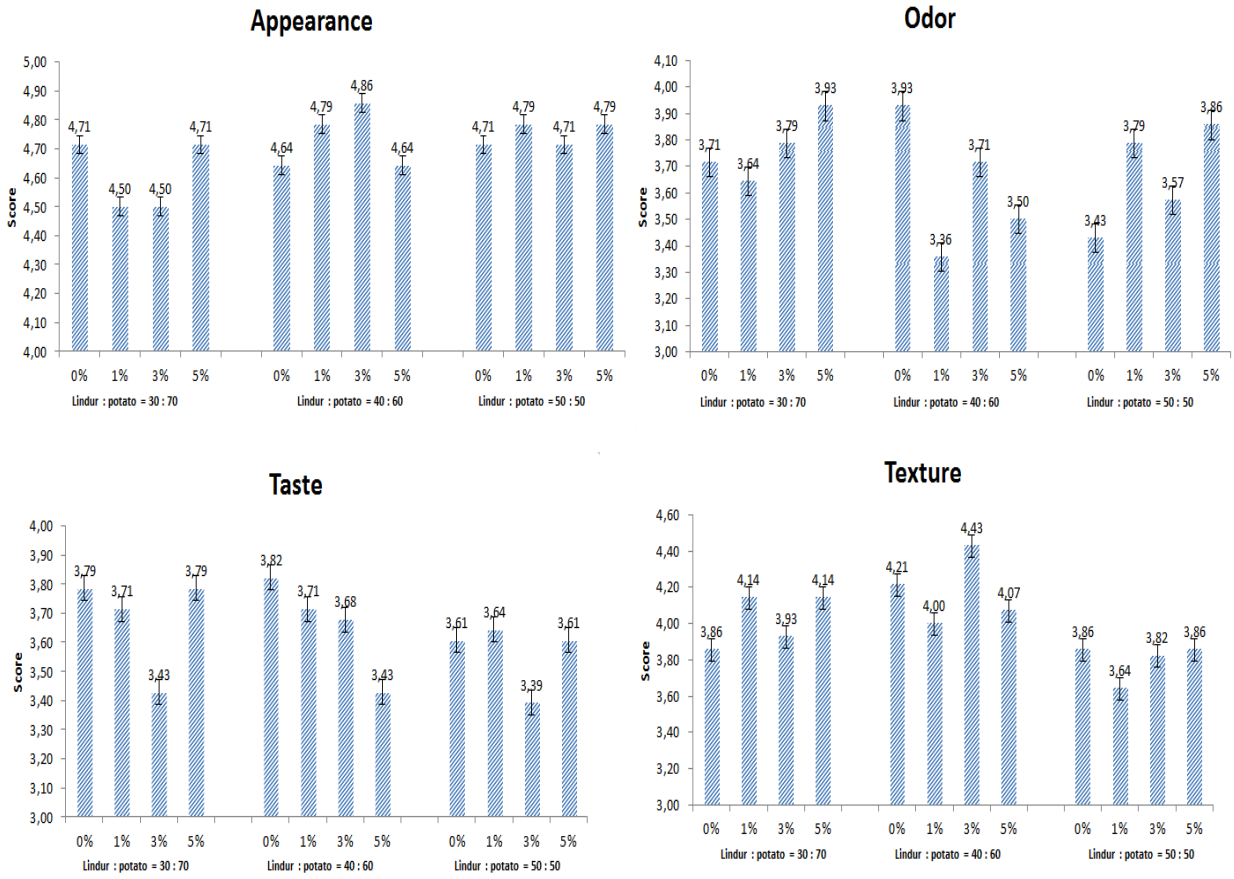

Figure 2. Results of descriptive scoring test of lindur fruit-potato simulation chips.

to have higher crispness (Siswantoro, 2009; Supriyadi, 2012). However, hardness values at some points, such as at ratio lindur fruit flour: potato flour of 30:70 with 0 and 3% shrimp shell powder were also high which might be caused by unevenness in the thickness of the samples due to manual sheeting process.

In addition, shrimp shell powder added into the formula affected differently to the hardness of simulation chips ($P<0.05$). Addition of 1% of shrimp shell powder produced higher hardness values for all ratios of lindur fruit flour and potato flour, while increasing concentration to 3 and 5% either increase or decrease the hardness values of the chips. Addition of 3% shrimp shell powder at the ratio of lindur fruit flour and potato flour of 30:70 increased the hardness of the chips dramatically, but at the ratio of lindur fruit flour and potato flour of 40:60 and 50:50 decreased the hardness significantly. Conversely, addition of 5% shrimp shell powder at the ratio of lindur flour and potato flour of 30:70 decreased the chips hardness.The chips hardness values increased dramatically at the ratio of lindur fruit flour and potato flour of 40:60 and 50:50. The addition of 3% shrimp shell powder was considered to be the best concentration that can improve crispness texture of simulation chips since it caused lowest hardness at the ratio of lindur fruit flour and potato flour of 40:60 and 50:50.

3.4. Sensory Evaluation of Lindur fruit-potato Simulation Chips

Lindur fruit-potato simulation chips were assessed by two different test, namely descriptive scoring test and hedonic test. Result of descriptive scoring test indicated that the use of lindur fruit flour: potato flour with ratio of 40:60 produced higher score compared to others (Figure 2). It is showed by the highest score for attribute of appearance (4.86) obtained by the addition of shrimp shell powder 3%, and for attributes of odor (3.93), taste (3.82) and texture (4.21) obtained by the use of lindur fruit and potato flour at the ratio of 40:60 without any addition of shrimp shell powder (0%). It revealed that the addition of shrimp shell powder did not induce the sensory attribute changes according to the panelists ($P>0.05$).

According to the score sheet of descriptive scoring test, the score of 4.86 for appearance means that the chips were approaching the highest value of score i.e neat shape, not perforated, flat surface and intact.

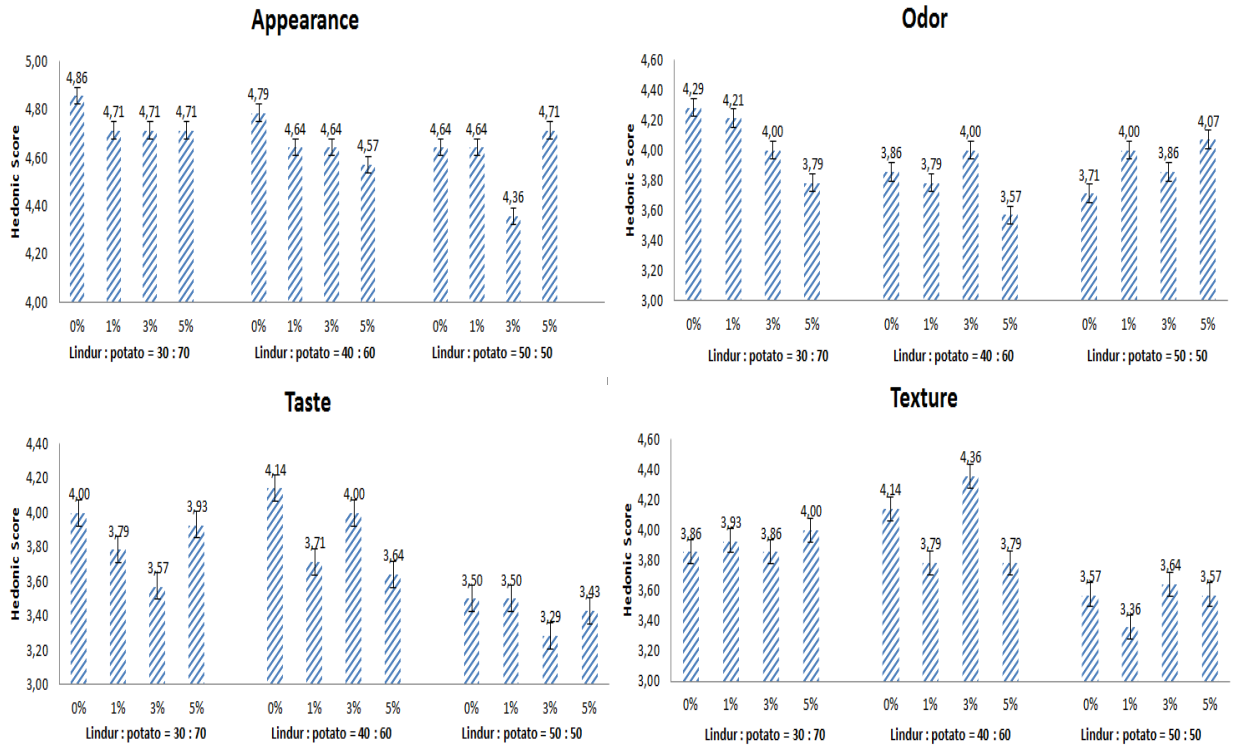

Figure 3. Results of hedonic test of lindur fruit-potato simulation chips.

For attribute of odour, the score of 3.93 means that the chips had savory smell and slightly strong desirable flavor; while the score of 3.82 for attribute of taste, means that the chips were less tasty and less savory but without disturbing taste. The score of 4.21 for attribute of texture means that the chips were less hard but easy to chew.

Statistic anaysis using Kruskal-Wallis test showed that there was no significantly different between treatments (P>0.05). Ratio of lindur fruit flour and potato flour of 40:60 was considered to give the best end products. The ratio yielded higher score for texture, appearance and taste, although it was slightly lower for odor. Texture, appearance and taste are the most important attribute for fried foods, including simulation chips, to be accepted by consumers (Olivares, 2010). Addition of 3% shrimp shell powder in the formula (40:60) was considered to be the best treatment since the products had the highest texture and appearance scores. However, good characteristics of odor also necessary to make the product more attractive for the consumers. Therefore, further effort should be taken to improve the odor of the simulation chips.

The result of hedonic test of lindur fruit-potato simulation chips is presented in Figure 3. Results of hedonic test showed that each formula demonstrated different panelist preferences of the chips. The trend was similar to the result of descriptive scoring test, meaning that the best characteristic of each attribute was chosen as the most preferred by panelists. For attribute of appearance and odor, the most preferred chips were obtained from the ratio of lindur fruit flour and potato flour of 30:70, while for attribute of taste and texture panelist preferred chips processed from the ratio of lindur fruit flour and potato flour of 40:60. The highest hedonic score for attribute appearance and odor was obtained from the ratio of lindur fruit flour and potato flour of 30:70 without addition of shrimp shell powder, i.e. 4.86 and 4.29 respectively. While for attribute of taste, the best chips was obtained from the ratio of lindur fruit flour and potato flour of 40:60 without shrimp shell powder (4.14) and for the texture was from the ratio of lindur fruit flour : potato flour of 40:60 with 3% of shrimp shell powder (4.14).

Based on the results, it can be concluded that to obtain simulation chips with sensory attributes preferred by panelists, still need some adjustments in the proportion of lindur fruit flour and potato flour. Ratio of lindur fruit flour and potato flour in the range of less than 40:60 might be considered to apply in the next study to get optimum quality of simulation chips. Addition of lindur fruit flour higher than the ratio mentioned above might affect the product appearance since the chips expressed darker color. In contrast, lower concentration of lindur fruit flour produced a

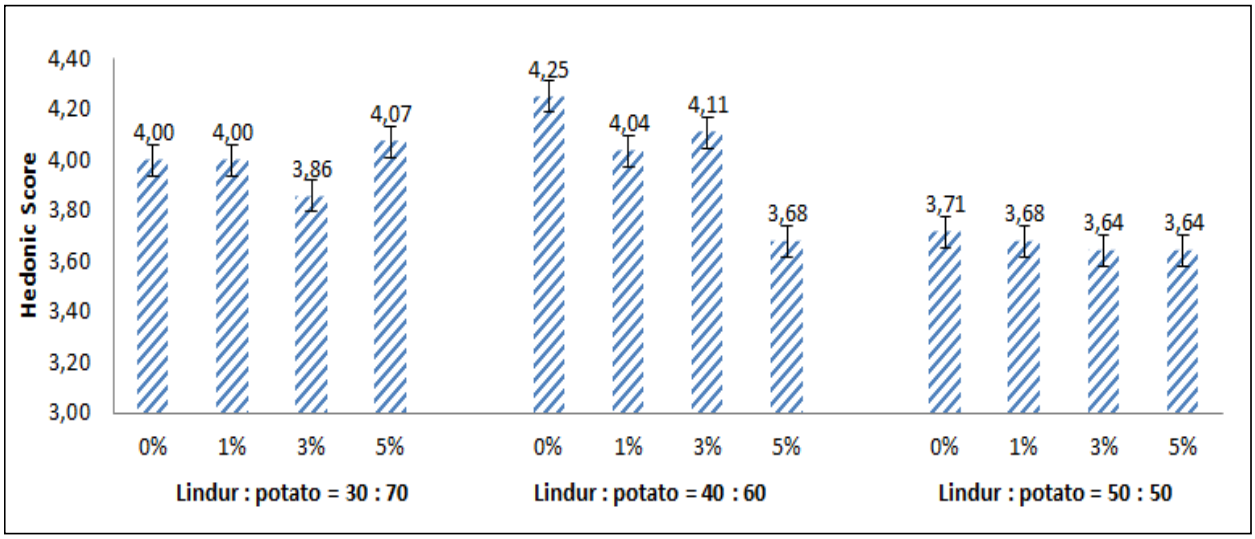

Figure 4. Overall panelist preference of lindur fruit-potato simulation chips.

specific colour to the chips after being fried. Similar phenomenon was occurred for odor, which is usually used as an indicator of material deviation. Panelists prefered chips formulated with the lindur fruit flour and potato flour ratio of 30:70. This is due to specific lindur fruit aroma which might influence the odor of simulation chips when added at higher proportion.

However, statistic analysis using Kruskal-Wallis test showed that there was no significant different between treatments (P>0,05). Ratio of lindur fruit flour and potato flour of 40: 60 was considered to be the best treatment that resulted in higher score for attributes of texture and taste. This fact is in accordance with the result of overall panelist preferences (Figure 4). Panelist chose simulation chips from lindur fruit flour and potato flour ratio of 40:60 formula. This result indicates that the use of lindur fruit flour and potato flour ratio of 40:60 produced chips with better characteristics and more preferable compared to other formula. This result was also in line with the result of hardness showing that lindur fruit flour and potato flour ratio of 40:60 produced the lowest hardness compared to others, meaning that this formula produced crispy chips (Figure 1). According to Sarofah et al. (2011), lower proportion of lindur fruit flour added to the formula produced higher fracturability and higher crispness.

Overall panelists mostly preferred simulation chips using the ratio of lindur fruit flour and potato flour of 40:60 without addition of shrimp shell powder. However, addition of 3% shrimp shell powder to the formula also produced slightly different panelist preferences to the simulation chips, with score of 4.11. Therefore, the ratio of lindur fruit flour and potato flour of 40:60 as well as 3% of shrimp shell powder were considered as the best treatment among of them.

4. Conclusion

Lindur fruit-potato simulation chips added with shrimp shell powder had 3.22-4.42% moisture content, 3.33-4.94% ash content, 3.77-5.83% protein content, 14.59-19.04% fat content, 71.06-76.34% carbohydrate content and 341.4-530.9 g/cm^2 hardness. Ratio of lindur fruit flour and potato flour of 40:60 as well as 3% of shrimp shell powder were recommended to be used in the formula for the production of crispy and tasty chips. Further study is suggested to improve chips appearance and odor.

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