

Evaluation of variabilities in Cooked Commercial Ga-kenkey Balls

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Abstract

The texture of Ga-kenkey, a fermented Ghanaian corn meal is essential to its taste. Aflatalization, cooking duration, and raw material all have an impact on this. Some factors can contribute to variability in texture of Ga-kenkey. The study thus seeks to assess the variability in colour, moisture, heat transfer profiles, texture profile analysis and stress relaxation of Ga-kenkey found in different position during cooking. The result showed that kenkey found in the bottom position had the highest moisture content (66.4+0.7), whiles kenkey found in the middle (62.7+0.7) with kenkey found at the top having the lowest moisture content (61.9+0.4). Kenkey in the top position displayed the lowest L* value (56.26+0.03), whereas kenkey in the bottom position displayed the greatest L* value (58.37+0.10). Kenkey produced from the top position recorded the highest hardness value (12.116+9.614) N/cm², whereas Ga-kenkey located at the bottom had the lowest hardness (3.066+0.515) N/cm². The bottom position kenkey had the highest level of gelatinization (50.4+0.1). There is variation in the degree of gelatinization, moisture content, colour, textural profile, heat penetration, stress relaxation for kenkey at different position cooked together. This variation is as a result of the *kenkey* position at contact with water used for cooking.

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Introduction

Ghana's coastal regions, including the nation's capital, Accra, are home to the traditional fermented maize meal product known as Ga-kenkey (Asante et al., 2011). Whole maize is soaked for one to two days at room temperature, ground, and then formed into dough during the kenkey processing process (Amponsah, 2010; Dzigbor, 2012). Unit operations involved with kenkey are non-standardized and differ significantly between processors as well as within a processor's batch. Layers of kenkey are introduced into the cooking pot by the placement of balls of kenkey in accordance with volumes of water utilised (Amponsah, 2010).

The texture of Ga-kenkey is influenced by ingredients used, process of aflatalization as well as the time frame kenkey is cooked (Sefa-Dedeh et al., 1989). Ga-kenkey considered by consumers to be good is neither very sticky nor crumbly (Sefa-Dedeh et al., 1989). Pressure/heat-induced starch gelatinization during cooking of the Ga-kenkey is greatly influenced by pressure as well as temperature. It has been noted that high-temperature compressed powder from





wheat gluten that has been moulded, when cooled, vitrifies into a hard substance when moisture content is absent or at low concentrations as a plasticiser (Jansensa et al., 2013). Pressure variability generated during cooking of Ga-kenkey in the same pot can also introduce some colour variabilities among Ga-kenkey in the same pot. In their study, Zhao et al. (2024) investigated how high-pressure treatment affected the physicochemical, adsorption, and structural features of kelp. They found that this treatment effectively decreased the kelp's particle size and raised the amount of soluble and total dietary fibre in the kelp.

The difference in position of the Ga-kenkey during cooking could result in different heat penetration of the Ga-kenkey during cooking. This could also contribute to differences in gelatinization rates at the different layers and thus textural differences among Ga-kenkey within different position in the cooking pot. The goal of this project was to develop and validate a mathematical model that would predict temperature profiles inside a wood cube that would be subjected to microwave heating (MWH). The model would take into account the effects of heat induction, which occurs when a wooden cube with known dielectric and physical properties is exposed to 2.45GHz microwaves at a nominal power of 2.3 KW, as well as heat transfer from the cube's surface due to perfect insulators (FC or PI) or free convection.

According to the observation, MWH causes a non-uniform distribution of temperature that is significantly influenced by surface heat loss and penetration depth (Dp). Additionally, homogenous mixing of materials that exhibit strong microwave properties to heat converters preserves the shape of the temperature profile while displaying a significant temperature increase when compared to virgin material exposed to the same power and heating time (Farag et al., 2012).

The kind and intensity of pretreatment conditions have a significant impact on texture after thermal processing; when all pretreatments are applied at the proper levels, the maximum hardness improvement is 2.4 times (Rastogi et al., 2008). Variations in the Ga-kenkey's degree of gelatinization can also be attributed to variations in heat penetration. According to Cruz-Romero et al. (2008), gelatinization is the process by which starch granules undergo a series of alterations when heated.

The pressurized starch's rheological characteristics and the degree of gelatinization attained through High Pressure (HP) treatment (Katopo et al., 2002). Therefore, the goal of the study is to evaluate the differences in colour, moisture content, texture, heat penetration, and degree of gelatinization among Ga-kenkey cooked in the same cooking pot.

Materials and Methods

Materials

Ga-kenkey balls within three layers in the one cooking pot were used for the study. The position of the kenkey ball was determined relation to the water used in cooking the Ga-kenkey. The bottom layer had kenkey sitting in the cooking water while the middle layer had kenkey just above the cooking water with the top layer having no contact with the water.

Experimental Design

Measurement on colour, moisture, profiles of heat transfer, and texture profile analysis and stress relaxation of Ga-kenkey within the different positions in the cooking pot were done. For contingency and to ensure that all variability that were encounters came from the cooking process and not the processors, someone who process Ga-kenkey in a popular location was identified and used for the





study.

Measurement of Colour for Ga-kenkey

A Minolta L*a*b* Chroma Meter was used to measure the colour of Ga-kenkey balls from each of the three layers inside the cooking pot using the CIE L*a*b* colour scheme. The standard white tile served as the calibration point for the Hunter L*a*b* measurements. The following colour coordinates were noted: b*(-b* = blueness, +b* = yellowness), a*(-a* = greenness, +a* = redness), and L* = brightness (0 = black, 100 = white).

Moisture content measurement for Ga-kenkey

Following cooking, three Ga-*kenkey* balls from each of the three layers (Top, Middle, and Bottom) in the cooking pot were tasted using a commercial Ga-*kenkey* processor. The Ga-kenkey was thinly sliced into 2 mm pieces from each layer in the cooking pot. The moisture content of the *kenkey* was measured under vacuum at 70 °C and 25 in Hg, in accordance with AOAC method no. 934.06. Three duplicates of each moisture measurement were made (AOAC, 2000).

Texture Profile Analysis for Ga-kenkey

After being cooked, three Ga-kenkey balls from each of the three layers inside the cooking pot were tested. After allowing the samples to reach room temperature, a cork borer was used to cut them into cylindrical shapes. After that, each cylinder was sliced into a conventional shape that had a diameter and height of 10 mm. The texture profile analysis method as outlined by Bourne (Bourne, 1978) was used to analyse the cylinders. A Texture Analyser (Sable Micro Systems Model TA. XT2, Texture Technologies Corp., Scarsdale, NT) with a 3.5 mm cylindrical probe was used to compress samples to half of their original height. Test speed: 1.2 mm/s, rupture test distance: 4 mm, distance: 5 mm (50%), force: 100 g, time: 5 seconds, load cell: 5 kg, trigger: auto – 5 g were the parameters for the Texture Analyser. The Texture Analyser provided the texture metrics hardness, springiness, cohesiveness, gumminess, and chewiness.

Temperature Profile for Ga-kenkey

K type thermocouples linked to a Cole Parmer 2-channel temperature Data Logger were used to track the cold point temperature of the *kenkey* balls while they were cooking. From the beginning to the finish of the cooking process, the temperature of the *kenkey* balls at the top, middle, and bottom levels of the cooking pot was observed. In order to create temperature profiles of the *kenkey* balls in relation to the cook water in the vessel during the traditional cooking of Ga-*kenkey*, temperature readings were taken five separate days when the *kenkey* was cooked by the processor.

Stress Relaxation analysis for Ga-kenkey

After the commercial Ga-kenkey processor had cooked the balls, three balls from each of the three layers inside the cooking pot were tested. Using a cork borer, the samples were sliced into cylindrical shapes. After that, each cylinder was sliced into a conventional shape that had a diameter and height of 10 mm. The Texture Analyser (Sable Micro Systems Model TA. XT2, Texture Technologies Corp., Scarsdale, NT) fitted with a 3.5 mm diameter cylindrical probe and a 10 N load cell was used to conduct the stress relaxation testing. At a crosshead speed of 0.3 mm/s, the test samples were compressed to a height of 5 mm. The sample was compressed for 80 seconds while this continuous compressive strain was given to it. Every test was run five times in duplicates.





Degree of Gelatinization for Ga-kenkey

Gelatinized maize flour that had been dried and ground was used to create standards that represented 0, 25, 75, and 100% starch gelatinization. To gelatinize the corn starch, mix 200g of corn flour with 100 ml of water. After that, the flour was boiled to create a paste. The resulting paste was cooked for 10 minutes at 120 °C and 40 Pa in a retort. After that, the paste was dried overnight at 60 °C in an air oven. A hammer mill was then used to grind the dried paste into flour. The absorbance values from the amylose/iodine blue value were then used to build a standard graph in accordance with Birch & Priestley's (1973) instructions. Ga-*kenkey* from the bottom, middle, and top layers of the pot were oven dried for an entire night at 60 degrees Celsius, and then they were ground into flour using a hammer mill. Next, the Ga-kenkey samples' level of gelatinization was assessed using the procedure outlined by Birch and Priestley (Birch & Priestley, 1973).

Data Analyses

Data from the temperature profile, colour, TPA, stress relaxation, degree of gelatinization, and moisture content were analysed using Statgraphic XV.11. Analysis of variance (ANOVA) was used to compare data with a probability of p<0.05. When an ANOVA revealed significant F values, Fisher's least significant difference (LSD) was employed to distinguish between means. Every measurement was done three times, and the mean values were recorded.

Results and Discussion

Moisture variation in Ga-kenkey

As indicated in Table 1, the bottom *kenkey* had the highest moisture content (66.4+0.7), followed by the middle kenkey (62.7+0.7), and the top kenkey had the lowest moisture content (61.9+0.4). There were no appreciable variations in the moisture content of the *kenkey* produced from the bottom and middle layers, despite the fact that the kenkey from the bottom layer had a clearly higher moisture content than that from the top layer. This suggests that variations in the *kenkey*'s amount of contact with the cooking water during cooking result in variations in the moisture absorption of the *kenkey* at the various layers of the cooking pot.

The variations in temperature and moisture penetration at different cooking layers inside the same cooking pot may be the source of the moisture content variable. Because the amount of moisture influences food's flexibility, which influences how consumers perceive texture, variations in moisture can vary the texture of the *kenkey* at the various layers of kenkey in the pot. According to Sfayhi-Terras et al. (2021), temperature and moisture penetration affect the texture of kernels. Food texture is influenced by the amount of moisture present (Alemu, 2023; Yang et al., 2021).

Colour variation in Ga-kenkey

Colour measurements were captured as L*, a*, b* with L* indicating level of lightness, a* indicating level of redness and b* indicating level of yellowness. Outcomes indicated a significant variation in the L*, a* and b* values among *kenkey* from the different positions after cooking. *Kenkey* at the bottom position recorded the highest L* value (58.37±0.10) with *kenkey* from the top position recording the least (56.26±0.03) (Table 1). Since the bottom *kenkey* is submerged in the cooking water, the values for colour readings for L* show that the colour of the bottom *kenkey* is lighter than that of the middle and top kenkey. This could be caused by the high temperature and moisture content at the bottom layer, or it could be because more soluble solids were lost into the cooking water. As the temperature rises, the





amorphous portion of starch in grains first goes through the glass transition phase, after which amylose leaches and the crystalline portions melt (Li et al., 2020). According to Srikaeo et al. (2005), cooking caused colour changes in wheat, with the grains becoming darker and the L* and a* values decreasing and rising, respectively. The findings show that the hue of the Ga-kenkey varies depending on the layer within the same cooking pot.

Texture Profile Variation in Ga-kenkey

Texture profile analysis is the process of quantifying and categorizing a product's mechanical attributes, usually related to its food content, in relation to the sensory qualities that are perceptible to humans. In order to guarantee that products succeed in the market, texture profile analysis of food is required to determine whether the textural qualities of a product would be within the recognized acceptable range by consumers before the product is sent to the market. As indicated in Table 1, every texture profile characteristic that was evaluated was found to be considerably different for the Ga-kenkey that was removed from the top, middle, and bottom layers.

Emphasis was made on the hardness, adhesiveness, and chewiness of Ga Kenkey. According to Civille and Szczesniak (1973), hardness is the amount of force needed to compress a material between molar teeth or between the tongue and palate. Ga-kenkey's hardness values indicate its level of softness. According to Table 1, kenkey produced from the top layer of the cooking pot had the highest hardness value (12.116+9.614) N/cm2, while ga-kenkey from the bottom layer had the lowest hardness (3.066+0.515) N/cm2. There were no similarities observed between any of the Ga-kenkey found in the various layers of the cooking pot. This implies that Ga-kenkey's softness highest at the bottom layer.

According to Civille & Szczesniak (1973), adhesiveness is the amount of power needed to remove stuff that sticks to the mouth, typically the palate during regular eating activities or on a surface. The adhesiveness of a Ga-kenkey indicates its stickiness. Customers in Ga-kenkey are willing to accept a certain amount of adhesiveness. Ga-kenkey from the cooking pot's bottom layer had the highest adhesiveness value (-1.491+0.791) Nxs, whereas Ga-kenkey from the top layer had the lowest adhesiveness value (-0.142+0.162) Nxs (Table 1). The adhesiveness of the Ga-kenkey varied significantly between the layers of the cooking pot, which implies that the kenkey's location within the pot throughout the cooking process affects the adhesiveness of the Ga-kenkey.

According to Civille & Szczesniak (1973), chewiness is the amount of time needed to masticate a sample at a steady rate of force application in order to get it to a consistency that is palatable. Minimal chewiness in ga-kenkey makes it more appealing. Ga-kenkey from the top layer of the cooking pot had a much greater chewiness value of 4.903+0.747) N/cm, whereas Ga-kenkey from the bottom layer had the least amount of chewiness (0.53+0.230) N/cm) (Table 1).

The Ga-kenkey's texture profile within the same cooking pot revealed that the texture of the various layers' ga-kenkey varied. And this might be because of variations in the degree of heat penetration and moisture absorption at the various levels, which lead to variations in the starch granule structure. Chen et al. (2009) found that boiling time significantly affects the textural properties of adhesiveness, cohesiveness, and elasticity, but not hardness, gumminess, chewiness, or springiness.

Research by Tóth et al. (2022) demonstrates that variations in variety cause variations in the textural properties of bread baked at different temperatures. According to Dou et al. (2023), frozen dough has distinct texture profiles depending on its moisture and protein content. Researchers Andersson et al. (2022) found that steaming increased cell shrinkage and loss of cell-cell adhesion more than boiling did when examining the effects of steaming and boiling on the microstructure, mechanical characteristics,





and sensory profile of three model root vegetables with different carbohydrate compositions.

Viscoelastic Variation for Ga-kenkey

Most food products, including kenkey, exhibit rheological characteristics that are partially elastic and partially viscous. Such viscoelastic materials take a limited amount of time to take up their new dimensions when a force is applied to them; this is not the case for purely elastic materials. Simple shear, simple compression, or bulk compression tests are used to characterize the viscoelastic properties of such foods. Transient measurements, such as stress relaxation, are employed, as well as dynamic measurements, such as creep compliance and dynamic mechanical analysis. With stress relaxation, a continuous strain is administered, and the stress's evolution over time is tracked. A typical *kenkey* stress relaxation curve is shown in Figure 1.

Firmness and elasticity values (or viscous and elastic components) were used to summarize the stress relaxation parameters. The stiffness and elasticity characteristics of Ga-kenkey from the various layers inside the pot differed significantly. As seen in Table 1, Ga-kenkey from the top layer recorded the maximum value for firmness, while Ga-kenkey from the bottom layer recorded the lowest firmness value (0.162+0.029). While the firmness of the Ga-kenkey from the top layer differed greatly from that of the middle layer, it was similar to that of the bottom layer. According to Table 1, elasticity among the Ga-kenkey was similarly observed to be low (24.507+5.194) in the intermediate layer of Ga-kenkey, with the highest elasticity value (32.789+4.982) in the top layer of Ga-kenkey.

The findings suggest that Ga-kenkey's firmness and flexibility are influenced by where it is located inside the cooking pot. The data demonstrated that while the elastic component of the top layer was much larger than that of the middle and bottom layers, the viscous components of kenkey from the bottom and middle layers were not significantly different. Nonetheless, the findings imply that the various layers inside the same cooking pot give Ga-kenkey distinct viscoelastic characteristics. Again, variations in heat penetration and moisture absorption may be the cause of these discrepancies. According to Wang et al. (2021), the incorporation of rice bran into wheat gluten alters its viscoelastic characteristics.

Variation in the Degree of Gelatinization for Ga-kenkey

The degree to which the starches were changed (or cooked) throughout the kenkey cooking procedure was determined by measuring the degree of starch gelatinization. Among the *kenkey* taken from the various strata inside the cooking pot, there were notable differences in the level of gelatinization. The lowest degree of gelatinization (38.7+0.1) was found in products derived from the top layer, followed by *kenkey* from the intermediate layer. Table 1 displays the maximum degree of gelatinization (50.4+0.1) for Ga-*kenkey* that was extracted from the bottom layer. This indicates that, in comparison to the middle and top *kenkey*, the Ga-*kenkey* from the bottom layer of the cooking pot is more gelatinized. The temperature profiles for the various layers in Figure 2 show how the rate of heat penetration at each layer varies depending on how differently the Ga-*kenkey* at each layer contacts the heat source. This could account for variations in the degree of gelatinization at the various layers within the same cooking pot.

Kenkey at the bottom layer was exposed to greater temperatures for a longer period of time than that at the top layer, as the figure illustrates. The findings also demonstrate how variations in moisture and heat penetration inside the same cooking pot cause fluctuations in the starch granules' gelatinization in the kenkey balls. According to Liu et al. (2020), variations in heat and pressure have an impact on the starch's gelatinization process, giving rise to distinct gel texture characteristics. Khantarate et al. (2022)





claim that various heat treatments have an impact on the starch granule structure of purple rice. The crystalline structure of breakfast cereals changed from A-type to V-type because of heat treatment during extrusion, according to Allai et al. (2023). This caused the starch's granular structure to be disrupted, its crystallinity to be reduced, and the formation of an amylose-lipid complex network to be encouraged.

According to Allai et al. (2023), increasing the conditioning moisture increased the degree of gelatinization (%), peak gelatinization temperature (Tp), and starch crystallinity (%) while decreasing the gelatinization enthalpy (Δ HG) and gelatinization temperature ranges. When wheat is heated, starch partially gelatinized due to changes in its structural properties. However, both mild and severe treatments result in an increase in the amount of starch degradation (van Rooyen et al., 2022).

The Temperature Profile Variability for Ga-kenkey

There is a lot of variation in the amount of time it takes for the kenkey's cold point to reach the boiling water temperature (100°C) in the cooking vessel, as seen by the temperature profile of *kenkey* at the various position during cooking (Figure 2). As seen in Figure 2, the *kenkey* at the bottom layer underwent the fastest rate of heat penetration over the cooking period, whereas *kenkey* located within the middle and top layers underwent the slowest rates.

Kenkey occupying the top position relies on steam generated by the water used in cooking for heating, as such steam was generated from the cooking water before they could heat up while kenkey occupying the bottom position, and was immerged in the cooking water, heated up more quickly from the boiling water. Depending on the material that surrounds the kenkey at each position during cooking there are different heat transfer rates. According to Bindu & Gopal (2008), cooking the same fish in a different medium results in varying degrees of heat penetration.

Conclusion

There is variation in the degree of gelatinization, moisture content, colour, textural profile, heat penetration, stress relaxation, for *kenkey* at different position cooked together. The positioning of *kenkey* in relation to the cooking water during the cooking process contributes to the variation. Moisture content, softness, adhesiveness, degree of gelatinization, and rate of heat penetration is higher in *kenkey* found in the bottom position. Chewiness, stiffness, and elasticity on the other hand is highest for *kenkey* found in the top position during cooking. The findings obtained in this research can help in standardizing Ga*kenkey* so that regardless of the position of the Ga*-kenkey* during cooking would result in, Ga*-kenkey* that have the same colour and textural properties would be obtained after cooking.

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References

- 1. Alemu, T. 2023. Texture Profile and Design of Food Product. J Agri Horti Res, 6(2), 272-281.
- Allai, F.M., Junaid P. M., Azad, Z.R.A.A., Gul, K., Dar, B.N., Siddiqui, S. A., Loenzo, J. M.2023. Impact of moisture content on microstructural, thermal, and techno-functional characteristics of extruded whole-grain-based breakfast cereal enriched with Indian horse chestnut flour. Food Chemistry 20.100959
- 3. Amponsah, A. 2010. The Ga-kenkey production process- investigating opportunities for water reuse and identification of sources of product quality variability. MPhil Thesis, Department of Nu-





- trition and Food Science, University of Ghana, Legon.
- 4. Andersson, J., Garrido-Banuelos, G., Bergdoll M., Vilaplana, F., Menzel, C., Mihnea, M., Lopez-Sanchez, P.2022. Comparison of steaming and boiling of root vegetables for enhancing carbohydrate content and sensory profile. Journal of Food Engineering 312.110754
- 5. AOAC. 2000. Official Method of Analysis. Association of Official Analytical Chemist. EUA.
- 6. Asante, N. D. K. Amponsah, A, Owusu-Brafi, N. K, Amoa, B., Saalia, F. K. (2011). Wastewater Minimisation in the Production of kenkey (A Traditional Ghanaian Corn Meal Product
- Bindu, J., Gopal, T.K. S. 2008. Heat Penetration Characteristics of Smoked Tuna In Oil And Brine In Retort Pouches At Different Rotational Speeds. Journal of Food Processing and Preservation 32. 231–246.
- 8. Birch, G. G., Priestley, R. J. 1973. Degree of Gelatinisation of Cooked Rice. Die Starke 2J. jahrg.98-100.
- 9. Bourne, M. C. 1978. Texture Profile Analysis. Food Technology. 32: 62-66,72.
- 10. Breidinger, S.L., Steffe, J.F. 2001. Texture map of cream cheese. Food Sci. 66, 453-456.
- 11. Chen, C. R., Marcotte, M., Taherian, A. 2009. Kinetic modeling of texture properties of bologna sausage under cooking conditions. International Journal of Food Properties, 12, 252–260.
- 12. Civille, G. V., Szczesniak, A. S. 1973. Guidelines to training a texture profile panel. Journal of Texture Studies, 4.204–223.
- Cruz-Romero, M.C. Kerry, J. P., Kelly, A. L. 2008. Fatty acids, volatile compounds and colour changes in high-pressure-treated oysters (Crassostrea gigas). Innovative Food Science and Emerging Technologies 9.54–61.
- Dou, X., Lv, M., Ren, X., He, Y., Liu, L., Zhang, G., Sun, Y., Zhang, N., Chen, F., Yang, C. H.
 2023. Test conditions of texture profile analysis for frozen dough. Italian Journal of Food Science,
 35 (4): 58–68
- 15. Dzigbor, A. 2012. Investigation of aflata cooking and mixing processes as causes of variability in Ga-kenkey, as well as design of equipment for mixing during Ga-kenkey production. MPhil thesis, Department of nutrition and food science, University of Ghana, Legon. 71-78.
- 16. Farag, S. Sobhy, A. Akyel, C., Doucet, J., Chaouki, J. 2012. Temperature profile prediction within selected materials heated by microwaves at 2.45 GHz. Applied Thermal Engineering 36.360-369.
- 17. Jansensa, K. J.A., Hongb, N. V., Telenc, L., Brijs, K., Lagraina, B., VanVuureb, A.W., Van Ackerb, K., Verpoestb, I, Van Puyvelded, P., Goderis, B., Smet, M., Delcour, J. A. 2013. Particulates using enzyme and vision system. Lebensm.-Wiss. U.-Technol. 36. 331–338.
- 18. Katopo, H., Song, Y., Jane, J.-L. 2002. Effect and mechanism of ultrahigh hydrostatic pressure on the structure and properties of starches. Carbohydrate Polymers 47 (3), 233–244.
- 19. Khantarate, S., Theanjumpol, P., Krittigamas, N., Suriyong, S. 2022. Effect of heat treatment on starch granule structure and nutrient content of germinated purple rice. Food Sci. Technol, Campinas, v42, e63820
- 20. Li, C., Wu, A., Yu, W., Hu, Y., Li, E., Zhang, C., Liu, Q.2020. Parameterizing starch chain-length distributions for structure-property relations. Carbohydrate Polymers. 241(1)2020, 116390





- 21. Liu, Y., Chao, C., Yu, J., Wang, S., Wang, S., Copeland, L. (2020). New insights into starch gelatinization by high pressure: Comparison with heat-gelatinization, Food Chemistry, 318,
- 22. Rastogi, N.K., Nguyen, L. T., Balasubramaniam, V.M. 2008. Effect of pretreatments on carrot texture after thermal and pressure-assisted thermal processing. Journal of Food Engineering.88 .541–547.
- Sefa-Dedeh, S., Plange, H. 1989. Processing of Ga-kenkey (komi) in Greater Accra region. A techno-economic study. Kellog International Report 03/1988.
- 24. Sfayhi-Terras, D., Hadjyahia, N.& Zarroug, Y. 2021. Effect of Soaking Time and Temperature on Water Absorption Capacity and Dimensional Changes of Bulgur. Cereal Chem., 98, 851–857
- 25. Srikaeo, K., Furst, J. E., Hosken, R.W., Ashton, J. F. 2005. Physical Properties of Cooked Wheat Grains as Affected by Cooking Temperature and Duration, International Journal of Food Properties, 8(3), 469-479
- Tóth, M., Kaszab, T., Meretei, A. 2022. Texture profile analysis and sensory evaluation of commercially available gluten-free bread samples. European Food Research and Technology. 248:1447–1455
- 27. van Rooyen, J., Simsek, S., Oyeyinka, S.A., Manley, M. 2022. Holistic View of Starch Chemistry, Structure and Functionality in Dry Heat-Treated Whole Wheat Kernels and Flour. Foods, 11, 207.
- 28. Wang, Z., Hao, J., Deng, Y., Liu, J., Wei, Z., Zhang, Y., Tang, X., Zhou, P., Iqbal, Z., Zhang, M., Liu, G.2021. Viscoelastic properties, antioxidant activities and structure of wheat gluten modified by rice bran, LWT,150,
- Yang, Z., Su, F., Xia, H. 2021. Moisture Content in Food Production Process Based on Wavelet Neural Network. J. Phys.: Conf. Ser. 1746 012053
- 30. Zhao, S., Pan, Z., Azarakhsh, N., Ramaswamy, H.S., Duan, H., Wang, C. 2024. Effects of high-pressure processing on the physicochemical and adsorption properties, structural characteristics, and dietary fiber content of kelp (Laminaria japonica). Current Research in Food Science 8 100671

