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Effect of streaming process on the quality of wheat (*Triticum aestivum* L.) kernel during extraction

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Abstract

Streaming is a process of routing wheat flour streams to produce flour products and continuing with the milling process using plan-sifters. This machine has six ranges of opening mesh that produce six-grain granulations divided into several flour streams. This study aimed to assess the streaming process effect on the quality changes of wheat kernel extraction. The triplicates observation was conducted on the same 56 flour streams with different multi-wheat blends. The ash, protein, moisture, and gluten quality of blended wheat were analyzed. The streaming process significantly changed grain quality ($p<0.001$). Increasing the mesh width in the streaming process increased ash content ($p<0.05$) and protein content ($p<0.05$). In addition, there was a decrease in water content ($p<0.05$) and gluten content ($p<0.05$) at a wider mesh opening. The streaming process produces more than 72% wheat flour. This study showed the vital role of the streaming process in the quality determination of wheat flour produced.

1. Introduction

Wheat (*Triticum aestivum* L.) is one of the staples for people and is consumed by most people worldwide. National wheat consumption in Indonesia rose yearly, reaching millions of tons annually (Munandar *et al*., 2019). Indonesia still has to import it in large quantities from Egypt, Australia, the USA, and Russia (Nur *et al*., 2020). Wheat is a grain that produces a dry edible seed that is commonly called a kernel that has three layers of dry weight percentage; endosperm with 82-83%, germ (embryo) with 2.5-3%, and the bran/outer layers with 3-14% (Barron *et al*., 2007). Wheat is milled into flour which becomes a raw material for processed food products (Dziki and Laskowski, 2005; Dziki, 2008). It is divided into two physical properties: hard wheat with high protein and soft wheat with low protein. Dziki and Laskowski (2010) also indicated that both types have their functionality in making flour-based products.

Wheat kernel extraction is carried out by milling the kernel core to the outermost layer of the kernel epidermis (Interflour unpublished report, 2014). In most cases, it can be done by milling into flour products with varied granulation because it is only consumed after milling (El-Porai *et al*., 2013; Wang *et al*., 2015; Tosi *et al*., 2018). Wheat milling is grinding wheat kernels to separate the endosperm from the outer layers (germ and bran) (Hemery *et al*., 2007). Nutritional compositions in the wheat kernel are not uniform, depending on which part of the kernel has been extracted. Hemery *et al*. (2007) also mentioned that the germ contains mainly lipids and protein, and bran layers contain dietary fiber and many other essential nutrients. Refined flour is derived from the endosperm rich in the concentration of starch (Kaczmarczyk *et al*., 2012; Sanchez-Muniz, 2012). In addition, a study by Tosi *et al*. (2018) also mentioned that the endosperm part of the wheat accounted for 80% of the dry weight of starchy storage tissue, which corresponds to producing white flour yield.

According to Interflour's unpublished report (2014), wheat flour processing follows wheat preparation, formulation, cleaning, dampening (water conditioning), grinding, purification, reduction, nutritional fortification, and streaming processes. Furthermore, wheat flour has several flour fractions (granulations) based on its nutritional value, characteristics, and colors, such as wheat flour, industry flour (semolina), pollard, and bran

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(Oghbaei and Prakash, 2019). Streaming is the last purifying process in milling wheat kernels into wheat flour, which is a process of routing/tracking the wheat flour fractions into either the wheat flour bins or pellet bins through the flour streams (flour streams). The flour streams contain wheat flour as the result of the extraction of endosperm, germ, and bran layers of the wheat kernels. In a previously unpublished report from Interflour in 2014, the range of the flour size in each flour stream is 80-130 microns derived from the purifier, plan-sifter, bran finisher, and vibro finisher. The flour manufacturing industry usually has several mill regions to process wheat into flour. Generally, 20-35 plan-sifters are in one mill region, 3-6 purifiers, 3-5 bran finishers, and 2-4 vibro finishers. Furthermore, each purifier, plan-sifters, bran finisher, and vibro finisher has 1-2 flour streams.

The streaming process is an essential step in making wheat flour products. Miskelly *et al*. (2010) reported that it could be used to determine the quality of produced flour by combining in total – as a 'straight grade' or 'straight run' flour. In the streaming process, several flour streams were excluded; thus, the flour produced can follow the wheat flour industry's quality standard. The quality level of ash, moisture, protein, and gluten are the main parameters in determining the class of the end-products of the wheat flour produced. Several studies showed decreased wheat flour quality due to processing (Van Der Borght *et al*., 2005; Kushiro, 2008; Silva *et al*., 2012; Delcour *et al*., 2012). Since the streaming process plays an essential role in wheat milling, an analysis of its effects on the decrease of wheat flour quality was determined. This study aimed to observe the streaming process's influence on the wheat kernel's quality changes during extraction. Besides, it also aims to determine whether the streaming process affects the declined quality of wheat flour produced based on the parameter of ash, moisture, protein, and gluten.

2. Materials and methods

2.1 Preparation of multi-wheat blends for milling

The raw wheat kernels of Canadian Western Red Spring (CWRS) from Canada, Dark Northern Spring (DNS) from the USA, and Australian Hard (AH) from Australia were blended for multi-wheat milling. The blends were prepared using the CWRS: DNS: AH mixture in different blend ratios (Table 1). The blends were conditioned (dampening and tempering treatments) before being milled. This study was conducted on the streaming process floor, production building of PT. Eastern Pearl Flour Mill Makassar (Interflour Group), South Sulawesi, Indonesia.

2.2 Wheat flour quality in the streaming process

The streaming process effect on wheat flour quality in this study was observed through the 56 flour streams. Flour samples were obtained from each flour stream and analyzed for chemical properties, including ash, moisture, protein, and gluten.

2.2.1 Determination of ash, protein, moisture, and gluten levels

The level of ash, protein, moisture, and gluten of wheat kernels and flour was analyzed with Near-Infrared Spectroscopy (NIR) Test Instrument (Infratec^{TM} 1241 Grain Analyzer, FOSS, Denmark) (Miskelly *et al*., 2010).

Table 1. The quality of processed wheat kernels in mill A of the production plant at PT. Eastern Pearl Flour Mills (EPFM), Makassar, Indonesia.

Wheat Quality (%)	Wheat Type		
	CWRS	DNS	AH
Protein	16.2	16.5	13.5
Ash	1.56	1.55	1.22
Moisture	14.5	11.9	15.3
Gluten	39.6	40.1	32.2
Blends	45-85	5-25	15-35

CWRS: Canadian Western Red Spring from Canada, DNS: Dark Northern Spring from USA, AH: Australian Hard from Australia.

2.2.1.1 Wheat kernels

The gluten level before the wheat kernels were milled into wheat flour is known as dry gluten. Wheat kernels to be tested were placed in the NIR sample hole, then set up the "Wheat" option on the NIR Test Machine. NIR analysis results can show the value of moisture, protein, ash, and gluten content.

2.2.1.2 Wheat flour

The flour to be tested was placed in a container (NIR Flour Spot) that was cleaned with a brush. The surface is rubbed evenly, and the lid is attached to the container. Set up the "Flour" option on the NIR Test Machine. In this analysis, only moisture, protein, and ash values are shown (without gluten values).

2.2.2 Wet-gluten level of wheat flour

Gluten level after the wheat kernels were milled into wheat flour is known as wet-gluten, which is analyzed with Gluten Index Instruments (Glutomatic^{R} 2200 and Gluten Index Centrifuge, Perten/PerkinElmer Inc., United States) according to the company's laboratory standard. Briefly, 10 g of wheat flour was weighed and put into a special filter cup. Then, 4.2 mL of 2% NaCl solution was added into the filter chamber and shaken until the liquid covered the entire flour surface. The filter chamber was placed on the Glutomatic, the water collecting cup was placed under the filter chamber, and the process began. After filtering, the remaining flour (the fraction that does not dissolve in water) is removed. The fraction is placed into the sieve cassette and placed inside the Gluten Index Centrifuge (centrifuged at 6000 rpm in 60 s). After the stop alarm rang, the sample was removed from both sides of the sieve cassette and weighed. The following formulation measured the wet-gluten level of the flour.

$$\text{Wet gluten } (\%) = \frac{\text{Weight of Flour From Washing}}{\text{Weight of Sample}} \times 100\%$$

2.3 Yield

Milling yield is the percentage of flour produced from the wheat kernels' milling process. The following formulation measured the produced yield of wheat flour processing.

$$\text{Yield} = \frac{\text{Flour Produced}}{\text{Milled Wheat Seeds}} \times 100\%$$

2.4 Data analysis

This study's results were analyzed using analysis of variance (ANOVA) with SPSS version 22 (SPSS Institute, USA). The significance of differences was defined at $p<0.05$ with Duncan and Tukey's test (Liu *et al.*, 2015).

3. Results and discussion

In this study, the changes in wheat kernel quality (ash content, moisture content, protein content, and gluten content) occurred after getting through the streaming process ($p<0.001$), which can be seen in Figure 1. However, the streaming process has different effects in altering the quality of wheat flour produced during extraction.

3.1 Effect of streaming process on ash content of wheat granulations

Ash is the residue after wheat flour combustion that expresses wheat's purity (Sakhare and Inamdar, 2014) and minerals are related to ash content (Yudhistira *et al.*, 2021). Ash content is the parameter in the observation of wheat kernel extraction, which is most easily observed by sight because the color appearance variable in flour indicates it. Wheat flour color is creamy or yellowish because of the presence of xanthophylls (flour pigments) (Miskelly and Suter, 2017) and bran contamination. The browner the color, the higher the ash, indicating the wheat kernels' higher extraction rate (percentage) (Miskelly *et al.*, 2010). Therefore, we sequenced the

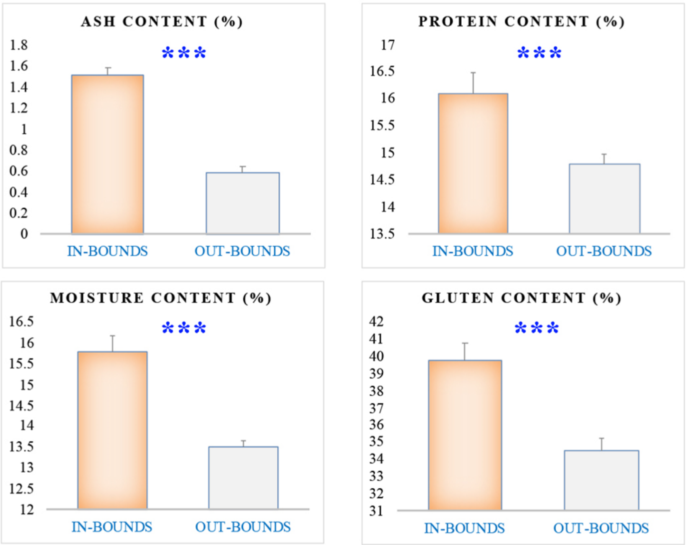

Figure 1. The quality of raw wheat kernels in the tempering bins (in-bounds) and the quality of wheat flour produced after streaming into the flour bins (out-bounds) on Mill A. Values are presented as means of triplicates (n = 3). Error bar shows standard deviation.
***Statistically significantly different at $p<0.001$.

flour streams due to their cumulative ash curve as this study's quality control parameter observation. In general, higher ash contained by the bran layers in the wheat kernels showed a decreased flour color (whiteness) with the increase of kernel extraction (Prabhasankar *et al.*, 2000). In flour processing, pearling (debranning) is conducted to achieve high-quality flour (refined flour) through the sieving process in plan-sifters. Pearling is the treatment of removing outer layers of wheat kernels to produce high-quality fined-flour that can reduce the concentration of enzyme activity, microbial load, mycotoxin, and heavy metal contaminants (Hareland, 2003; Laca *et al.*, 2006; De Brier *et al.*, 2015). The fractionation process can be carried out at this stage using 'histological fractionation' to separate different constitutive layers of the bran and obtain a fraction in one particular tissue (usually the aleurone layer). In addition, 'macromolecular fractionation' aims to break down tissue cells and separate the subcellular constituents (Hemery *et al.*, 2007). The inclusion of this aleurone layer decreased the whiteness of the refined flour.

This study has proven that the streaming process is very influential in controlling the ash content of wheat flour. If one of the flour streams containing high ash content is removed, thus the flour ash content decreases, as seen in Figure 2 ($p<0.05$). Ash content in wheat flour affects the process and the final product (flour properties), including the product's color (the crumb on bread and noodle) and the level of dough stability. This study shows that the higher the ash content, the worse the flour quality, and vice versa. If the ash content of the flour is too high, there is a possibility that many bran

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layers enter the flour bins, which shows that the grinding quality is not good (Sakhare *et al*., 2015). The ash content of the powder (refined flour) may be affected by the contamination of bran layers and different grinding methods (Udomrati *et al*., 2020). Therefore, ash level is greatly influenced by grinding and cultivar practices. The ash content generally represents the milling process and can indicate how much white flour has been processed (Kang *et al*., 2019). Grain shape and texture, as well as the technical conditions of grinding, especially the extraction rate, affect the level of mineral loss. However, when all these variables are defined, the distribution of minerals across different grinding fractions ultimately depends on how the elements are unevenly distributed in the kernel. While grinding reduces mineral content, availability increases due to decreased antinutrient content (Oghbaei and Prakash, 2013). This study assumed that excluding flour streams is an absolute thing to be done to get the specified flour quality in different grades (Table 2). It can be seen in Figure 2 that flour streams with a mesh size of >900 microns were removed because this channel produces flour with an ash content of more than 1.20% and is undesirable.

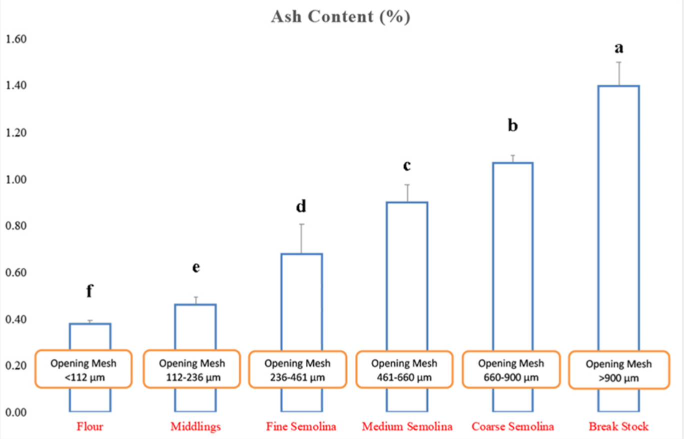

Figure 2. The ash content of 56 flour streams on Mill A. Values are presented as means of triplicates (n = 3). Error bar shows standard deviation. Bars with different notations are statistically significantly different at p<0.05.

3.3 Effect of the streaming process on the moisture content of wheat granulations

The water content indicates the amount of water contained in the flour. Moisture content has an essential role in wheat processing and the flour yield is related to the water content (Yudhistira *et al*., 2019; Yudhistira *et al*., 2020). The conditioning process (dampening and tempering) is a step to increase the moisture content to achieve the target moisture content of the wheat to be milled and leads to the efficiency of the milling process (Dennett and Trethowan, 2013; Baasandorj *et al*., 2015). Adding water serves to equalize the moisture diffusion in the wheat kernel to be ground. Thus, it influences its biochemical composition and physical properties, such as hardness and brans' friability (Andrejko *et al*., 2011; Dziki *et al*., 2014; Ahmed *et al*., 2015; Hourston *et al*., 2017). Controlling the moisture content in the wheat kernels aims to optimize the quality of flour produced since over-conditioning leads to a decrease in flour extraction rate thus, it should be checked during the milling process (Kweon *et al*., 2009; Warechowska *et al*., 2016). In a previous study, the grinding force of the mill used during extraction affected the wheat flour's moisture content (Liu *et al*., 2015). The other factor that influences the moisture degradation of the flour produced might be caused by the evaporation due to high intensity during the processing and tempering process (Lagrain *et al*., 2010; Protonotariou *et al*., 2015; Sakhare *et al*., 2015). Reduced particle size results in a higher water absorption index (WAI) (Kang *et al*., 2019). Protonotariou *et al*. (2015) reported that the water content reduces with decreasing particle size, as a larger surface area is required for interaction.

Figure 3 shows a decrease in moisture content on wheat kernels after being extracted into flour in the streaming process (p<0.05). Generally, wheat flour is only taken from the endosperm extract to produce good quality wheat flour with white color and higher moisture content. This study shows that some flour streams were excluded because they contained lower moisture, which can affect the proper flour moisture. It can be seen that the flour streams with wider opening mesh are proportional in having lower moisture and browner color. Controlling the moisture content of wheat flour is essential; flour's moisture content must be less than 14% to prevent microbial growth (Li *et al*., 2013). Nevertheless, the miller can monitor the moisture content of the extracted wheat kernels through the streaming process.

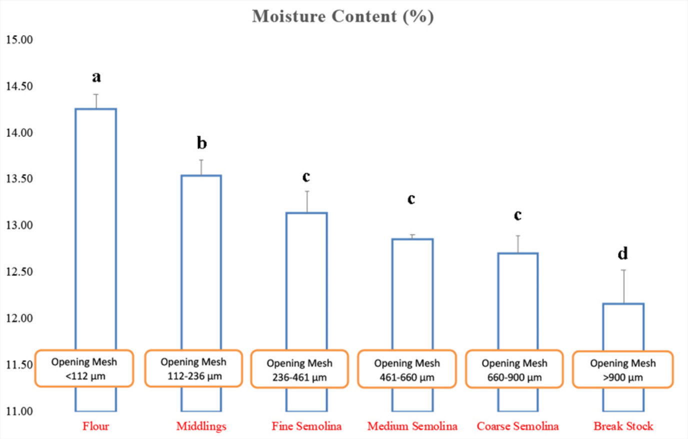

Figure 3. The moisture content of 56 flour streams on the Mill A. Values are presented as means of triplicates (n = 3). Error bar shows standard deviation. Bars with different notations are statistically significantly different at p<0.05.

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3.4 Effect of the streaming process on the protein content of wheat granulations

Protein content in wheat flour is one of the most critical parameters in determining sustainability for the end-use and quality of wheat flour (Ooms and Delcour, 2019). The higher the protein, the better the flour quality (Shewry *et al*., 2003). However, it depends on the flour's functionality to produce the product's dough. The results in Figure 3 showed that the greater the amount of extraction, the higher the protein content in whole-grain extraction (Prabhasankar *et al*., 2000). During the streaming process, the smaller the opening mesh on the flour streams, the lower its protein content. It correlated to the variety of protein compositions in the wheat kernel that declines in a gradient from the outer to inner starchy of the kernel (Baasandorj *et al*., 2015; Tosi *et al*., 2018). In this study, the flour streams also show the differences in protein content that corresponds to the research by previous studies (Wang *et al*., 2007; Liao and Chen, 2015) that showed the mill streams have a quantitative difference in high molecular-weight polymeric proteins. An earlier study also indicated that milling extraction rates affect the protein content and composition of flour because the various parts of the grain differ in protein content and structure (Baasandorj *et al*., 2015). In this study, the protein content is directly proportional to the ash content (Figure 4). The flour streams containing high ash content were removed due to high ash content causing low flour quality. Thus, the streaming process is fundamental in controlling the protein quality standard of wheat flour produced set by the millers. Shewry (2009) mentioned that the quality of a flour type depends not only on the protein availability but also on the quality of the protein because this is related to the gluten content – gluten is part of a protein, but protein is not necessarily gluten. Since the distribution of monomeric and polymeric proteins governs wheat flour properties and baking quality, thus protein content and protein quality need to be balanced (Henry and Wrigley, 2018).

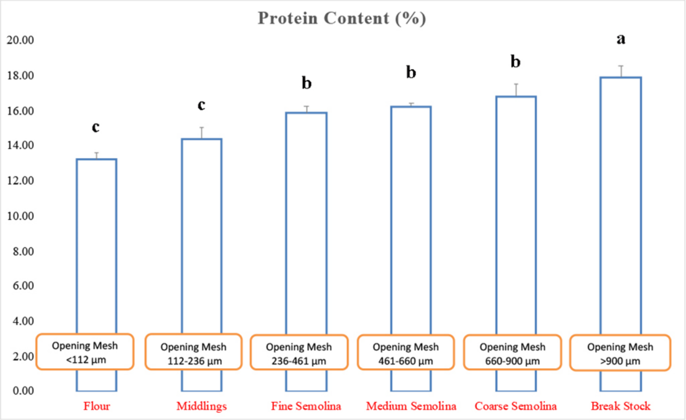

Figure 4. The protein content of 56 flour streams on Mill A. Values are presented as means of triplicates (n = 3). Error bar shows standard deviation. Bars with different notations are statistically significantly different at $p<0.05$.

Protein content can be a significant factor in the final role of wheat flour (Khan, 2016) that correlates with wet gluten, which is a substantial factor in the rheological properties of the dough. Instead of streaming, grinding type also has a significant role in determining the protein content of the extracted wheat (Liu *et al*., 2015). Every cultivar milled with a hammer mill (HM) had a slightly higher protein content than that milled with a jet mill (JM) (Lee *et al*., 2020). This is consistent with the previous study, in which wheat milled with HM had a higher protein content than ultra-fine mills (Liu *et al*., 2015). Furthermore, the carbohydrate content also follows the trend in protein amount, which shows a higher content of carbohydrates in the HM group than in the JM group. The reduced particle size separates the starch granules from the protein matrix. In addition, the increased operating speed causes a decrease in aggregate size, and starch granules can be removed from the protein matrix (Angelidis *et al*., 2016). About 80% of the kernel protein is found in the endosperm and about 20% in the outer layer. However, the protein found in the outer layer of wheat germ (especially aleurone) contains more essential amino acids than endosperm protein (Carcea *et al*., 2020). Wet-milled wheat bran has a higher water-extractable protein content of about 4.25-4.64% compared to coarse wheat bran, which is only 2.91%. This can be clarified by structural degradation during milling; the opening of aleurone cells leads to increased protein concentration (Brouns *et al*., 2012). Rosa-Sibakov, Poutanen and Micard (2015), wet milling has a smaller volume of soluble protein than dry milling. It is related to the formation of disulfide or covalent protein aggregates (Rosa-Sibakov *et al*., 2015).

3.5 Effect of the streaming process on the gluten content of wheat granulations

Gluten is an amorphous mixture of protein gliadin and glutenin insoluble in salt solutions (Dias *et al*., 2011). A previous study by Wang *et al*. (2015) showed that gliadin and glutenin have differences in structure and function. Glutenin provides density or hardness, and gliadin offers the soft and sticky structure responsible for binding. Gluten is derived from the endosperm of wheat, which has a high potential for hydrogen bonding (Lagrain *et al*., 2010).

Figure 5 shows the increasing amount of gluten content as the extraction occurred, but it will naturally degrade on particular bran layers (Noort *et al*., 2010). It generally happens in the aleuron layer, the innermost single layer of wheat bran, and so on (Brouns *et al*., 2012). An earlier study assumed the phenom affected by the following cases; albumin and globulin that have poor

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quality than gluten are the main compositions of bran, bran can attenuate the gluten network, and bran pretreatment that decreases the quality of gluten causes denaturation of protein (Liu *et al*., 2015). The glutens' glutenin fraction is more sensitive to extractability loss during the milling process (heating) than its gliadin fraction (Lagrain *et al*., 2010). At these elevated temperatures, a direct function of cross-links networks' increasing density is achieved through protein extractability loss. The functional quality of the end-product produced depends on the gluten content; thus, it is the main factor in choosing wheat varieties (Wang *et al*., 2015; Gupta *et al*., 2016).

It can be seen in Figure 5 that the flour streams containing medium semolina start experiencing a reduction of gluten content. Therefore, instead of maintaining the high quality of flour produced, the exclusion of several flour streams containing lower gluten was applied to keep the gluten content of the end-flour product. Moreover, gluten contains equivalent toxic proteins (glutenin and gliadin) that are vital in celiac disease (See *et al*., 2015; Shewry and Tatham, 2016). Thus, the content in the end-flour product should be controlled by the millers. The flour's protein content also differs depending on the variety of wheat (hard, medium, or soft), along with variations in the development of gluten tissue and the properties of the dough (Kang *et al*., 2019). The finer fraction has a higher dry gluten content than the coarser fraction when wheat flour is fractionated by sieving (Sakhare *et al*., 2014). The quantity and consistency of gluten from the central endosperm is smaller than that of the dorsal and ventral endosperms (Indrani *et al*., 2007).

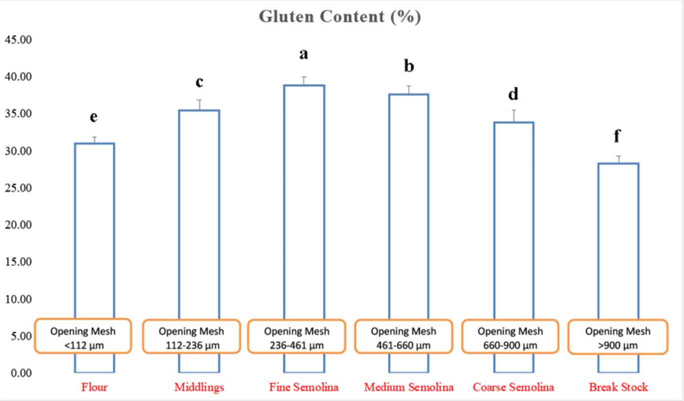

Figure 5. The gluten content of 56 flour streams on Mill A. Values are presented as means of triplicates (n = 3). Error bar shows standard deviation. Bars with different notations are statistically significantly different at $p<0.05$.

3.6 Effect of streaming process on quality parameters of wheat granulations

The above results show that the relationship between each parameter is close affecting each other. It is evidenced by the relationship curves between the parameters of wheat kernel extraction in Figure 6. The ash content curve is directly proportional to the protein content curve but inversely proportional to the moisture content curve. In contrast, the gluten content curve combines protein and moisture curves (increased then decreased curves). After sequencing the flour streams due to their cumulative ash contents, this study's results agreed with the observations of the earlier findings (Tulse *et al*., 2014; Sakhare *et al*., 2015). Furthermore, previous studies also reported that an increase in the moisture content leads to a decrease in flour protein content and reduces the amount of gluten (Liu *et al*., 2015; Warechowska *et al*., 2016). Therefore, the streaming process is very influential in decreasing the ash, protein, moisture, and gluten content in wheat flour produced. The exclusion of several flour streams caused a reduced quality content of the wheat flour produced to meet the grade standard set by the millers in Table 2. As a result, this study reports the production of high-protein wheat flour based on the quality produced during the streaming process. According to the infographics on the website of Interflour Group in the Indonesia branch (Anonim, 2021), which is represented by PT. Eastern Pearl Flour Mills Makassar divides its products into three types of flour named high protein flour (>13%), medium protein flour (11-13%), and low protein flour (<11%) based on their purposes. In general, the purpose of flour products is divided into several types, such as in making bread, noodles, biscuits, and multi-purpose.

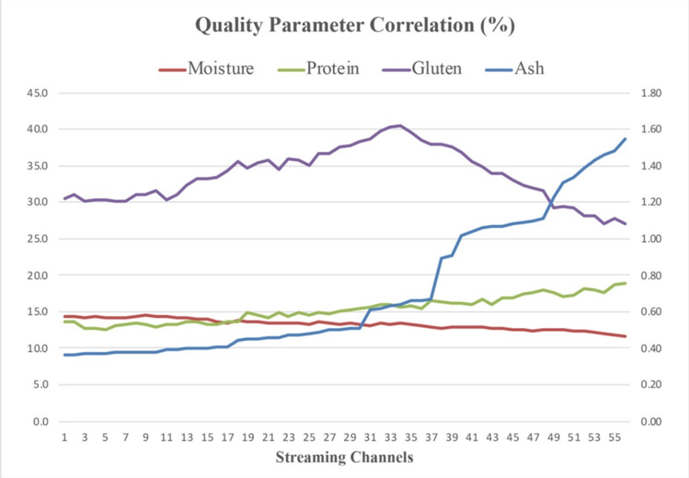

Figure 6. Correlation between the quality parameters (Ash, Moisture, Protein, Gluten) of the milled wheat in the flour streams of Mill A.

3.7 Effect of the streaming process on the yield of wheat flour

In this study, the amount of processed wheat was 1,100 tons in Mill A at PT. Eastern Pearl Flour Mills, Makassar, South Sulawesi, Indonesia. With that amount, it can produce wheat flour of around 800 tons, with a flour yield of more than 72%. The result corresponds

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with the observations by (Garvin *et al*., 2011) that indicated the flour extraction rate ranges from 73 to 77% (depending on the milling process). The decrease in milling yield was caused by the kernel size that contains a low proportion of endosperm as the primary starch source besides it correlated to the ash level of the flour produced (Kweon *et al*., 2009; Baasandorj *et al*., 2015). The quality degradation percentage of wheat flour in the streaming process is caused by the quality adjustment of the wheat kernels' ash, protein, gluten, and moisture contents since the quality content in all flour streams differs from each other (Garvin *et al*., 2011). In wheat flour milling, the exclusion was conducted on several high ash flour streams for secondary production, which generally contain high nutritional content (Brouns *et al*., 2012; Prückler *et al*., 2014; Rosa-Sibakov, Poutanen, and Micard, 2015; Rosa-Sibakov *et al.,* 2015).

The major phytonutrients in wheat are primarily localized in the bran and germ, which are removed during the milling process, as those are considered detrimental to the end-product utilization (Ciccoritti *et al*., 2018; Oghbaei and Prakash, 2019). In the streaming process, removing several flour streams containing high ash levels aims to control the quality of produced flour, thus affecting the quality of ash, moisture, protein, and gluten. Therefore, in processing an average of 1,100 tons of wheat, only around 800 tons of wheat flour is produced. Removing the flour containing high ash decreased the quality content of ash, protein, moisture, and gluten in the flour produced. The extraction rate in the wheat flour milling process at Mill A was more than 72% yield, where the remaining yield was removed from the straight run of the flour bins. The data above is based on the testing that has been done on the production plant at the PT. Eastern Pearl Flour Mills Makassar, Indonesia. According to several studies, proper flour processing generally produces 70-84% milling flour yield, while bran and pollard produce 26-30%. The increase in the water content of hard wheat grains resulted in a reduction in the flour yield, with the proportion of the flour forming fraction retained (Warechowska *et al*., 2016).

Table 2. The standards quality of high flour products at PT. EPFM.

Quality Parameter	Grade Content (%)
Protein	min 14.0
Ash	max 0.6
Moisture	max 13.5
Gluten	min 34.5

The end-products of the wheat flour should approach this grade content.

4. Conclusion

This study reveals that the streaming process has a vital role in altering the quality content of wheat kernels after being milled into wheat flour. It occurred due to the transferring treatment (exclusion) of several flour streams that contain high ash content to achieve the products' quality standard and grade set by the company. Besides, the decrease in the quality of wheat flour was caused by the amount of multi-wheat blends (wheat formulation) that were applied to produce the wanted-level flour products. In this study, with different blends, the quality result between inbounds and outbounds has the same grade contents set by the millers. However, further study is still required to explore the effect of the streaming process on the overall quality of flour produced during extraction (i.e., the process of adding food additives such as iron, zinc, vitamin, folic acid, and more).

Conflict of interest

The authors declare no conflict of interest.

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