Conference Paper

Study on the Physical Characteristics of Macaroni Made of Cassava Waste and Corn Flour by Applying Different Sizes of Die Extruder and Frequency of Moulding

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Abstract

The frequency of moulding using a die size can affect the texture of pasta. Macaroni that use cassava waste and corn flour (macaroni *Raja*) as raw material had a good appearance, but its texture was brittle. Therefore, the appropriate pressure was needed to improve the brittle's texture. Providing the proper pressure can be implemented by setting the frequency of moulding and the size of die used. The objective of study was to determine the appropriate frequency of moulding with the size of extruder die so that it produces macaroni with the best characteristics. The method used in this study was random analysis design with 4 treatments and 6 repetitions. The treatments include one time with big die, one time with small die, two times with big die and two times with small die. The results of study showed that two times moulding by using small die gave the best result, which contains 2.935,911 gF of hardness before rehydration, 106.05% rehydration power, 0.9687 gF of rubberiness, 1,223.488 gF of hardness after rehydration, -2.3389 gF of adhesiveness and 9.15% of solid lost from cooking.

Keywords: Moulding, die size, macaroni, texture, composite flour.

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1. Introduction

Diversification of food is an effort to increase the availability of various food that based on local resources to meet diverse food consumption pattern, balance nutrition, and food safety, as well as to develop food businesses and improve the welfare of society [1]. One effort to diversify food is optimization of local food in accordance with the potency and local wisdom. Local food usually is processed into flour to keep the shelf life of raw material longer and to make it easier for further processing. The used flour can be single flour, which was made of just one kind of raw material or composite

flour, which made of two or more sources of raw material. The use of composite flour is to get the proper characteristics of the raw materials in accordance with the desired product and has a certain functional characteristics [2]. Composite flour can also be used for making various kind of processed food such as cakes, cookies, bread, biscuits, noodles and many other kind of pasta. Pasta is produced commercially into various forms, one of those is macaroni, the product that liked by many people because it is easy to prepare, very practical and it can be used as main ingredient in different type of cooking. In addition, macaroni is relatively easy to be produced, packaged and durable in storage.

Composite flour of corn and cassava waste, in this paper which is refered as *Raja*, is local raw material that can be used in making macaroni and it also has an advantage in the appearance of yellow color. Therefore, this raw material can produce macaroni with the color similar to the commercial macaroni [3]. Pasta that is made of composite flour of non-wheat differs with those made of wheat flour. The different is in the gluten content. When the gluten in wheat flour is kneaded, it can form dough that is cohesive, extensible and elastic, whereas non-wheat flour do not contain gluten. This becomes problem in the making of pasta from composite flour made of cassava waste and corn flour (*Raja*). Appropritae processing is essential in order to obtain the characteristic of pasta in general.

Technology of extrusion is applied in the production of pasta that use composite flour as raw material where the formation of the dough rely on pressure and proper slide movement of moulding and the gelatinization process to obtain the best characteristics [4]. The gelatinized starch acts as binding material in pasta making and it plays a role in forming the dough so that it influences the dough and the characteristic of the resulting pasta [5]. The dough of pasta that has been gelatinized will produce better pasta macaroni if receiving enough pressure during moulding. Process of delivering pressure gives an influence to the characteristic of the resulting products because it has an important role in the formation of product structure [6]. Proper amount of pressure becomes an essential procedure in the making of composite flour to produce a good product. One method of giving enough pressure is by increasing the frequency of moulding or moulding repetition to obtain stronger section of pasta and not easy to be broken off or brittle [7]. Another factor related to the moulding of extruder is the die sizes used. Pressure on flow rate of the extruder was influenced by the size of die [8]. The use of different die sizes in the extruder will influence pressure difference received by the dough when moulding. In addition, the right size of the die is aimed to suit the required pressure that is needed in moulding to produce macaroni pasta with the best characteristics. Good quality of pasta [9] should be low value in the cooking lost,

hardness, stickiness, high elongation and high rubberiness. Based on this explanation, the characteristics of composite flour of cassava waste and corn (*Raja*) is influenced by the appropriate pressure and the die sizes of extruder that is used to obtain the best characteristics of pasta macaroni. The aim of this study was to determine the frequency of the dough moulding and the use of appropriate die sizes of extruder to obtain pasta macaroni with the best quality.

2. Materials and Methods

Materials used in this study were cassava waste flour of *Karikill* clone, corn flour of Pioneer 21 varieties, eggs, salt, olive oil and water. Comoposition of cassava waste flour and corn flour was 20: 80. The materials were prepared into dough. Tools used in this study consisted of a cold extruder, oven, pan, analytical balance, spoons, knives, spatulas, steamer, basin, gas stove, disc mill and a sieve of 80 mesh. Equipments used for analysis were oven, stainless steel bowls, desiccator, iron clamp, panic and texture analyzer.

Research method used was based on Experimental Method by using Randomized Block Design (RBD), consisting of 4 treatments and 6 repetitions. The treatments tested were the frequeny of moulding and the different sizes of die extruder as follows, A = Macaroni 1time moulding with Big Die (BD, outer diameter 0.9 cm and inner diameter 0.7 cm), B = Macaroni 1time moulding with Small Die (SD, outer diameter 0.7 cm and inner diameter 0.5 cm), C = Macaroni 2times moulding with Big Die (BD, outer diameter 0.9 cm and inner diameter 0.7 cm) and D = Macaroni 2 times moulding with Small Die (SD, outer diameter 0.7 cm and inner diameter 0.5 cm).

3. Results and Discussion

Statistical test showed that frequency of moulding with different die sizes gave significantly different value on the hardness of macaroni *Raja* before rehydration (see Figure 1). Hardness values was influenced by the frequency of moulding and die sizes used. Higher moulding frequency with smaller die sizes resulted in the greater hardness on macaroni *Raja*. Moulding 2 times with small die can produce greater pressure, where the higher the pressure, the greater the hardness.

Die sizes influence pressure in the extruder, where, the smaller the size of die, the greater the resulting pressure [10]. Two times moulding produces greater compression level compared with 1time moulding [11].Therefore, moulding out 2 times with smaller

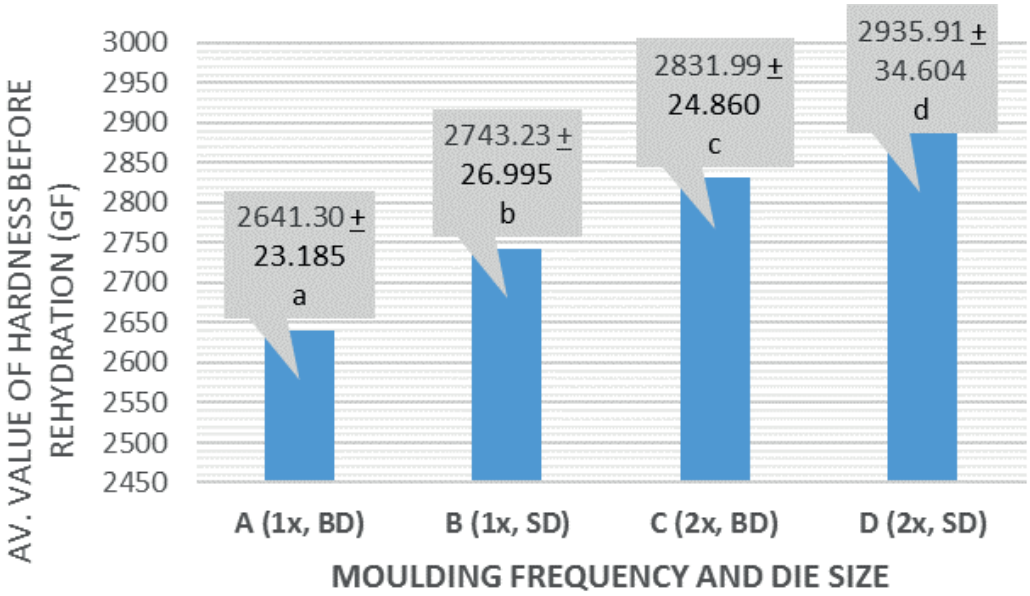

Figure 1: The Influence of Moulding Frequency and Die Sizes on Hardness. Figures marked with the same letter, are not significantly different at 5% level.

dies resulted in a greater pressure. The increasing pressure will give macaroni with the greater hardness value. The more pressure will give macaroni with greater hardness [4]. This statement is in accordance with the analysis result of 2 times moulding treatment, by using small die that producing the highest hardness value, has the highest hardness of 2935.911 gF.

These results were in accordance with Muhandri [4] that level of compression on the dough will determine the texture of product and the bond between particles, where appropriate compression level will produce product that has strong holding capacity. During the moulding process, pressure and friction on the dough occurred, causing the rupture of starch granules so that the free amylose content of starch granules increases. The more quantity of amylose were freed, the harder the resulting product. Based on this description, the more pressure is given, the harder the resulting macaroni.

Moulding process of macaroni *Raja* involves heat energy generated from friction between materials and materials with the extruder barrel. The existing heat influences protein structure, where high temperature causes intermolecular bonds in protein, so that the protein was denatured. Denatured protein causes changing in the configuration of polipeptide chain, and the protein molecules become tight, resulted in the hard product characteristic [12]. The higher the compression level at moulding, the higher the friction between materials to produce hard texture. Extruder used in the making of macaroni *Raja* was cold extruder type, so that heating process was conducted outside

extruder. Heating was carried out in a dryer oven at 70°C for 4 hours. Drying is a transformation process of heat and water simultaneously [5]. Hot air that brought by dryer media, was used to evaporate water present in the material, so that it will produce product with low moisture content. The more water in material is evaporated, the product of macaroni *Raja* becomes drier and harder.

During drying, formation process of strong matrix structure occurred through hydrogen bonds between amylose in a food stuff. The formation of matrix structure of amylose causes macaroni *Raja* became harder. The more quantity of amylose freed during gelatinization and moulding processes, made the matrix structure formed during drying in the oven became strong, producing macaroni *Raja* with higher hardness. Amylose that was freed from starch granule will form strong matrix structure through hydrogen bond during 'retrogradation' process. Macaroni *Raja* of 2 times moulding with small die resulted in product with the highest hardness value of 2935.911gF.

Hardness of macaroni *Raja* before rehydration is expected to have high hardness value. The high value indicates that the resulting macaroni *Raja* has strong, not brittle and not easily broken characteristics. Commercial macaroni has a hardness value of 3948.398 gF. Present study showed that the highest hardness value of 2935.911 gF. This was obtained from macaroni *Raja* derived from 2 times moulding, using small die. Resulting product has a smaller value compared with the control value, so that macaroni *Raja* product was less hard compared with commercial macaroni.

3.1. Rehydration Power of Macaroni Raja

Based on the statistical test, frequency of moulding, using different die sizes did not give significant difference on the rehydration power of macaroni *Raja*. The effect of moulding frequency using different die sizes on the macaroni *Raja* is shown in Figure 2. The absorption of product water is influenced by total content of amylose and amylopectin [13]. Frequency of moulding using different sizes of die will influence product structure as a result of compression level on the dough but do not change the amount of amylose and amylopectin of foodstuff. During moulding process, the pressure and friction on the dough causes flour granules, broken, so that amylose freed from starch granules increases [4]. Amylose that freed from starch granules will form strong matrix structure through hydrogen bonds during retrogradation. Amylose has a straight and narrow chain, resulting in a hard texture. Frequency of moulding using different sizes of die give an influence to the macaroni hardness, but does not influence water absorption power or rehydration.

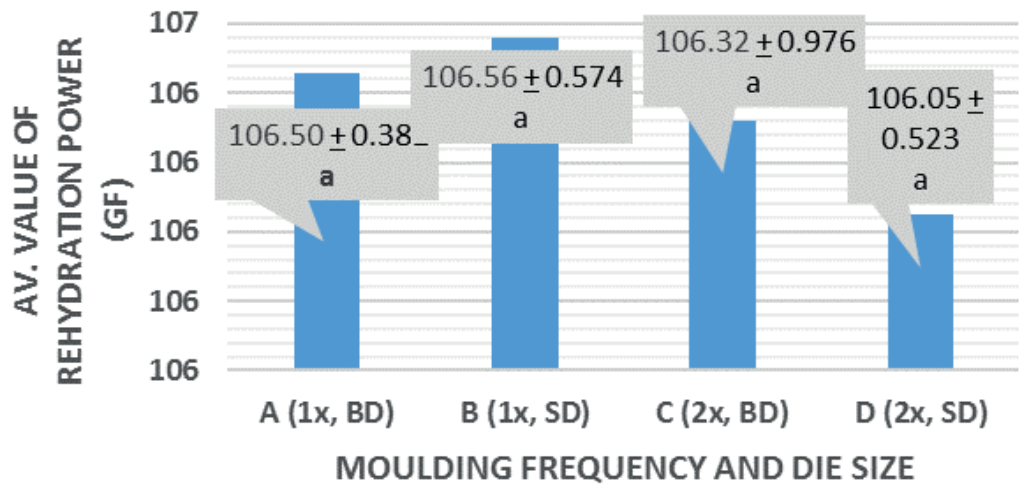

Figure 2: The Influence of Moulding Frequency and Die Sizes on Rehydration. Figures marked with the same letter, are not significantly different at 5% level.

3.2. Rubberiness of Macaroni Raja after Rehydration

Frequency of moulding, using different sizes of die, gave significant different effects on the rubberiness of macaroni after rehydration (Figure 3). Rubberiness value is influenced by moulding frequency and the die sizes used. High frequency of moulding using smaller size of die produces the greater rubberiness value. Moulding out 2 times by using small die produce higher pressure, which is in turn, this higher pressure will produce greater rubberiness value. The combination of the frequency of moulding with die sizes affects the degree of compression during moulding. Putra (2008) stated that the compression rate is influenced by the frequency of moulding and the die sizes used. Moulding twice (2 times) generate greater compression rate than moulding one time (1 time). Smaller dies produce greater pressure because the pressure is inversely proportional to the area of mold die. So, moulding 2 times using smaller dies produce a greater pressure.

Increasing pressure produces macaroni with the higher rubberiness [4], i.e, moulding 2 times with small dies with the rubberiness value of 0,9687gF. Furthermore, there are several factors that must be met in order to produce good pasta, gelatinization, compression or pressure and shear stress or appropriate friction. Flour, the raw material for making pasta requires sufficient compression during moulding. This is because the starch granules are still stuck in the flour granule so that it is essential of having breakdown mechanisms in flour granules. Breaking down of flour granules aims to separate starch from the flour granules, in order to be gelatinize well in the heating process.

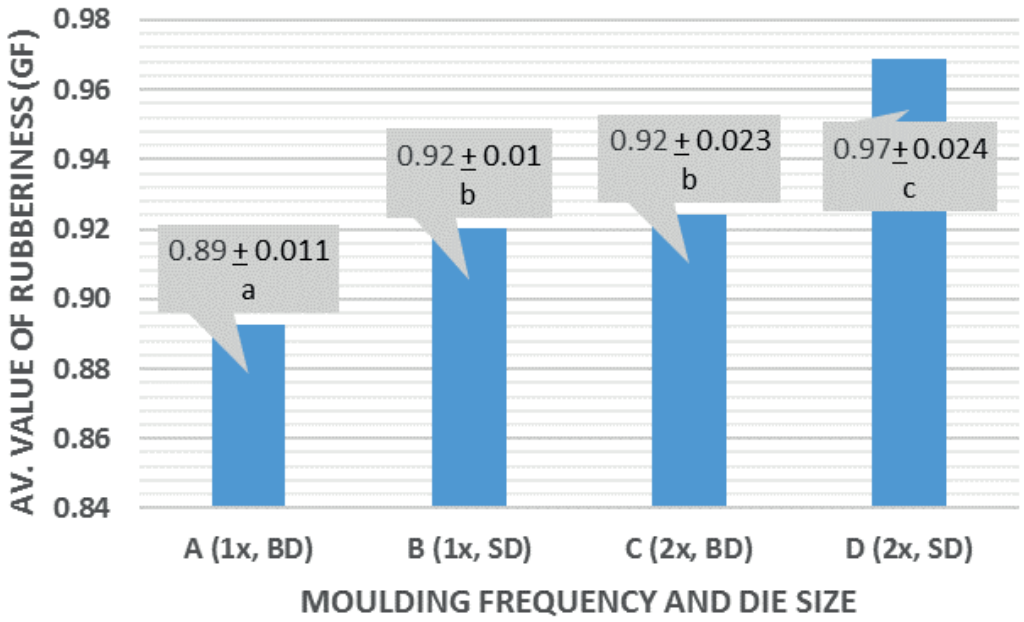

Figure 3: The Influence of Moulding Frequency and Die Sizes on the Rubberiness after Rehydration. Figures marked with the same letter are not significantly different at 5% level.

The level of pressure at the time of moulding, gave an influence on gelatinization. Gelatinization is not only influenced by water and heat, but also affected by pressure. With a high shear stress, does not need a lot of water for the gelatinization [14]. The heat caused by friction between particles the time of moulding, and the pressure given during moulding will increase the gelatinization of macaroni. Starch gelatinization process causes the macaroni can form mass that elastic cohesive, so that the higher the degree of gelatinization, the higher the rubberiness of macaroni after rehydration [6]. Macaroni *Raja* with 2 times moulding, using smaller dies has the highest gelatinization value because this was the treatment that has the highest degree of compression and friction between raw materials, producing the most chewy macaroni *Raja* with a value of 0.9687 gF. Dry pasta was rehydrated by boiling in hot water to produce a cooked pasta with chewy characteristics. Rubberiness of pasta was produced due to penetration process of water into the dry pasta when boiling. Hot water absorbs into the starch granules because the starch granules have a very large hydroxyl group [12]. Penetration of water on the starch granules that has the highest levels of gelatinization produce macaroni *Raja* that has a high level of rubberiness as well. Macaroni *Raja* that printed 2 times with small dies produce macaroni *Raja* with the most rubberiness with the value of 0.9687 gF.

The expected rubberiness value of macaroni *Raja* is high rubberiness values. High value of rubberiness showed that the resulting macaroni *Raja* has the characteristics

of chewy, elastic cohesive and not brittle. Based on the analysis, the rubberiness value of commercial macaroni is 0.995 gF. The highest rubberiness value was obtained from macaroni *Raja* with 2 times moulding using smaller dies that is equal to 0.9687 gF. The resulting product has a smaller rubberiness value than the control product, so that the macaroni *Raja* products were less chewy than the commercial macaroni.

3.3. Hardness of Macaroni Raja after Rehydration

Frequency of moulding with different die sizes provides a significantly different effect on the hardness of macaroni *Raja* after rehydration (Figure 4). Hardness after rehydration was affected by the frequency of moulding and die size used. Moulding 2 times with a small die can produce a greater pressure with greater pressure levels can also produce greater hardness value after rehydration. This is in accordance with the statement that moulding 2 times using smaller die sizes produces greater pressure, whereby a greater pressure can also produce greater hardness value [11].

Hardness of pasta is not only affected by gelatinization but also influenced by the microstructural changes due to the level of pressure when moulding [9]. The higher the level of pressure, the higher the density of macaroni, it causes less penetration of water and heat into macaroni pasta during cooking. Based on this, macaroni hardness increases with the degree of compression, as with macaroni *Raja* with moulding 2 times, using smaller die sizes, has a high hardness value of 1223.488 gF. The hardness value of macaroni *Raja* after rehydration is expected to have low hardness value. Low hardness value indicates that the resulting macaroni *Raja* identic with soft texture. Pasta is identic with chewy texture, so it is expected to have rubberiness texture, instead of hard.

Based on the analysis results, the hardness value of commercial macaroni is 1683.6385 gF. The highest hardness value is the treatment with 2 times moulding, using smaller dies that is equal to 1223.488 gF. The resulting product has a greater value than the control, so that the macaroni *Raja* products was not harder than the commercial ones.

3.4. Stickiness of Macaroni Raja after Rehydration

Figure 5 shows that frequency of moulding using different sizes of die gave significant effect on the stickiness levels of macaroni *Raja* after rehydration. Stickiness value is influenced by the frequency of moulding and the size of die used. Higher moulding

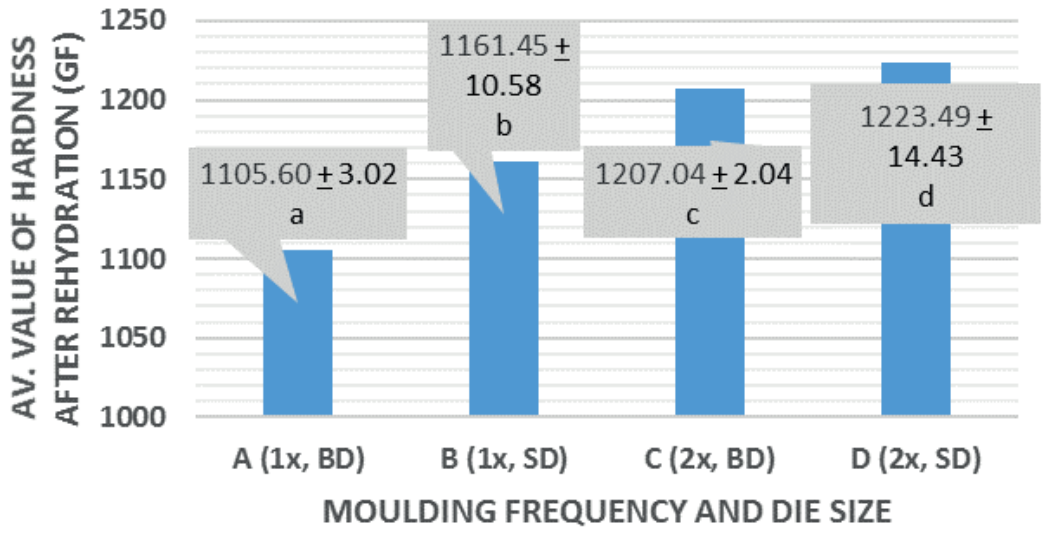

Figure 4: The Influence of Moulding Frequency and Die Sizes on the Hardness after Rehydration. Figures marked with the same letter are not significantly different at 5% level.

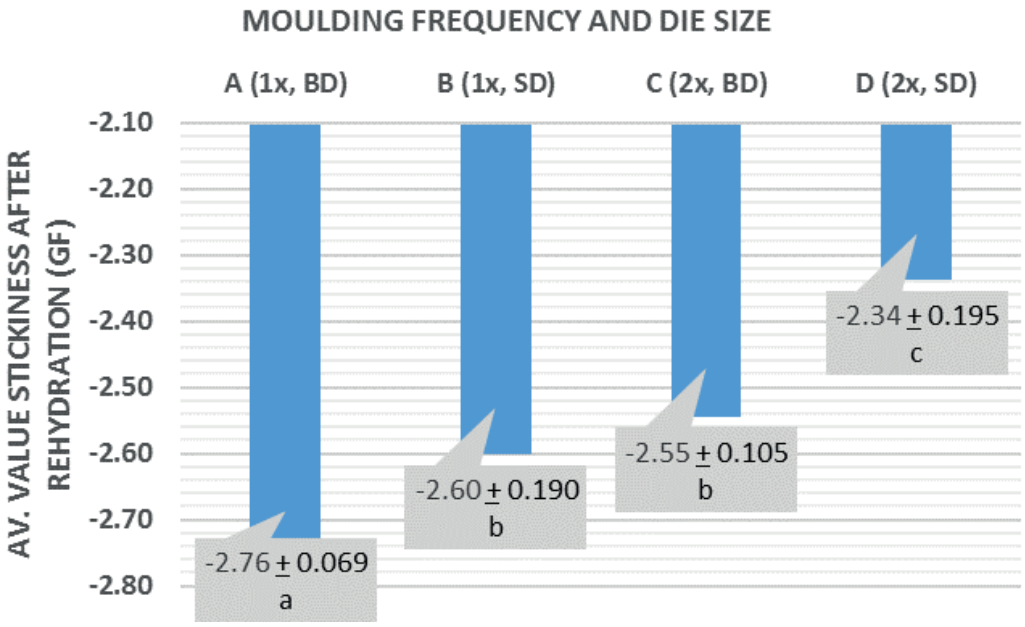

Figure 5: The Influence of Moulding Frequency and Die Sizes on the Stickiness after Rehydration. Figures marked with the same letter are not significantly different at 5% level.

frequency with smaller die sizes can generate the greatest pressure, so that resulting macaroni has a smaller stickiness value. Stickiness value was based on o value of the x-axis. If the value is away from the o value, then the stickiness value becomes greater. However, if the value is closer to the value of o, the stickiness value becomes smaller. Moulding 2 times generates small stickiness value, because it is the most distant from the o value x-axis.

The higher the rate of gelatinization, the more amylose out of the starch granules [9]. The more amylose out of the starch granules, the hydrogen bonding between amylose will be increasingly formed when retrogradation. This causes the stickiness of the pasta to decline. Friction as well as the higher levels of compression will increase the gelatinization and causes the decrease in stickiness of pasta macaroni. Friction and compression rate was the highest in the treatment of two times moulding, using small die sizes, resulting in the macaroni *Raja* with the lowest stickiness value of -2.3389 gF. Starch gelatinization is caused by temperature, pressure and friction. Gelatinization increased at a rate of higher friction, the time and of the higher process temperatures [6]. Better gelatinization makes hydrogen bonds between amylose well formed, so that amylose on the macaroni was not easily separated when the macaroni was cooked, which resulted in the decrease in stickiness. Cooking macaroni raja with 2 times moulding, using small die sizes produces the least sticky macaroni. This is because the amylose on the surface were not easily separated when the macaroni was cooked, indicating a structure of macaroni that formed was strong.

Stickiness value of macaroni *Raja* after rehydration, was expected to have a low stickiness values. Low stickiness value indicates that the resulting macaroni raja has a good appearance and a good texture.

Based on the analysis, the stickiness value of commercial macaroni is -3.528 gF. The lowest stickiness value of macaroni *Raja* was given by the treatment of 2 times moulding, using smaller die that is equal to -2.3389 gF. The resulting product has a smaller value than the control, so that product of macaroni raja was not more sticky compared with the commercial macaroni.

3.5. Solid Lost from Cooking

Frequency of moulding using different die sizes, according to statistical analysis, provided significant different influence on the solid lost from cooking (Figure 6). The value of 'solid lost from cooking' was influenced by the frequency of moulding and the size of die used, where high moulding frequency with smaller die sizes will produce the smaller lost solid values. Moulding 2 times using small die can produce a greater pressure, resulting in small solid lost values.

Moulding frequency using different die sizes affects gelatinization level of pasta macaroni. The higher the frequency of moulding with smaller die sizes produce greater pressure, resulting in greater gelatinization levels. This is because the level of gelatinization will increase at a rate of higher friction, time and process temperatures [6].

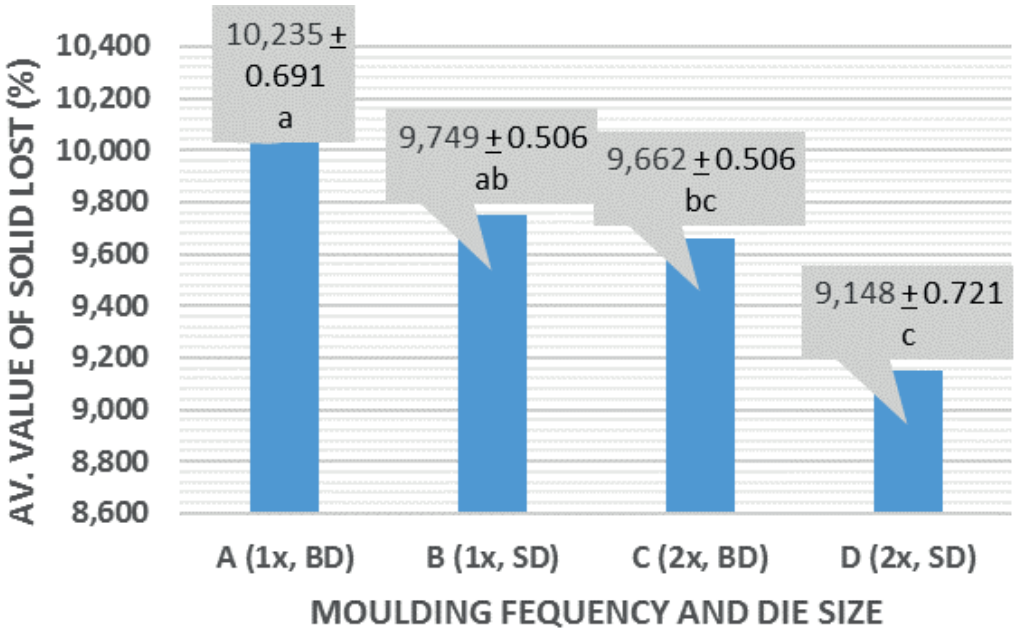

Figure 6: The Influence of Moulding Frequency and Die Sizes on the Solid Lost from Cooking after Rehydration. Figures marked with the same letter are not significantly different at 5% level.

The solid lost from cooking depends on gelatinization that occurred [9]. Gelatinization that occurred perfectly can cause more amylose released from the starch granules. This led to a growing number of hydrogen bonds formed between polymer amylose which makes the structure of pasta became more solid and not easily broken when cooked. Macaroni *Raja* with 2 times moulding, using small die produces macaroni with the lowest value of solid lost that is equal to 9.75%. These results were in accordance with the previous statement, that moulding 2 times with a small die will produce the highest level of gelatinization, so when macaroni was cooked it will have the lowest value of solid lost due to the amylose matrix that formed was strong.

Macaroni *Raja* with the treatment of 2 times moulding, using small die with the highest pressure level has the lowest solid lost value, which is in accordance with the statement [15]. Moreover, the high solid lost levels was due to the dough is not enough undergoes compression and shear, so that the structure of the pasta less strong. The lower the value of solid lost, the better and the more homogenous the resulting pasta.

The expected solid lost value of macaroni *Raja* is the lowest value, because it indicates that the produced macaroni raja has a fine texture and homogeneous thus not easily broken when cooked. Analysis data shows that the solid lost in commercial macaroni value was 9.93%. The highest solid lost value was on macaroni *Raja* of 2 times moulding with smaller dies that was equal to 9.15%. The resulting product has

a smaller value than the control, so that the macaroni *Raja* products after rehydration had less solid lost compared with commercial ones.

3.6. Characteristics of the Dough

The characteristics of dough were observed for degree of hardness, stickiness, and rubberiness. The resulting dough had a hardness value of 464.658 gF, stickiness of -27.2496 gF, and the value of rubberiness of 0.1867 gF. The process that occurs in dough preparation was the mixing process, where dry raw materials were mixed with liquid raw material. Water that was mixed with flour while mixing the raw material caused the starch granules in the flour absorb water and swollen. The absorption of water by the starch granule has not entered to a stage of gelatinization, because there is no influence of high temperatures that cause gelatinization process [16]. Gelatinization process can cause the dough becomes hard, chewy and not too sticky. The hardness, stickiness and rubberiness of the observed dough, did not have a high value, this is due to the gelatinization has not occurred.

4. Conclusions

Frequency of moulding using different die sizes provided a significantly different effect on macaroni *Raja* in terms of hardness prior to rehydration, rubberiness after rehydration, hardness after rehydration, stickiness after rehydration and solid lost due to cooking, as well as providing non significant effect on the rehydration power. Macaroni *Raja* that was produced at a frequency of moulding 2 times using small dies size (outer diameter 0.7 cm and inner diameter 0.5 cm), produces macaroni *Raja* with the best physical characteristics. This product has a hardness value before rehydration 2935.911 gF, rehydration power 106.05%, rubberiness 0.9687 gF, hardness after rehydration 1223.488 gF, stickiness -2.3389 gF and solid lost due to cooking 9.15%.

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