Development of Sorghum Flour not Passing Sieve as Fried Chicken Flour with Pregelatinization Technique

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ABSTRACT

Sorghum flour that not passing sieve can be reused effectively as an ingredient for fried chicken seasoning flouur. To achieve the desired quality, it must be modification, and one of the effective methods for modification is through the flour pre-gelatinization process before use. This research aims to improve the characteristics of sorghum flour that not passing sieve by applying the pre-gelatinization process to produce good fried chicken seasoning flour. Subsequently, a completely randomized design (CRD) was used with two treatments, namely sorghum flour that not passing sieve without going through a pre-gelatinization process, and sorghum flour that not passing sieve that had been pre-gelatinized. The pre-gelatinization process is able to change the physical characteristics of the resulting flour which is characterized by an increase in peak viscosity (PV) of 1310.25 cP and trough viscosity (TV) of 374.50 cP. Similarly, there was a decreased in breakdown viscosity (BD) was 198.50 cP, the final viscosity (FV) was 2174.25 cP, and the setback viscosity (SB) was 2148.75 cP. The paste temperature was 74.39 °C, while the peak gelatinization time (peak time in minutes) remained unchanged at 7.00 minutes and was able to increase the water absorption capacity to 195.75%. The use of pre-gelatinized sorghum flour that not passing sieve in fried chicken flour can produce seasoned flour with a crunchy texture and high friability value, has a favorable value for the attributes of color and good appearance. The proximate analysis of fried chicken flour, it shows that pre-gelatinization treatment of sorghum flour can cause a significant decrease in protein content of up to 7.99% and a significant increase in water content of up to 11.27%. The research results show that pregelatinized sorghum flour improves its characteristics so that it becomes the right choice for developing fried chicken flour products.

Keywords: Sorghum flour; seasoning flour; pregelatinization; flour modification

INTRODUCTION

Sorghum (*Sorghum bicolor L.*) is a cereal crop commonly consumed as a staple food, alongside wheat, rice, corn, and barley (Sirappa, 2003). This crop exhibits relatively high productivity in Indonesia, yielding approximately 4 to 6 tons per hectare (ha), making it highly promising for use in processed food products (Human & Indriatama, 2020). One of the significant applications of sorghum is in the production of flour. However, a common challenge encountered in the processing is the low yield of sorghum flour and the significant amount of flour failing to pass through the sieve during processing. This results in a byproduct

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of sorghum flour processing with larger particles that cannot pass through an 80-sieve mesh. Sorghum flour not passing sieve has a high nutritional content and it provides a great opportunity to be converted into high value food products

The use of sorghum flour not passing sieve can be developed into instant seasoning flour to meet consumer needs for products that are fast and instant in serving (Chukwumah et al., 2017). However, the primary raw material in the production of instant seasoning flour products is wheat, often imported from other countries. Therefore, the development of sorghum flour as a raw material is expected to reduce the need for wheat and optimize its utilization.

Seasoning flour is a convenient powdered food ingredient produced by blending flour with various spice additives to expedite meal preparation (Rahimi & Ngadi, 2014). There is a wide array of seasoning flour variants available today, such as fried chicken, banana fritter, and tempeh fritter. Fried chicken flour serves as a coating or breading for chicken meat pieces, improving their flavor with spices, creating an appealing appearance after frying, and delivering a satisfyingly crispy texture (Voong et al., 2019). One of the key characteristics of fried chicken flour is Its ability to form a good dough and coat the chicken pieces effectively. This becomes one of the challenges when using sorghum flour because of its lower water absorption capacity than wheat. To address this, modifications are required for sorghum flour that does not pass through the sieve, and one effective method is pre-gelatinization. According to (Florentina et al., 2016), pre-gelatinization treatment of rice flour can significantly improve the Water Holding Capacity (WHC). Additionally, sorghum flour processed through pre-gelatinization can improve the water absorption index (Mtelisi et al., 2020). Therefore, this research aims to improve the properties of seasoning flour produced from sorghum flour that does not pass through the sieve using the pre-gelatinization process, ultimately yielding high-quality fried chicken flour.

METHODS

Materials

The materials used include sorghum flour from the bioguma variety that is not passing through the 80-mesh sieve (MinaSorghum, Yogyakarta), commercial all-purpose wheat flour (Segitiga Biru, Bogasari), tapioca flour, cornstarch, baking soda, powdered white pepper, powdered garlic, seasoning, salt, and materials used for physical, chemical, and sensory analysis.

The equipment used includes a rice cooker (Maspion, Indonesia), blender (Vienta, Indonesia), food dehydrator type MKS-FDH6 (Getra, Indonesia), a digital scale, an 80-mesh flour sieve, saucepan, thermocouple (Hyelec), Rapid Visco Analyzer (Perten model TecMaster, Swedia), Texture Analyzer (Model TA-XT2, Texture Analyzer, Texture Technologies Corp., Scarsdale, NY, USA), and equipment used for physical, chemical, and sensory analysis.

Pregelatinization Process (Alfatah et al., 2022)

To create a 15% v/v concentration suspension, 150 g of sorghum flour was dissolved in 1000 mL of water. The pragelatinization process was then carried out in a rice cooker. Stirring was carried out during the cooking process to prevent clumping of the suspension. This process was performed twice, first at the 5th minute of the cooking (at a temperature of 50-55 °C) and then at the 15th minute of the cooking (at a temperature of 70-75 °C). The peak of pragelatinization at the 20th minute was indicated by the sorghum flour forming a perfect paste at a temperature of 75-80 °C. Subsequently, the sorghum paste was spread into a thin layer on a stainless-steel plate lined with baking paper, and it was then dried using a food dehydrator at 90 ˚C for 50 minutes. The dried product was powdered using a blender, and the particle size was standardized using an 80-mesh sieve. The resulting pregelatinized sorghum flour was packaged in PP plastic.

Amylograph Characteristics Test (Lai et al., 2001)

The amylograph characteristics of sorghum flour were determined using a Rapid Visco Analyzer. A sorghum flour suspension of 13.8% (w/w) was prepared by placing 4 g of sorghum flour (on a dry basis) in an aluminum tube containing 25 g of distilled water. Programmed heating and cooling cycles were employed at a constant shear rate, where the sample was equilibrated at 35 ˚C for 2 minutes, heated to 95 ˚C at a heating rate of 11.8 ˚C/minute, then maintained at 95 ˚C for 2.5 minutes, followed by cooling to 35 ˚C at the same rate.

Water Absorption Test (Das et al., 2019)

Water absorption was measured using 10 g of flour placed in a watch glass, and distilled water was gradually added to the sample through a burette. The flour and distilled water mixture was stirred until a dough was formed, and the volume of water used to create the dough was expressed as the water absorption capacity which is calculated using Equation 1.

$$Water\ absorption\ capacity = \frac{water\ volume (mL)}{weight\ of\ flour\ (g)}\ x\ 100 \qquad (1)$$

Table 1. Formulation of fried chicken flour dough

Composition (%)	Treatment		
	Control	TLTG	TLG
Sorghum flour with pregelatinization		40	
Sorghum flour without pregelatinization			40
Commercial wheat flour	40		
Rice flour	30	30	30
Cornstarch	18	18	18
Baking soda	1	1	1
Powdered pepper	3	3	3
Powdered garlic	4	4	4
Seasoning	1.5	1.5	1.5
Salt	2.5	2.5	2.5

Preparation of Fried Chicken Flour (Gamonpilas et al., 2013)

The fried chicken flour formulation consists of sorghum flour not passing through the sieve without (TLTG) and with pre-gelatinization (TLG) in a 60:40 ratio, mixed with other ingredients such as tapioca flour, cornstarch, baking soda, powdered pepper, powdered garlic, seasoning, and salt. The formulation is shown in Table 1.

Application of Fried Chicken Flour (Rahimi & Ngadi, 2014)

The seasoning flour produced was then applied to make the fried chicken flour dough, which was prepared by mixing all dry ingredients with water in a ratio of 1:1.3 (w/v), then stirred using a mixer for 10 minutes at low speed. Pieces of chicken breast, measuring (30 x50x10 mm) were placed in a container and coated with 8 g of the flour dough. A total of 1.5 L of cooking oil was poured into a deep-fat fryer. Before frying, the cooking oil was preheated to 180 ± 2 °C, measured using a type-K thermocouple, and the samples were fried for 5 minutes while the oil temperature was maintained.

Texture Test (Adrah et al., 2022)

The fried chicken flour was subjected to a texture test using a Texture Analyzer. The breading on the fried chicken was peeled off for texture analysis. The test uses a ¼-inch spindle at a penetration speed of 5 mm/s.

Organoleptic Response (de Paula et al., 2021)

The organoleptic response of the fried chicken samples coated with the seasoning flour was conducted using a hedonic test. It included 32 untrained panelists with an age range of 18-50 years. Subsequently, each panelist was randomly presented with samples immediately after the frying process and was asked to assess the level of liking for quality attributes (color, appearance, taste, texture, and oil absorption level) using a seven-point hedonic scale (7 = very like 6 = like 5 = somewhat like 4 = neutral, 3 = somewhat dislike, 2 = dislike, and 1 = very dislike).

Proximate Analysis Test (AOAC, 2019)

The proximate content was measured on the breading that adhered to the fried chicken. The analysis included moisture content using the oven method, ash content, and protein content using the Kjeldahl method. Moreover, the fat and carbohydrate content was analyzed by the difference method.

Statistical Analysis

The results from the hedonic test were subjected to analysis using the Friedman method. Friedman is utilized to compare various samples based on the ordinal preferences expressed by panelists who assign numbers according to the ordinal scale. This test assesses whether the total rankings for each condition or treatment significantly deviate from what would be anticipated by chance (Pimentel et al., 2016). The recommended statistics for the Friedman test are as follows (Equation 2).

$$Fr = \frac{12}{nk(k+1)}(T_1^2 + T_2^2 + \cdots + T_k^2) - 3n(k-1) \quad (2)$$

Fr = Friedman coefficient
n = The number of data
k = The number of qualities tested (appearance, color, appearance taste, crispiness level, and oil absorption level)
T = Rank for each treatment

Where the Friedman test results indicate a significant difference detected between treatments, i.e., the null hypothesis of the test is rejected. The posthoc tests are conducted to determine which treatments differ from one another using the following equation (Equation 3).

$$|R_{.k} - R_{.j}| \geq z_{1-\frac{a}{k(k-1)}}\sqrt{\frac{nK(K+1)}{6}} \quad (3)$$

Where $1 - \frac{a}{k(k-1)}$ is the quantile of the standard Normal distribution (Pereira, Afonso, & Medeiros, 2015). The results of the Amylograph Characteristics test were analyzed using a t-test. Water Absorption, Texture, and Proximate Content Test results were analyzed using ANOVA or one-way ANOVA followed by Duncan's multiple range test at a significance level of 0.05%. All data were collected and analyzed using RStudio software (Copyright 1989, 1991 Free Software Foundation, Inc. 51 Franklin St, Fifth Floor, Boston, MA 02110-1301 USA).

RESULTS AND DISCUSSION

Characteristics of Amylography of Sorghum Flour Pregelatinization

An amylography test of the flour was conducted to understand its characteristics during cooking. Subsequently, the parameters observed include peak viscosity (PV), trough viscosity (TV), breakdown viscosity (BD), final viscosity (FV), setback viscosity (SB), peak time of gelatinization (Min), and pasting temperature (°C). The results of the amylography characteristics test using RVA on sorghum flour samples that were subjected to the pre-gelatinization process indicate that the pre-gelatinization process of sorghum flour not passing through the sieve can indeed alter the characteristics of the resulting flour, as shown in Table 2.

This research indicates that the peak viscosity (PV) in flour pre-gelatinization is higher than in non-gelatinized flour, such as TLG sorghum flour, which has a peak viscosity (PV) value of 1310.25 cP. This value shows a significant difference at a 1% significance level, and the maximum viscosity represents the highest viscosity value attained during the heating process, indicating the ease of forming dough when cooked. Maximum viscosity also reflects the strength of the dough formed during the gelatinization process in processing (Aini et al., 2016). The investigation by dos Santos et al. (2019) showed that the maximum viscosity of pregelatinized sweet potato starch through spray drying is significantly higher than that of non-pre-gelatinization sweet potato starch. This result can be attributed to the more structured molecular arrangement of sweet potato starch granules after the gelatinization process, leading to increased water retention capacity. The increase in peak viscosity in sorghum flour pre-gelatinization is highly advantageous for seasoning flour products as it indicates the flour's ability to absorb water effectively, resulting in better dough formation. This parameter is also used as an indicator of easily digestible starch when cooked and represents the strong dough formed during the gelatinization process in food processing (Sofi et al., 2020).

Table 2. Characteristics of amylography of sorghum flour pregelatinization

Characteristic	TLG	TTLG	Uji-t
Peak viscosity (PV)	1310.25±646.10	232.50±17.97	1.94**
Trough viscosity (TV)	374.50 ±18.21	34.50±6.45	1.94***
Break down (BD)	198.50±11.82	607.00±251.63	1.94**
Final viscosity (FV)	2174.25±192.70	3585.00±970.87	1.94*
Set back (SB)	2148.75±187.98	2881.75±576.31	1.94*
Peak time (Min)	7.00±24.12	7.00±17.08	1.94^{ns}
Pasting temp (°C)	74.39±9.71	90.82±0.39	1.94**

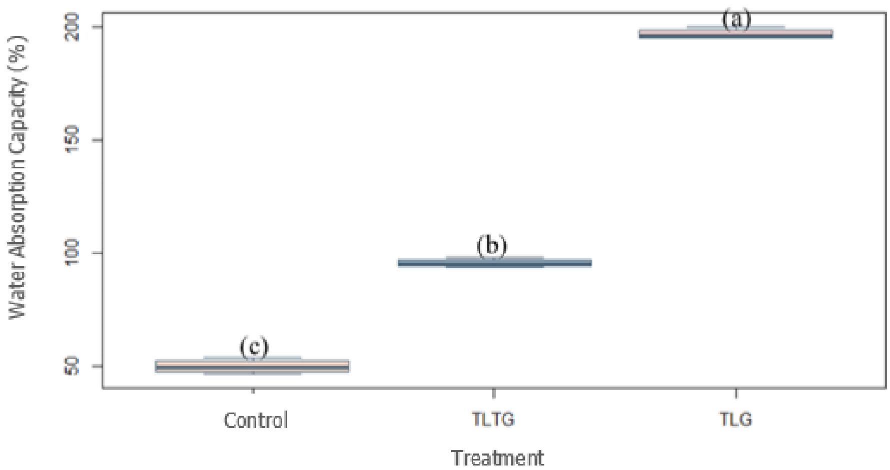
Note: The data presented is the mean ± SD, n=4, with ns indicating no significant difference at the 0.05 level; * indicating a significant difference at the <0.05 level, and ** indicating a significant difference at the <0.01 level according to the t-test. TLTG: the sorghum flour that does not pass through the sieve without pre-gelatinization. TLG: the sorghum flour that does not pass through the sieve with pre-gelatinization.

Hot paste viscosity and breakdown viscosity (BD) are interrelated amylography parameters. Subsequently, parameters such as trough viscosity (TV) and breakdown viscosity (BD) help characterize the stability of starch paste due to heating and stirring during the processing (Gamonpilas et al., 2013). The results show an increase in trough viscosity in the TLG sorghum flour sample, which becomes 374.50 cP, and a decrease in breakdown viscosity (BD) to 198.50 cP, and this, difference is statistically significant at a 1% significance level. Food products subjected to steaming and cooking processes require pasta stability to maintain product structure (Balet et al., 2019). High trough viscosity (TV) values and low breakdown viscosity values indicate good stability during heating. Additionally, according to (Singh et al., 2006), a high breakdown value means that swollen starch granules have brittle properties and are not resistant to heating. In contrast, the desired characteristic of seasoning flour is to have dough strength that can withstand heat, preventing it from becoming brittle and allowing it to coat the ingredients effectively during the cooking process.

The next parameters are final viscosity (FV) and setback viscosity (SB), indicating the starch's tendency to retrograde (dos Santos et al., 2018). During the cooling process, there is an increase in paste viscosity due to the association of starch molecules, reflecting the starch's retrogradation tendency. This research shows a decrease in final viscosity (FV) and setback viscosity (SB) with FV values of 2174.25 cP and SB values of 2148.75 cP for TLG sorghum flour. This difference is statistically significant at a 5% significance level. According to dos Santos et al., (2018), during cooling, starch molecules, primarily amylose, reassociate to form a gel structure, increasing viscosity. The investigation of dos Santos et al., (2018) also mentioned that the final viscosity of cassava and carrot starch pre-gelatinization decreases due to the degradation of macromolecules during the heating treatment. These characteristics are in line with the expected product characteristics because having lower final viscosity and setback viscosity (SB) values is desirable. High setback viscosity indicates that starch is more prone to retrogradation, potentially forming a gel during cooling (Balet et al., 2019).

Peak time pre-gelatinization is the duration it takes to reach peak viscosity, determined when the RVA records the maximum viscosity during the heating process, which occurs when the viscosity values from the RVA reach their peak (Kusnandar, 2019). This research shows that the peak gelatinization time of the samples is not significantly different, with a peak gelatinization time of approximately 7 minutes.

Gelatinization temperature refers to the temperature at which starch granules and proteins begin to absorb water, leading to an increase in viscosity (Lestari et al., 2015). Furthermore, it is the temperature range that causes nearly all the starch to achieve maximum swelling. This research shows that pre-gelatinization treatment can lower the gelatinization temperature. TLG sorghum flour has a temperature of approximately 74.39 °C. Reducing the gelatinization



Note: According to the Duncan multiple range test, the figure presented shows the means ± SD, n=4, and the same letter notations indicate no significant difference at P=0.05. TLTG: the sorghum flour that does not pass through the sieve without pre-gelatinization. TLG: the sorghum flour that does not pass through the sieve with pre-gelatinization.

Figure 1. Water absorption capacity of flour

temperature in the flour can also result in lower cooking temperature and time.

Water Absorption Capacity

Water absorption capacity analysis is carried out to determine the value of a flour's ability to absorb or retain water. A high water absorption capacity is crucial for sorghum flour, as it facilitates the formation of dough and effective coating of ingredients during cooking. Subsequently, this research shows that the water absorption capacity of TLG flour is higher at 195.75% compared to TLTG at 95.75% and the control at 50.15%, as shown in Figure 1.

The high water absorption capacity observed in pregelatinized flour is likely a result of starch damage caused by elevated temperatures. As reported by Lee et al., (2012), the use of sufficiently high temperatures (100±5 °C) in drum drying processes can damage starch granules, causing more amylose chains to leach out of the granules, making it easier for water to diffuse into the granules. The water absorption index increases when starch granules are damaged (Nakamura & Ohtsubo, 2010).

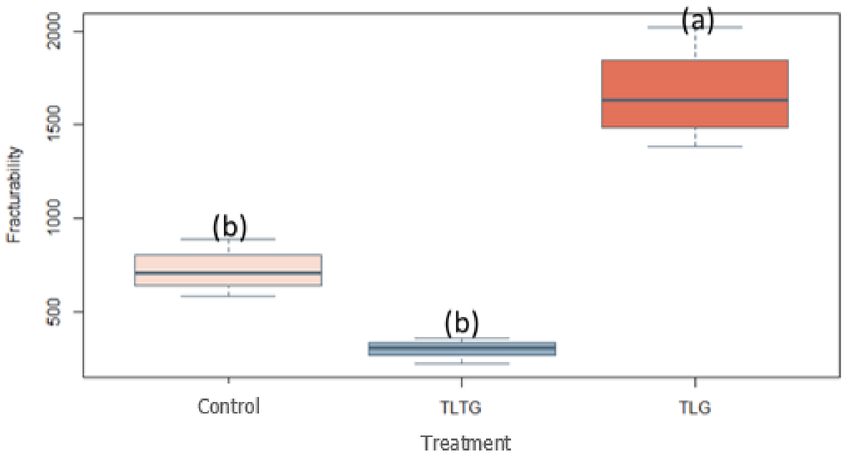
Texture

In the context of the seasoning flour product, texture plays a crucial role, especially in fried chicken flour. The measured samples were under predefined temperature and time settings. In the product of fried chicken flour, the most important textural parameter is its crispness, which can be measured through a fracturability test using a Texture Analyzer. Fracturability is the force required to create cracks in the food matrix and can be observed from the first peak shown in Figure 2.

In this research, the texture analysis measured the fracturability values of the fried seasoning flour formulations. During the texture analysis test, it is worth noting that the first peak, which indicates fracturability, often went undetected and did not appear on the graph. This was because the sample broke immediately broke after the first compression, resulting in only the maximum peak (hardness value) was detected. This observation is important for understanding how quickly the samples reached their maximum hardness during testing. The hardness values negatively correlate with crispness. The higher the maximum peak value, the lower the crispness value, as it requires greater force to break the product (Voong et al., 2018).

The research data show a difference in fracturability values among the three tested samples. Seasoning flour made from TLG has a higher fracturability value than TLTG or control flour treatments. The analysis of variance indicates that all five seasoning flours differ significantly at the 5% significance level for texture analysis.

One factor influencing the crispiness of seasoning flour-coated food is the particle size of the flour. Finer particles in the flour can absorb more water, and when frying is completed, the water will evaporate, leaving empty pores, some of which will be filled with oil. These empty pores contribute to the food's crisp texture when eaten (Sejati, 2010).



Note: The figure presented shows the means ± SD, n=4, and the same letter notations indicate no significant difference at P=0.05 according to the Duncan multiple range test. TLTG: the sorghum flour that does not pass through the sieve without pre-gelatinization. TLG: the sorghum flour that does not pass through the sieve with pre-gelatinization.

Figure 2. The texture of fried chicken flour coating

Table 3. Hedonic test results for fried chicken flour samples

Quality Attributes	Treatment		
	Control	TLTG	TLG
Color	110.0 (a)	36.0 (b)	94.5 (a)
Appearance	105.5 (a)	46.5 (b)	110.5 (a)
Taste	97.5 (a)	77.5 (b)	91.0 (ab)
Crispiness	96.5 (a)	77.0 (b)	93.0 (ab)

Note: The table presented provides the total rankings, n=32, and similar letters indicate no significant difference at P=0.05 according to the Friedman test. TLTG: the sorghum flour that does not pass through the sieve without pre-gelatinization. TLG: the sorghum flour that does not pass through the sieve with pre-gelatinization.

Organoleptic Characteristics

Regarding organoleptic characteristics, hedonic tests were conducted to assess consumer acceptance of the product as represented by the panelists. The results of the tests indicate that TLG has a better acceptance level than TLTG, both in terms of color and appearance attributes. However, the treatments had no significant differences in taste and crispiness attributes. The data from the organoleptic response is shown in Table 3.

Color is often the first parameter considered by consumers when choosing a product. In the hedonic test results, it is shown that the seasoning flour sample with pre-gelatinization treatment improved consumer preference for the color of the resulting product and did not significantly differ from the control, which is the seasoning flour made from wheat flour. The color of sorghum flour influences the color of the fried chicken flour through non-enzymatic browning reactions, including the *Maillard* reaction. When aldoses/ketoses are exposed to heat and react with amino groups, various components such as flavor, aroma, and dark-colored polymers are produced, as seen in the frying process of chicken coated with seasoning flour (Adrah et al., 2022).

Taste is a crucial aspect of food selection for consumers, as it is the response to chemical stimuli reaching the taste buds on the tongue, including basic tastes such as sweet, sour, salty, and bitter. The hedonic test results for the taste parameter revealed that the seasoning flour sample with pre-gelatinization treatment improved consumer preference for the taste of the resulting product. The TLG seasoning flour sample was preferred by consumers compared to TLTG. The flavor of a product is influenced by the aroma of the food ingredients used, the crispiness, and the level of food maturity.

Crispiness is a parameter that can be assessed using the sense of mouth-feel, and it is related to the product's texture, which can be described as a series of cracks perceived in the mouth due to low-level force. The sensation of crispiness includes detecting small cracks in the mouth, which are often accompanied by a sound that occurs when the food breaks or crumbles (Voong et al., 2018). Subsequently, the test results for the crispiness parameter showed that TLG treatment improved consumer preference for the crispiness of the resulting product. This improvement could be influenced by the higher viscosity of the seasoning flour dough pre-gelatinization, which is better at absorbing water. This, in turn, affects the thickness of the coating that adheres

Table 4. Proximate composition of coating flour on fried chicken

Proximate Values	Treatment		
	Control	TLTG	TLG
Protein content (%)	7.03±0.35^b	9.80 ±0.62^a	7.99±0.72^b
Ash content (%)	3.55±0.33^a	2.92±032^b	3.40±0.17^{ab}
Fat calories (kcal/100g)	145.87±56.51^b	199.71±10.57^a	186.25±23.28^{ab}
Total fat (%)	16.21±6.28^b	22.19±1.17^a	20.69±2.59 ^{ab}
Moisture content (%)	9.58±0.86^b	8.25±0.65^b	11.27±0.69^a
Total calories (kcal/100g)	428.49±36.12^{ab}	466.23±9.73^a	444.76±10.88^{ab}
Carbohydrate content (%)	63.62±5.43^a	56.83±0.83^{ab}	57.64±2.38 ^{ab}

Note: The table presented shows the means ± standard deviations, n=4, and similar letter notations indicate no significant difference at P=0.05 according to the Duncan multiple range test. TLTG: the sorghum flour that does not pass through the sieve without pre-gelatinization. TLG: the sorghum flour that does not pass through the sieve with pre-gelatinization.

to the fried chicken. The thickness of the coating is one of the factors influencing the product's texture. Additionally, crispiness is influenced by the flour's ability to absorb and retain water. If the coating flour absorbs a significant amount of water during frying, the water will evaporate, leaving empty pores, some of which will be filled with oil, resulting in a porous texture that feels crispy when eaten (Sejati, 2010).

Proximate Composition

The results of proximate analysis for all formulations of fried chicken flour show that pre-gelatinization treatment of sorghum flour can lead to changes in the chemical characteristics (protein content, ash, fat, moisture, carbohydrates, fat calories, and total calories) of the resulting products, as shown in Table 4.

The test results indicate a significant decrease in protein content and an increase in moisture content in the TLG fried chicken flour. However, there was no significant difference in fat content, ash content, fat calorie, total calorie, and carbohydrate content among the different treatments. The decrease in protein content can be attributed to the gelatinization process, which involves heat and leads to damage to the structural components of the protein. The increase in moisture content results from the higher water absorption capacity in gelatinized flour. This is consistent with research by Kim et al., (2021) which showed a 1.7-fold increase in water absorption capacity in rice flour subjected to superheated steam treatment.

CONCLUSION

In conclusion, the gelatinization process applied to the sifted sorghum flour resulted in changes in the physical characteristics of the flour. This was evident from the increased peak viscosity (PV) and trough viscosity (TV), as well as decreased breakdown viscosity (BD), final viscosity (FV), setback viscosity (SB), and pasting temperature (°C). However, the peak time (Min) remained unchanged. These alterations in the amylograph characteristics indicated that the gelatinization process could improve the suitability of sifted sorghum flour for making fried chicken seasoning flour. Additionally, the gelatinized sifted sorghum flour exhibited higher water absorption capacity, making it easier to form dough and providing a better coating for chicken pieces. Using gelatinized sifted sorghum flour as the base for fried chicken flour resulted in a crispy texture, as shown by the high fracturability value. Organoleptic response using hedonic tests indicated that the fried chicken flour made from gelatinized sifted sorghum flour was better received in terms of color and appearance. Meanwhile. The proximate analysis showed that the gelatinization treatment significantly reduced protein while increasing moisture content in the resulting flour.

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