Effects of Selected Bread Improver on the Physicochemical and Proximate Property of Wheat-Cassava Composite Bread

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ABSTRACT

*Wheat flour with cassava flour substitution was done which weakens the continuous gluten network needed for gas retention and loaf development. This study examined the incorporation of guar gum, ascorbic acid, Panok® and STK Royal as improvers in bread prepared from a 90:10 wheat-cassava composite flour. The experimental set up included improver levels of 0.5, 1, 2 and 3%, while the end-product data available for this paper compare the 3% treatments with an untreated control. Loaf dimensions, bread yield, oven spring, specific volume, proximate composition, CIE L*a*b* colour and sensory attributes were evaluated. The stated statistical procedure adopted was analysis of variance followed by Duncan's multiple range test set at $p < 0.05$. Moisture ranged from 14.08% in the control to 17.76% in the ascorbic-acid treatment, and crude protein ranged from 8.06% in the control to 11.67% in the STK Royal treatment. Panok® gave the highest loaf height (10.88 cm), specific volume (3.57 cm^3/g) and L* value (64.87). Guar gum gave the highest bread yield (134.66%), whereas ascorbic acid gave the highest oven spring (3.20 cm). Sensory scores were generally higher for improver-treated breads than for the control; STK Royal recorded the highest flavour score (8.57), Panok® the highest taste score (7.93), and guar gum the highest overall acceptability score (7.73). The findings indicate that the tested improvers were associated with different technological and sensory responses.*

KEYWORDS

Wheat-cassava composite bread, cassava flour, bread improvers, guar gum, ascorbic acid, specific volume, sensory quality

I. INTRODUCTION

Bread quality depends strongly on the dough matrix ability to retain fermentation gases and to maintain structure during baking. Wheat flour became necessary to this process because hydrated gluten proteins form a visco-elastic network. Adding cassava flour can support the use of a locally available crop and vary flour supply, but cassava flour does not contribute to gluten. As cassava substitution increases, the resulting composite dough may therefore show weaker structure and change water absorption, pasting property of bread-making performance.

Bread improvers are used to change dough handling, gas retention, loaf development, crumb structure and storage-related value. Hydrocolloids can alter water binding, viscosity and structural stability, which are relevant in cereal structure with a weakened or absent gluten network. Specific volume is commonly used as an integrated technological indicator because it relates loaf expansion to loaf mass and reflects the ability of the formulation to absorb gas during proofing and baking.

Ascorbic acid is an oxidative bread improver whose effects are mediated through dough redox chemistry and gluten-network strengthening rather than by simple acidification. Experimental studies show that organic acids, including ascorbic acid, can modify dough visco-elasticity and resistance to extension. Recent work also confirms that the response to commercial or individual improver systems is formulation-dependent, making dose and flour strength important experimental variables.

In Nigeria, earlier studies have demonstrated that improvers can influence the yield, oven spring, specific volume, texture and acceptability of 90:10 wheat–cassava bread. More recently, Ukoro et al. (2023) reported that breads containing selected improvers achieved higher sensory scores than untreated wheat–cassava controls. Building on these findings, the present study evaluates four selected improvers—guar gum, ascorbic acid, Panok® and STK Royal—within a 90:10 wheat–cassava formulation and compares their effects on the physicochemical, proximate, colour and sensory properties of the resulting bread.

II. MATERIALS AND METHODS

A. Materials

Wheat–cassava composite flour containing 10% cassava flour was prepared. Other bread ingredients comprised granulated sugar, iodized salt, baker's yeast, shortening, potable water and calcium propionate. The improvers evaluated were guar gum, ascorbic acid, Panok® (a commercial bread improver) and STK Royal (a commercial bread improver). All materials were purchased from retail outlets in Gboko Township, Benue State, Nigeria, and were stored under refrigeration (4 ± 1 °C) prior to use.

B. Treatment design and preparation

Each improver was separately incorporated into the 90:10 wheat-cassava composite flour at nominal levels of 0.5, 1, 2 and 3% (basis to be verified). The flour and improver mixtures were blended at approximately 1200 rpm for 10 mins, packaged in high-density polyethylene bags and stored under refrigeration. Bread without an improver served as the control. The paper describes the experiment as a completely randomized design with three replications. For the end-product analyses presented in this article, only the 3% treatment of each improver was compared with the control.

C. Bread production

Dry ingredients were mixed before yeast dispersed in water was added. Dough was kneaded manually to obtain a smooth, non-sticky consistency dough, proofed for approximately 90 min, transferred to prepared pans and baked at 220 °C for 10 min. Baked bread were cooled to room temperature, packed in polyethylene bags and held on the laboratory bench for analyses.

D. Physical measurement of Bread

The Loaf height, width, length and thickness were measured as physical dimensions using meter rule. Bread yield, oven spring and specific volume were also evaluated. Specific volume was calculated as loaf volume divided by loaf mass, while bread yield was calculated as baked loaf mass divided by flour mass and multiplied by 100.

$$\text{Specific volume } (cm^3/g) = \text{loaf volume } (cm^3) / \text{loaf mass } (g)$$

$$\text{Bread yield } (\%) = \text{baked loaf mass} / \text{flour mass} \times 100$$

E. Proximate composition

The moisture, ash, crude fat, crude protein and crude fibre were determined for the bread samples. Carbohydrate was calculated by difference as:

$$\text{Carbohydrate } (\%) = 100 - [\text{moisture } (\%) + \text{ash } (\%) + \text{crude fat } (\%) + \text{crude protein } (\%) + \text{crude fibre } (\%)]$$

F. Colour measurement

Bread colour was expressed using L*, a* and b* coordinates, where L* represents lightness, a* the red-green axis and b* the yellow-blue axis.

G. Sensory evaluation

Ten panelists evaluated colour, flavour, taste, crust texture, crumb texture and overall acceptability using a nine-point hedonic scale, anchored from 1 (dislike extremely) to 9 (like extremely). The sensory comparison was conducted on the breads containing 3% improver and the control.

H. Statistical analysis

The data were analysed by analysis of variance (ANOVA), with mean separation by Duncan's multiple range test at $p < 0.05$, and that experimental measurements were conducted in three replications.

III. RESULTS

A. Physical attribute of the Bread

The physical measurement of the bread samples shown in Table 1. Panok® and STK Royal recorded the greatest loaf heights, 10.88 and 10.39 cm, respectively, compared with 8.33 cm for the control. Ascorbic acid produced the greatest loaf length (13.50 cm), while STK Royal recorded the greatest thickness (9.53 cm).

Table 1: Physical property of wheat–cassava composite bread containing selected improvers
Improver Height (cm) Width (cm) Length (cm) Thickness (cm)

Improver	Height (cm)	Width (cm)	Length (cm)	Thickness (cm)
Guar gum	6.17^{d}	7.17^{b}	10.50^{b}	8.47^{ab}
Ascorbic acid	6.13^{d}	7.01^{b}	13.50^{a}	8.10^{b}
Panok®	10.88^{b}	8.50^{a}	10.17^{b}	9.30^{a}
STK Royal	10.39^{b}	7.56^{b}	7.83^{b}	9.53^{bc}
Control	8.33^{c}	7.83^{ab}	8.00^{c}	8.00^{c}

B. Bread yield, oven spring and specific volume

Bread yield was highest for guar gum (134.66%), followed by STK Royal (133.00%) and Panok® (132.50%). Ascorbic acid had the highest reported oven spring (3.20 cm), while Panok® had the highest specific volume (3.57 cm^3/g). The control had the lowest bread yield (123.50%) and specific volume (3.14 cm^3/g).

Table: 2. Bread yield, oven spring and specific volume

Improver	Bread yield (%)	Oven spring (cm)	Specific volume (cm^3/g)
Guar gum	134.66 ± 1.02^{b}	2.54 ± 0.02^{b}	3.41 ± 0.02^{c}
Ascorbic acid	125.75 ± 2.02^{a}	3.20 ± 0.52^{b}	3.31 ± 0.02^{b}
Panok®	132.50 ± 5.02^{b}	3.09 ± 0.02^{b}	3.57 ± 0.02^{d}
STK Royal	133.00 ± 1.01^{b}	3.04 ± 0.03^{b}	3.44 ± 0.02^{c}
Control	123.50 ± 0.02^{a}	2.79 ± 0.02^{a}	3.14 ± 0.02^{a}

C. Proximate composition

Moisture was lowest in the control (14.08%) and highest in the ascorbic-acid treatment (17.76%). Crude protein ranged from 8.06% in the control to 11.67% in STK Royal bread, while crude fat ranged from 6.04% in the control to 11.05% in STK Royal bread. After calculation by difference from the reported proximate means, carbohydrate ranged from 60.34% in STK Royal bread to 71.25% in the control.

Table: 3. proximate composition of wheat-cassava composite bread

Treatment	Moisture (%)	Ash (%)	Crude fat (%)	Crude protein (%)	Crude fibre (%)	Carbohydrate (%) †
Ascorbic acid	17.76 ± 0.01^{a}	1.51 ± 0.01^{a}	10.69 ± 0.01^{a}	8.10 ± 0.01^{c}	0.03 ± 0.01^{ab}	61.91
Panok®	16.07 ± 0.01^{b}	1.12 ± 0.01^{b}	8.95 ± 0.01^{b}	9.34 ± 0.01^{b}	0.01 ± 0.01^{b}	64.51
Guar gum	14.98 ± 0.01^{c}	1.30 ± 0.01^{b}	6.79 ± 0.01^{c}	8.95 ± 0.01^{b}	0.04 ± 0.01^{a}	67.94

STK Royal	16.01 ± 0.01^{b}	0.92 ± 0.01^{c}	11.05 ± 0.01^{a}	11.67 ± 0.01^{a}	0.01 ± 0.01^{c}	60.34
Control	14.08 ± 0.04^{b}	0.56 ± 0.03^{c}	6.04 ± 0.04^{b}	8.06 ± 0.02^{a}	0.01 ± 0.03^{b}	71.25

D. Colour characteristics

Panok® had the highest reported lightness value (L* = 64.87), compared with 60.11 for the control. The* values ranged from 0.055 to 0.215 and b* values from 34.12 to 38.60. Because measures of dispersion and verified inferential statistics were not supplied for Table 4, the colour results are interpreted descriptively.

Table: 4. Reported CIE colour coordinates

Treatment	L*	a*	b*
Guar gum	61.97	0.142	38.45
Ascorbic acid	61.40	0.215	38.60
Panok®	64.87	0.056	35.00
STK Royal	62.31	0.065	38.31
Control	60.11	0.055	34.12

E. Sensory attributes

The control had the lowest reported mean score for every sensory attribute. STK Royal had the highest colour (7.73), flavour (8.57) and crust-texture (8.13) scores. Panok® had the highest taste (7.93) and crumb-texture (7.93) scores, while guar gum had the highest overall-acceptability score (7.73).

Table: 5. Sensory evaluation of Bread on a nine-point hedonic scale

Treatment	Colour	Flavour	Taste	Crust texture	Crumb texture	Overall acceptability
Guar gum	7.60	7.27	7.46	7.33	7.47	7.73
Ascorbic acid	7.23	6.97	6.77	6.73	6.23	7.57
Panok®	7.27	6.90	7.93	7.73	7.93	7.07
STK Royal	7.73	8.57	7.50	8.13	7.83	7.58
Control	5.13	5.20	5.37	5.50	5.50	5.50

IV. DISCUSSION

A. Physical performance and loaf development

The four improvers did not affect all bread-quality attributes uniformly, indicating that each improver operates through a distinct mechanism. Panok® and STK Royal were associated with the greatest loaf heights, while Panok® also produced the highest specific volume. In composite breads, cassava substitution dilutes the proportion of gluten-forming proteins, which modifies moisture distribution and dough rheology; the partial restoration of loaf dimensions by certain improvers may be attributed to their ability to enhance dough viscosity, modify interfacial behaviour or strengthen the remaining gluten network.

Specific volume is a widely accepted technological marker of bread aeration and structural retention, because it integrates loaf volume with loaf mass. In the present study, Panok® recorded the highest specific volume (3.57 cm^3/g), followed by STK Royal (3.44 cm^3/g), guar gum (3.41 cm^3/g), ascorbic acid (3.31 cm^3/g) and the control (3.14 cm^3/g). All improver-treated breads exceeded the control in specific volume, suggesting that each improver contributed, albeit to different degrees, to improved gas retention during proofing and baking.

Guar gum produced the highest bread yield (134.66%), which may be attributed to the well documented capacity of hydrocolloids to enhance water retention and modify dough viscosity, thereby reducing baking loss and increasing retained mass. This inference should be tempered by the fact that dough water absorption, water activity and baking loss were not directly quantified in the present study.

B. Ascorbic acid and oven spring

Ascorbic acid produced the highest oven spring (3.20 cm), consistent with its established role in modifying wheat-dough redox chemistry and strengthening the gluten network during mixing and proofing. Ascorbic acid is oxidised to dehydroascorbic acid during dough mixing, wh ich in turn promotes the formation of disulphide bonds within and between gluten proteins, thereby increasing dough resistance to extension and gas retention capacity. Recent investigations emphasise that the magnitude of improver effects can depend on flour strength, ingredient interactions and dosage, underscoring the importance of reporting treatment identity and concentration.

C. Proximate composition

The improver treatments were associated with differences in moisture, fat and protein contents. The higher moisture observed in the ascorbic-acid treatment (17.76%) may influence crumb softness, perceived freshness and product mass, although water activity and staling kinetics were not measured in the present study. The apparent increases in crude fat and crude protein—particularly in the STK Royal treatment—should be interpreted cautiously because the exact ingredient compositions of the commercial improvers (Panok® and STK Royal) were not disclosed by the manufacturers; these products may themselves contribute fat and protein to the composite formulation. Moreover, proximate composition is a compositional measure and does not, by itself, establish improved nutrient bioavailability or health benefit.

Carbohydrate values were recalculated by difference from the reported mean proximate components. On this corrected basis, the control had the highest calculated carbohydrate content (71.25%), while STK Royal had the lowest (60.34%). The reduction in carbohydrate content in the improver-treated breads is consistent with the displacement of flour—and hence starch—by the added improvers.

D. Colour and sensory quality

Panok® produced the highest lightness value (L* = 64.87), indicating the lightest crumb among the treatments. Bread colour is influenced by formulation and processing factors, including water distribution, the availability of reducing sugars and amino compounds for Mallard browning, pH and thermal history. Because the location of the colour measurement (crust or crumb) was not specified and Table 4 lacks variability estimates, the present data support only a descriptive association between treatment and colour.

The sensory results demonstrate a clear separation between the control and the improver treated breads across all evaluated attributes. These findings are consistent with those of Ukoro et al. (2023), who reported that breads containing selected improvers achieved higher sensory scores than untreated wheat–cassava bread. The superior sensory performance of the improver-treated breads may be attributed to improvements in loaf volume, crumb structure and flavour development associated with the respective improver mechanisms. The relatively small differences in overall acceptability among the improver-treated breads (7.07–7.73) suggest that all four improvers were broadly acceptable at the 3% inclusion level, although guar gum was marginally preferred.

V. LIMITATIONS

Several limitations were acknowledged. First, the end-product comparison is restricted to the 3% treatment level; the effects of lower inclusion rates (0.5, 1 and 2%) are not reported here. Second, the commercial compositions of Panok® and STK Royal were not disclosed by the manufacturers, which constrain mechanistic interpretation of treatment effects on proximate composition and dough rheology. Third, colour data are presented without measures of dispersion or inferential statistics, limiting the conclusions to descriptive associations. Fourth, the sensory panel comprised only ten semi-trained assessors, which may constrain the statistical power and generalizability of the sensory findings. Fifth, carbohydrate values were calculated by difference rather than determined analytically and replicate-level data were unavailable for reanalysis.

VI. CONCLUSION

The four bread improvers evaluated in this study—guar gum, ascorbic acid, Panok® and STK Royal—each modulated distinct quality attributes of 90:10 wheat–cassava composite bread at the 3% inclusion level. Guar gum produced the highest bread yield (134.66%), Panok® the highest specific volume (3.57 cm^3/g) and lightness (L* = 64.87), ascorbic acid the highest oven spring (3.20 cm), and STK Royal the highest crude protein (11.67%), flavour (8.57) and crust texture (8.13) scores. Guar gum received the highest overall acceptability score (7.73), while Panok® was preferred for taste (7.93) and crumb texture (7.93). These findings indicate that the selection of a bread improver for wheat–cassava composite formulations should be guided by the target quality parameter. Further research should investigate the effects of these improvers across a range of inclusion levels and cassava substitution ratios, and should include direct measurements of dough rheology, water activity and staling kinetics.

A. Declarations:

The authors declare no conflict of interest.

B. Acknowledgements:

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