JOSTIR Publication 2025 | ISSN: 1118-3896 Special Issue December 2025 | 7-12

Journal of Science, Technology and Innovation Research
Volume 1 Special Issue | December 2025

Effect of Different Improvers on Gluten-Free Cassava Bread for Enhanced Sensory Attributes, Physical Quality and Proximate Composition

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ABSTRACT

The search for substitute flours and useful additives to mimic the characteristics of wheat-based bread has been spurred by the growing demand for gluten-free goods. This study assessed the impact of many hydrocolloid improvers, including carboxymethyl, gelatin, and psyllium husk. cellulose (CMC) and xanthan gum (XAG)—on the physical attributes, sensory attributes, and approximate composition of bread made using premium cassava flour (HQCF). The cassava sample used for this study was sourced from the National Root Crops Research Institute Umudike. Standard bread-making procedures were applied, after which analysis on sensory evaluation, physical quality and proximate composition were was conducted using a 20-member panel on a 9-point hedonic scale, vernier caliper and standard laboratory chemicals respectively. A wheat-based positive control (WPC) and a cassava-based negative control (CNC) were used for comparison. Results showed that bread samples with improvers exhibited varied sensory outcomes, with PSH-enhanced bread, scoring highest in texture (6.40), taste (6.10), chewiness (6.50), and overall acceptability (6.50) among the gluten-free variants, followed by CMC. GET and XAG showed moderate to low sensory acceptance. The physical parameter showed that the height, length, width and weight ranged from 8.34 to 9.58, 14.87 to 16.86, 9.33 to 73 and 471 to 598, respectively. The result showed that among the improved bread samples, samples CMS and PSH increased the height and width of the bread, while sample XAN had a low value in all physical parameters investigated. The study concludes that hydrocolloid improvers can significantly enhance the sensory attributes and physical parameters of gluten-free cassava bread, making it a viable alternative to wheat-based bread, particularly for individuals with gluten intolerance or celiac disease

Keywords: Gluten-free, cassava, bread, sensory, proximate and physical properties

Introduction

Wheat flour is processed from whole wheat. It is a vital source of amino acids, minerals, beneficial phytochemicals, and dietary fibre in the human diet. Wheat flour, when processed, comes in a yellow form, due to the presence of xanthophyll pigment in the endosperm (Ficco *et al.,* 2014). To make the flour appealing to consumers. It is then polished into white flour using a bleaching agent of benzoyl dioxide, azodicarbonamide, chlorine gas and calcium peroxide, promoting its gluten content (Ganga *et al*., 2020).

The gluten protein component of wheat flour creates a viscoelastic dough that may then be processed into bread, pasta, and other food products. Wheat flour has some health implications attached to its consumption. An example of these health implications is celiac disease, which is an autoimmune disease that damages the bowel surface and the intestinal lining (permeability), thus preventing its ability to

doi.org/10.51459/jostir.2025.1.Special-Issue.056

absorb nutrients (Smyth, 2017). To surpass gluten intolerance, a diet with gluten-free or low-gluten food is advised. There are many alternative flours to wheat flour, which can be used for the production of bread. White bread is made from wheat flour and other ingredients. To achieve elasticity during bread production, the flour must contain gluten, which is the main property of wheat flour. Ingredients with similar characteristics to gluten can be utilised to replace wheat flour (Day 2017). Gluten-free products have been highlighted to have good texture, aroma and taste (Rybicka *et al.,* 2019). The substitution of wheat flour, which is commonly utilized for commercial products that contain higher nutrient density, will be beneficial for those seeking to consume gluten-free products (Breshears and Crowe, 2013) Local food ingredients that can be utilised as raw materials for making gluten-free white bread include: rice flour, sorghum flour and cassava flour etc. Cassava is a tuberous crop and an important food source for over 200 million people. Nutritionally, it is rich in carbohydrates and low in protein, minerals, vitamins, etc (Sengar 2022). Cassava flour is devoid of gluten, and bread produced from cassava flour is heavy and lacks the desired textural quality. Non-gluten flours, such as rice, sorghum, millet, and cassava, cannot effectively trap gases; therefore, food additives known as hydrocolloids are needed to perform the same function as gluten and achieve the desired results (Sharanagat *et al*., 2022, Lazaridou *et al*. 2007) reported that the inclusion of hydrocolloid into a gluten-free flour base (rice and corn flour) could mimic the viscoelastic properties of gluten and result in improved structure, mouthfeel, acceptability and shelf-life of these products. Gelling agents that provide stretchy properties will be an alternative to gluten and improve cassava bread production. The objectives of the study are to:

1. Produce gluten-free cassava bread with different improvers (hydrocolloids)
2. Determine the sensory attributes and market viability of the gluten-free cassava bread
3. Determine the physical properties of the gluten-free cassava bread
4. Determine the nutritional composition of the gluten-free cassava bread

Materials and Methods

The Cassava was sourced from the National Root Crops Research Institute, Umudike. The cassava sample was processed into high-quality cassava flour (HQCF). It was processed into bread using different gelling agents such as psyllium husk, gelatin, CMC, and xanthan gum. Improvers were not added in the control samples, which are: (Wheat positive control (WPC) and cassava negative control (CNC).

Table:1 Ingredients with Measurement

Samples	Improvers	Cassava flour	Flaxseed	Water	Sugar
CMS	3g	90g	10g	200ml	30g
CNC	3g	90	10g	200ml	30g
PSH	3g	90	10g	200ml	30g
GET	3g	90	10g	200ml	30g
WPC	3g	90	10g	285ml	30g
XAG	3g	90g	10g	215ml	30g

CMC (carboxymethylcellulose), CNC, (cassava negative control), PSH (psyllium husk), GET (gelatin), WPC (wheat positive control). XAG (xanthan gum).

Table 2: Sensory Parameters for Gluten-Free Bread with Different Improvers

Sample	Crumbs	Texture	Flavour	Taste	Chewiness	Appearance	G/A
PSH	7.50^{bc}±0.9 5	6.40^{b}±1.39	5.90^{b}±1.55	6.10^{ab}±2.02	6.50^{ab}±1.61	6.75^{ab}±1.07	6.50^{b}±1.24
GET	6.90^{bc}±1.25	5.60^{bc}±1.23	6.20^{b}±1.11	5.60^{b}±2.11	5.40^{bc}±2.21	6.90^{a}±0.97	5.90^{bc}±1.86
CNC	7.00^{bc}±1.72	6.00^{b}±2.34	6.00^{b}±1.84	6.00^{ab}±2.20	6.10^{bc}±2.45	6.60^{ab}±0.82	5.80^{bc}±2.50
WPC	8.00^{a}±0.92	7.70^{a}±0.80	7.40^{a}±2.01	7.30^{a}±2.00	7.50^{a}±0.95	7.00^{a}±1.03	8.40^{a}±0.50
CMC	7.70^{ab}±0.80	6.10^{b}±1.62	5.90^{b}±2.02	6.00^{ab}±2.38	5.60^{bc}±2.11	6.55^{ab}±0.83	6.40^{bc}±2.39
XAG	6.70±2.20	4.70^{c}±1.72	5.30^{b}±1.89	4.90^{b}±2.27	4.80^{c}±2.19	6.35^{b}±0.81	4.70^{c}±2.52

Key: CMC (carboxylmetinycellulose), CNC, (cassava negative control), PSH (psyllium husk), GET (galantine), WPC (wheat positive control), and XAG (xanthan gum)

Water is a source of variability and experimental error, which must vary as shown in Table 1 so that the consistency of the doughs prepared would be similar. Other ingredients like sugar, a pinch of salt, egg and baking fat were added. The dough was proofed at 25–30 °C for 20 min and was subsequently baked at 215 °C for 20–25 min.

The product's nutritional makeup and customer acceptability were assessed using standard analytical techniques. This study used a sensory parameter panel with 20 participants, both male and female. The participants rated the overall acceptability of the different bread formulations on a nine-point hedonic scale, with 1 denoting extreme dislike and 9 denoting extreme liking.. The breads were deemed accepTable if their average scores for overall acceptability exceeded 5 (representing a neutral stance of neither liking nor disliking). Proximate composition: moisture, ash, crude fibre, protein and carbohydrate were determined as described by the Association of Official Analytical Chemists. To analyse the data, analysis of variance along with Duncan's multiple range test was employed using SPSS version 12.002, with a significance level set at $P < 0.05$.

Results and Discussion

Table 2 shows the sensory parameters of gluten-free bread with different improvers. The score for the crumbs ranged from 6.70 to 8.00, with the wheat positive bread (WPC) scoring the highest value of like, with samples PSH, CNC and CMC having values that indicate like moderately. From the Table 3, it shows that the Panelists scored bread produced with improvers (PHS, CMC, XAG) very low in terms of flavour. This has a value of 4, which indicates neither like nor dislike this is an indication that the improver affected the flavour of the samples, except for sample GET. The texture ranged from 4.70-7.70. Sample WPC has the highest value of 7.70, which is moderate, while samples PSH and CMC have scores which indicate like. The texture of bread improved with psyllium husk is more accepTable than the other gluten-free breads. The texture of the bread is one of the physical qualities that consumers check when making a purchase. It is an important characteristic in bread, where it competes equally with appearance and flavour. This has been reported that the texture of a food product is an essential factor contributing significantly to consumer preference and acceptability of a food product Hassoun *et al*., 2022; Olakanmi *et al*., 2023. This suggests that hard bread will not appeal to the eye and will not be accepTable to consumers.

The flavour shows no significant difference among the hydrocolloid-improved breads. This is in line with the findings of Roseli *et al. (*2004), whose bread produced with different improvers showed no significant difference in flavour. Among the bread produced with improvers, the sample containing psyllium husk has the highest score and is more

Table 3: Physical Quality of Gluten-Free Bread With Different Improvers

Samples	Height	Length	Width	Weight
CMS	9.58	16.58	9.67	545g
CNC	7.48	15.88	9.73	552g
PSH	9.12	16.86	9.33	555g
GET	8.53	16.78	9.67	552g
WPC	8.34	14.87	9.68	471g
XAG	8.72	16.76	9.14	598g

Key: CMC (carboxylmetinycellulose), CNC, (cassava negative control), PSH (psyllium husk), GET (galantine), WPC (wheat positive control), and XAG (xanthan gum).

Table 4: Proximate Composition of Gluten Free Bread with Different Improvers

Sample	Protein	Fiber	Ash	Fat	Moisture	Cho
CMC	$6.82^{c}\pm0.08$	$0.64^{a}\pm0.07$	$1.35^{bc}\pm0.22$	$14.63^{b}\pm0.74$	$35.90^{bc}\pm0.71$	$40.67^{bc}\pm1.82$
CNC	$7.81^{a}\pm0.02$	$0.62^{a}\pm0.04$	$1.37^{b}\pm0.10$	$18.42^{a}\pm0.07$	$33.60^{cd}\pm0.00$	$38.19^{c}\pm0.12$
PSH	$5.15^{f}\pm0.07$	$0.43^{b}\pm0.06$	$1.18^{bc}\pm0.06$	$14.24^{b}\pm0.56$	$37.30^{b}\pm1.27$	$41.71^{b}\pm0.65$
GET	$6.11^{d}\pm0.01$	$0.54^{a}\pm0.02$	$0.95^{bc}\pm0.04$	$14.71^{b}\pm0.34$	$36.40^{bc}\pm0.00$	$41.30^{bc}\pm0.35$
WPC	$5.84^{e}\pm0.06$	$0.42^{b}\pm0.00$	$2.01^{a}\pm0.29$	$14.49^{b}\pm0.04$	$31.80^{d}\pm2.55$	$45.45^{a}\pm2.16$
XAG	$7.40^{b}\pm0.22$	$0.56^{a}\pm0.01$	$1.27^{bc}\pm0.01$	$17.31^{a}\pm1.18$	$41.90^{a}\pm0.42$	$31.62^{d}\pm0.0$

Key: CMC (carboxylmetinycellulose), CNC, (cassava negative control), PSH (psyllium husk), GET (galantine), WPC (wheat positive control), and XAG (xanthan gum).

accepTable than the others in all the parameters investigated except flavor and appearance. However, this was closely followed by bread baked from CMC. The result shows that bread improvers such as the CMC, psyllium husk, and xanthan gum increased the bread height more than the positive control and the cassava negative control bread, which are bread produced with wheat flour and cassava flour with no improver. Among the improvers used, the psyllium husk gave higher values in terms of height, length, and width, with XAG recording the highest weight. This report is in line with the findings of Roseli *et al. (*2004 who reported that hydrocolloid offers extra strength to the gas cells through baking, thereby increasing the gas retention, and by extension gives better volume. The increase in volume does affect the shape of bread slices.

Table 4 shows the proximate composition of gluten-free bread with different improvers. The protein content ranges from 5.15% (PSH) to 7.81% (CNC). CNC (7.81%) and XAG (7.40%) exhibited the highest protein levels, indicating their potential for improving the structure and texture of gluten free bread. Higher protein content contributes to better dough elasticity and gas retention. The range of dietary fiber concentrations was 0.42% (WPC) to 0.64% (CMS). The highest fiber concentrations were found in CMC (0.64%) and CNC (0.62%), indicating their potential use in formulations that support digestive health and satisfy health-conscious consumers. The comparatively lower fiber percentage of WPC (0.42%) suggests that some consumer preferences may choose a more soft bread with a finer crumb structure. Mineral composition of the individual elements, ranged from 0.95% (GET) to 2.01% (WPC). The sample WPC (2.01%) showed the highest ash level, indicating the availability of important elements including iron, calcium, and magnesium that are necessary for adequate nutrition. GET (0.95%), on the other hand, showed the lowest ash percentage, suggesting a more refined composition. Furthermore, the samples containing hydrocolloids had low ash content values, which is consistent with the findings of Muna *et al*. (2024), who found that bread made with wheat flour had a greater ash content.

The percentage of the fat ranged from 14.24% (PSH) to 18.42% (CNC). In gluten-free bread formulations, the CNC sample (18.42%) had the highest fat content, which could increase mouthfeel and flavor retention.

On the other hand, PSH (14.24%) had the lowest fat content, making it especially appropriate for low-fat dietary applications. The moisture content varied between 31.80% (WPC) and 41.90% (XAG). The XAG sample (41.90%) had the highest moisture level, which might make the bread softer, but it might also shorten its shelf life because of its greater vulnerability to microbial growth.

On the other hand, WPC (31.80%) had the lowest moisture content, making it a drier product with better storage stability. The moisture content found in this investigation is somewhat greater than the SNI 2018-mandated permissible standard of 40% moisture in bread. The range of the carbohydrate content was 31.62% (XAG) to 45.45% (WPC). The WPC sample had the highest carbohydrate content (45.45%), making it an energy-dense formulation appropriate for people with high calorie requirements.n contrast, XAG (31.62%) had the lowest carbohydrate content, indicating rendering it suited for low-carbohydrate dietary regimens.

Conclusion

The study concluded that all of the sensory characteristics examined were impacted by the improvers. Sample PSH outperformed the other loaves made with improvers in terms of texture, flavor, chewiness, and overall acceptability. Sample CMC in crumbs, flavor, chewiness, and overall acceptability came next. According to the study, improvers such carboxymethylcellulose, PSH psyllium husk, and gelatine can be employed to achieve good physical, sensory, and proximate composition qualities that are competitive with wheat-based bread.

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