

PROXIMATE COMPOSITION, BREAD CHARACTERISTICS AND SENSORY EVALUATION OF COCOYAM-WHEAT COMPOSITE BREADS

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ABSTRACT

This study was carried out to investigate proximate composition, bread characteristics and sensory evaluation of cocoyam-wheat composite breads at different levels of cocoyam flour substitution for human consumption. A whole wheat bread (WWB) and cocoyam-composite breads (CCB1, CCB 2 and CCB 3) were prepared in triplicate at 0, 10, 20 and 30% levels of cocoyam flours substitution respectively and assessed for proximate composition, bread characteristics and sensory attributes. The results indicate that carbohydrate, crude fiber, and ash contents of the cocoyam-composite breads increased significantly ($p < 0.05$) while the moisture and protein contents decreased significantly with progressive increase in the cocoyam flour substitution. The significant ($p < 0.05$) highest ash, fibre and carbohydrate values of 1.61, 1.54 and 70.40 g/100g dm respectively were observed in 30% cocoyam-wheat composite bread compared to lowest values of 1.15, 0.29 and 63.25 g/100g dm, respectively in 100% wheat bread. The significant ($p < 0.05$) higher moisture and protein values of 20.99 and 12.54 g/100g dm were observed in 100% wheat bread compared to lowest values of 17.31 and 9.04 g/100g dm, respectively in 30% cocoyam-wheat composite bread. Bread characteristics showed that, the loaf weight of cocoyam composite breads increased significantly ($p < 0.05$) while loaf volume and specific loaf volume decreased significantly ($p < 0.05$) with increasing cocoyam flour substitution. The significant ($p < 0.05$) highest loaf weight of 229.33 g was observed in 30% cocoyam-wheat composite bread compared to 208.33, 221.67 and 225 g observed in 100% wheat bread, 10 and 20% cocoyam-wheat composite breads respectively. The highest loaf volume and specific loaf volume of 800 and 3.49 cc were observed in 100% wheat bread compared to lowest values of 580 and 2.78 cc respectively observed in 30% cocoyam-wheat composite bread. The sensory evaluation showed no significant ($p > 0.05$) differences in sensory attributes of taste, aroma and acceptability between the 100% wheat and 10% cocoyam-wheat composite breads ($p < 0.05$). In conclusion, this study has shown that the use of cocoyam flour in bread making is feasible and that incorporation of up to 10% of the flour into wheat flour produced acceptable bread with similar taste and aroma comparable to 100% wheat bread. Nevertheless, it is important to consume this bread with other protein rich diet in order to supplement the reduction resulted from substitution.

Key words: Cocoyam, proximate, bread, sensory, quality

INTRODUCTION

Cocoyam (*Xanthosoma sagittifolium*) is herbaceous perennial plant belonging to the araceae family and constitutes one of the six most important root and tuber crops world-wide [1]. They are among the major crops grown in wetlands with minimal inputs and offer high potential for alleviating food insecurity and income constraints. Cocoyam is rich in digestible starch, good quality protein, vitamin C, thiamin, riboflavin, niacin and high scores of proteins and essential amino acids [2, 3]. However, in spite of its nutritional importance, cocoyam has not received any deliberate attention to address its research and development. It receives low research priority in all regional agricultural research centres and therefore, its contribution to food security and economy is underestimated [4]

Wheat flour is one of the major conventional ingredients in bread making due to its gluten fraction, which is responsible for the elasticity of the dough by causing it to extend and trap the carbon dioxide generated by yeast during fermentation [5]. However, in tropical countries, wheat production is limited and importation of wheat flour to meet local demand is a necessity [6]. Tanzania imports over 90% of its annual wheat demand of about 360,000 tones per year from countries like Australia, Canada, and Russia among others which costs substantial amount of foreign exchange. Considerable effort has been made to promote the use of composite flours in which flour from locally grown crops replaces a portion of wheat flour for use in breads, thereby decreasing the demand for imported wheat and stimulating production and use of locally grown non-wheat agricultural products [7]. Studies on the use of various oilseeds, legumes and high protein seeds in bread making have been reported [8, 9]. These studies showed that 2 to 10% non-wheat flour can be used in breads without undesirable changes in bread characteristics and sensory attributes of breads. Moreover, cocoyam, cassava, plantain and other tubers crops have been reported to be alternative sources of major raw materials for bread making [5, 10, and 11]. This suggest that, opportunities and support for the use of cocoyam flour for production of baked goods if feasible would help to lower the dependency of developing nations on imported wheat. This study therefore, aimed at investigating the chemical composition, bread characteristics and sensory attributes of cocoyam-composite breads at different levels of cocoyam flour substitution for human consumption.

MATERIALS AND METHODS

Study location

The study was carried at the Department of Food Science and Technology, Sokoine University of Agriculture, (SUA), Morogoro, Tanzania in 2008

Materials

Cocoyam (*X. Sagittifolium*) samples were collected randomly from farmers along the Lake Victoria basin in Kagera region. A 100% hard winter wheat flour, yeast (instant dry yeast), fat, baking powder, sugar and salt were purchased from local shops in Morogoro, Tanzania. Reagents and chemicals for proximate analysis were obtained from Sigma-Aldrich chemical suppliers, Nairobi Kenya and are of analytical grade.

Research design

Completely randomized design (CRD) was used in the study and principal factor was bread types (WWB, CCB 1, CCB 2, and CCB 3). The samples were analyzed for proximate composition, baking characteristics and sensory attributes. The effects of the principal factor on these parameters was determined

Preparation of cocoyam flour

Fresh corms were thoroughly washed with tap water, peeled using a stainless steel knife, rewashed and cut into 0.5 cm thick slices. The slices were dried to a constant weight in an oven set at 105°C for 24 hours before milling into flour using a grinder fitted with a 500-µm mesh sieve. Flour obtained was packed in polyethylene bags and stored at 4° C ready for preparation of composite flours [12].

Preparation of cocoyam/wheat composite flour

Cocoyam-wheat composite flour was processed by blending wheat and cocoyam flours. Predetermined proportions of 10, 20 and 30 part by weight of cocoyam flour mixed with 90, 80 and 70 part by weight of wheat flour to obtain 10, 20 and 30% of cocoyam/wheat composite flour respectively. 100% wheat flour was used as a control bread sample. The flours were packed in polythene bags and stored at -18 °C until analysis.

Bread making

The whole wheat (WWB) and composite breads (CCBs) were made by mixing the flour with weighed ingredients; 5 g salt, 40 g shortening, 20 g yeast and 60g sugar in 500 ml water followed by stirring using a Kenwood mixer (Model A 907 D) for 5 min to obtain a dough. The dough was allowed to ferment in a bowl covered with wet clean muslin cloth for 55 min at room temperature (~25°C). Later, the dough was punched and scaled to 250 g dough pieces. The dough pieces were proofed in a proofing cabinet for 90 min at 30°C in 85% relative humidity and baked at 250°C for 30 min [6]. The breads were cooled to room temperature and then assessed for their proximate composition, bread characteristics (loaf weight, volume, as well as sensory attributes like crust and crumb colour, taste, aroma, texture and general acceptability.

Proximate analysis

Proximate composition of the whole wheat and the composite bread samples were determined using AOAC methods [13]. Moisture content (% MC) was determined by drying samples in an oven at 105°C for 24 hours. Crude protein percentage (% CP) was determined by Kjeldahl method AOAC method No 920.87 [13] with the Kjeltac 8400 analyzer unit (FOSS, Sweden) and the percentage nitrogen obtained was used to calculate the % CP using the relationship: % CP = % N X 6.25. Ether extract percentage (% EE) was determined using Soxhlet system HT-extraction technique AOAC method No 922.06 [13] and percentage ash (%) was determined by incinerating the samples in a muffle furnace at 550°C for four hours. The ash was cooled in a desiccator and weighed. Crude fibre percentage (% CF) was determined by dilute acid and alkali hydrolysis AOAC method 991.43 [13]. Carbohydrate was calculated by difference.

Evaluation of bread characteristics

Bread characteristics were evaluated by measuring the loaf weight, loaf volume and specific loaf volume. Loaf weight was measured 30 minutes after the loaves were removed from the oven using a weighing balance whereas loaf volume was measured using the rapeseed displacement method as modified by Giami *et al.* [6] as follows: A box of fixed dimensions (23.00 x 14.30 x 17.21 cm) of internal volume 5660.37 cm³ was put in a tray, half filled with pearled barley, shaken vigorously 4 times, then filled till slightly overfilled so that overspill fell into the tray. The box was shaken again twice, and then a straight edge was used to press across the top of the box once to give a level surface. The seeds were decanted from the box into a receptacle and weighed. The procedure was repeated three times and the mean value for seed weight was noted (C g). A weighed loaf was placed in the box and weighed seeds (3500 g) were used to fill the box and leveled off as before. The overspill was weighed and from the weight obtained the weight of seeds around the loaf and volume of seed displaced by the loaf were calculated using the following equations by AACC method 10-05.01 [14]:

Seeds displaced by loaf (L) = C g + overspill weight – 3500 g.

$$\text{Volume of loaf (V)} = \frac{L \times 5660.37 \text{ cm}^3}{C}$$

The specific loaf volume was determined by dividing the loaf volume by its corresponding loaf weight (cm³/g) as described by Araki *et al.* [15]

Sensory evaluation procedures

Sensory evaluation based on the sensory attributes were conducted by using a standard five points hedonic scales method (where 1 = dislike very much and 5 = like very much) as described by Larmond [16]. A total of 30 semi-trained panelists aged 18 and above years old were involved in the evaluation for crust and crumb colour, aroma, taste, texture and overall acceptability. Among these panelists, 13 and 7 were males and females, respectively. The bread samples were sliced into pieces of uniform thickness (2 cm), coded with 3-digit random number using statistical random tables and served to the panelists at around 11.15 a.m with distilled water for rinsing the mouth after every sample taste in a randomized order. The panelists were instructed to rate the attributes indicating their degree of liking or disliking by putting a number as provided in the hedonic scale according to their preference.

Statistical data analysis

Data obtained were analyzed using SAS statistical package [17]. One way ANOVA was performed to determine the differences in proximate composition, baking and sensory characteristics of the bread samples. Means separation were done by use of Fisher's Least Significant Difference test (LSD) at $p \leq 0.05$.

RESULTS

Chemical composition

Table 1 shows the result of the proximate composition of the cocoyam-wheat composite bread samples. The analysis of variance on all proximate analysis data showed significant differences between the bread samples at $p < 0.05$. The moisture content values were 20.99% and 17.31% for the 100% wheat bread (WWB) and 30% cocoyam-wheat composite bread (CCB 3), respectively. This result implies that, the moisture content of the samples decreased with increase in the levels of cocoyam flour. Crude protein values were 12.54% and 9.04% for the 100% wheat bread (WWB) and 30% cocoyam-wheat composite bread (CCB 3) respectively while fat contents values were 2.02% and 0.54% for 100% wheat bread (WWB) and 30% cocoyam-wheat composite bread (CCB 3), respectively. This means that, the protein and fat content significantly decreased as the amount cocoyam flour substitution increased. It is therefore suggested that, consumption of this bread with other protein rich diet is of greater nutritional importance in order to compensate the reported reduction. Furthermore, fibre contents values were 0.29% and 1.54% for 100% wheat bread and 30% cocoyam-wheat composite bread, respectively implying a significant increase in fibre content with increasing the amount cocoyam flour substitution levels.

The result also showed carbohydrate content of 63.25 % and 70.49% for 100% wheat bread and 30% cocoyam-composite bread, respectively which suggest significant increase in carbohydrate contents as the cocoyam flour substitution level increased. The ash content were 1.51% and 1.61% for 100% wheat bread (WWB) and 1.61% for 30% cocoyam-composite bread, (CCB 3) respectively which also showed a significant increase in the ash content as the cocoyam flour substitution levels increased. The increase in carbohydrate and ash contents shows that, cocoyam based bread is nutrient dense than 100% wheat bread.

Bread characteristics

Results on the baking characteristics of wheat and cocoyam composite bread are given in Figure 1. The loaf weight of cocoyam composite breads increased with increasing levels of cocoyam flour while loaf volume decreased significantly ($p < 0.05$) with increase in percentage of cocoyam flour.

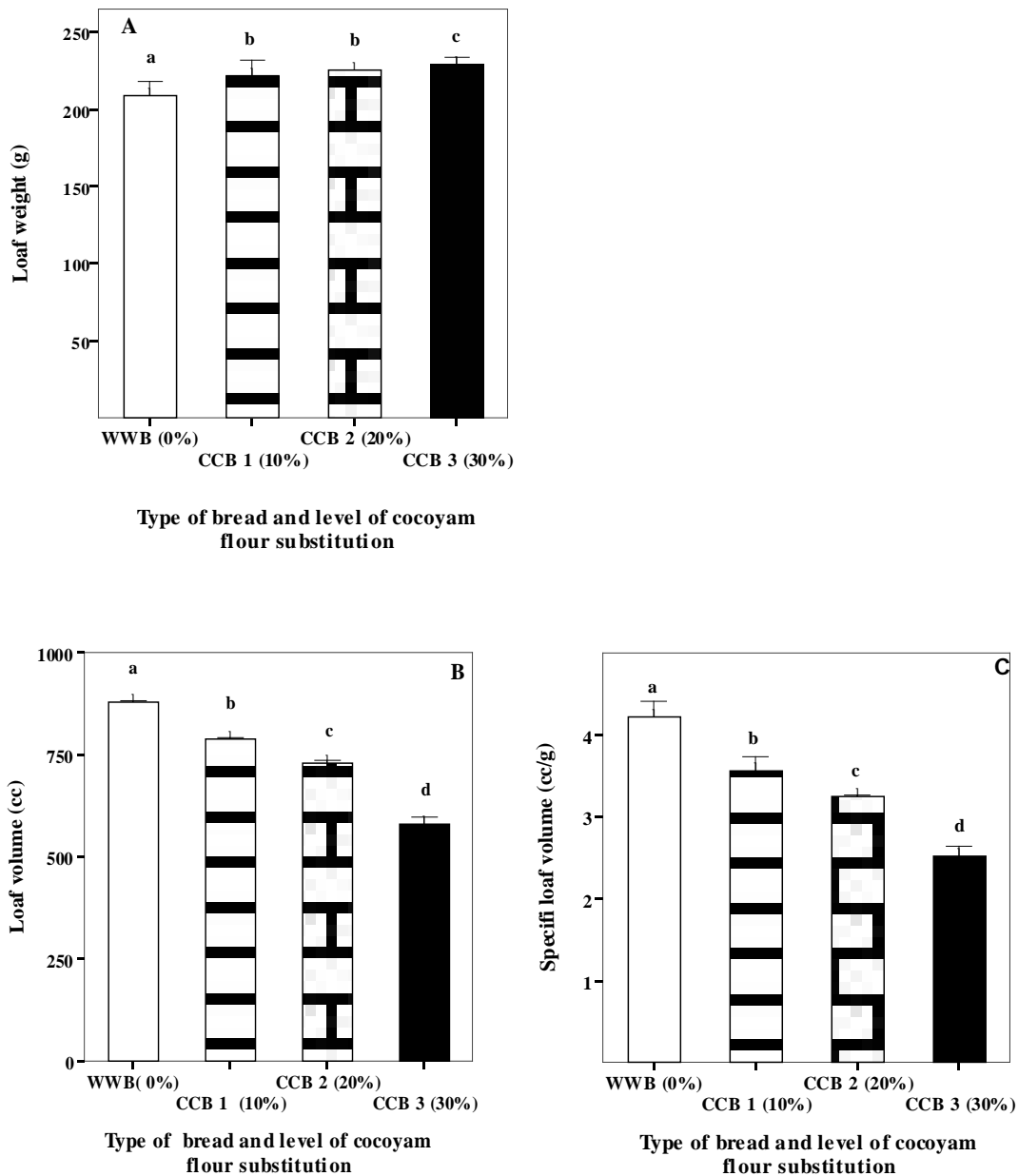


Figure 1: Baking characteristics (weight, volume and specific volume) of 100% wheat and cocoyam-wheat composite bread samples. Means with different letters between the bars are significantly difference at 5% level of significance

The weights of all cocoyam based bread were significantly ($p < 0.05$) higher than the 100% wheat bread while volume was less than the value for 100% wheat bread. Further increase up to 30% cocoyam flour produced unappealing loaf

Sensory evaluation

Figure 2 shows the results of the sensory attributes of the cocoyam-wheat composite bread samples. From these results, it follows that the mean hedonic score values for all tested sensory attributes were significantly different between the bread samples at $p < 0.05$. However, the mean separation showed no significant difference ($p > 0.05$) in taste, aroma and overall acceptability between 100% wheat and 10% cocoyam composite bread (CCB 1).

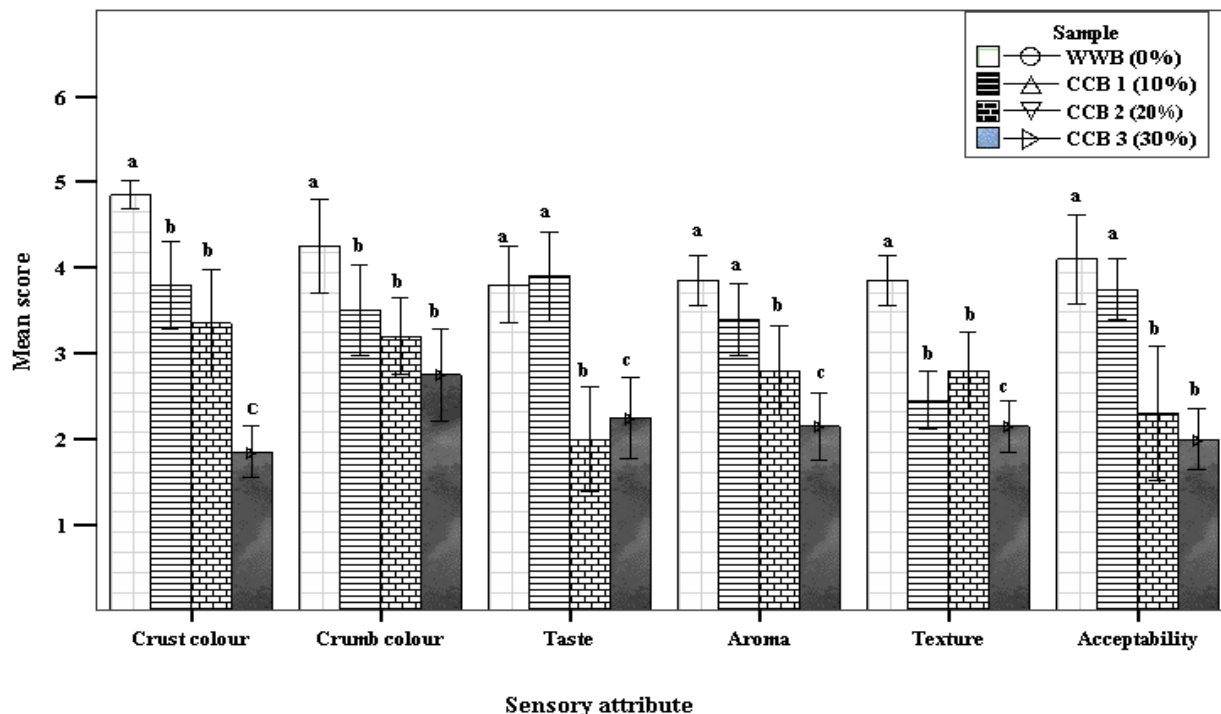


Figure 2: Sensory attributes of whole-wheat and cocoyam-wheat composite breads samples. Means with different letters between the bars are significantly difference at 5% level of significance

The 10% composite bread sample (CCB 1) had the highest mean score for taste. It was also observed that as the amount of cocoyam flour increased, the bread samples scored less for colour, taste, aroma and acceptability as shown on Figure 4. This implies that cocoyam flour could substitute wheat up to 10% to prepare bread with no significant difference in taste, aroma and acceptability.

DISCUSSION

Proximate composition

The moisture content of the whole wheat and composite breads decreased significantly at increased levels of cocoyam flour substitution. This trend is similar to the findings reported by Mepba *et al.* [5] and Eddy *et al.* [10], but differs from studies reported by Njintang *et al.* [12] and Olaoye *et al.* [18], who found out that, moisture content of the composite breads increased with increasing non-wheat flour

substitution. And this was attributed to a greater water holding capacity of the non-wheat flour than the wheat flour [19].

The significant ($p < 0.05$) decrease in the protein content in composite breads with increasing levels of cocoyam flour substitution may be explained by the fact that, cocoyam is a poor source of protein. It is a good source of carbohydrate predominantly starchy and consumed as an energy yielding food [20]. The significant ($p < 0.05$) increase in the fibre content was due the reason that, wheat flour had lower fibre content values (0.29%) compared to cocoyam flour. According to Schneeman [21] the crude fibre contributes to the health of the gastrointestinal system and metabolic system in man. Because crude fibre consists of cellulose and lignin, its estimation affords an index for evaluation of dietary fibre whose efficiency has been implicated in a variety of gastrointestinal disorder. By increasing intestinal mobility, fibre causes increased transit time for bile salt derivatives as deoxycholate, which are effective chemical carcinogen, hence reducing incidence of carcinoma of the colon [10]. Moreover, the observed significant increase in carbohydrate with increase in cocoyam substitution levels may be attributed to the high contents of carbohydrate in cocoyam. The carbohydrate predominates all solid nutrients in roots and tubers [22]. The increase in ash content could be attributed to the higher levels of ash in the cocoyam flour as compared to wheat flour.

Bread characteristics

The observed significant ($p < 0.05$) increase in loaf weight with increasing amount of cocoyam flour substitution was due to less retention of carbon dioxide gas in the blended dough, hence providing dense bread texture [23]. On the other hand, the less loaf volume and specific volume of the composite breads were probably due to the dilution effects on gluten with addition of cocoyam flour to the wheat flour. The Gluten fraction is responsible for the elasticity of the dough by causing it to extend and trap the carbon dioxide generated by yeast during fermentation. When gluten coagulates under the influence of heat during baking, it serves as the framework of the loaf, which becomes relatively rigid and does not collapse. The percentage of wheat flour required to achieve a certain effect in composite flours depends heavily on the quality and quantity of wheat gluten and the nature of the product involved [5]. A minimum protein content of 11.0% in wheat flour is necessary for the production of yeast-leavened bread [24]. Cocoyam flour has very low crude protein of 7 [25] with no gluten; consequently they could not be used solely for bread making. Therefore, based on the findings of this study, a limit of up to 10% substitution level with wheat flour in bread making is necessary to produced acceptable bread with weight and volume characteristics comparable to 100% wheat bread.

Sensory evaluation

The significant increases in mean colour scores for composite breads at increasing cocoyam substitution levels goes in line with the findings by Raid and Klein [26] who noted that, as the level of non-wheat flour in blends is increased, the crust colour of the bread changes from creamy white to dull brown or dark. The darker crust colour may be attributed to the reddish brown colour of the cocoyam flour and greater amount of the maillard reaction between reducing sugars and amino acids protein.

Furthermore, breads made from non-glutenous flour has the crust and hard crumb structure of cake rather than conventional bread and its appearance becomes less acceptable as substitution levels of non-wheat flour increases [27]. Similarly, results of this study showed as the amount of cocoyam flour increased to 30%, bread was less acceptable.

CONCLUSION

In the view of the results, a similar proximate, sensory and baking quality comparable to 100% wheat bread was observed in 10% cocoyam-composite bread. This suggests that bread of good nutritional and sensory qualities could be produced from up to 10% cocoyam flour substitution in wheat flour. Findings of this study have potential to promote the production and diversification of cocoyam consumption in Tanzania and other African countries.

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Table 1: Proximate composition of whole-wheat (WWB) and cocoyam-wheat composite bread (CCBs) samples (g/100g dry matter)

Samples	Moisture	Ash	Protein	Fibre	Fat	Carbohydrate
WWB	20.99 ^a	1.15 ^a	12.54 ^a	0.29 ^a	2.02 ^a	63.25 ^a
CCB_1	18.47 ^b	1.22 ^b	11.94 ^b	0.64 ^b	1.79 ^b	65.82 ^b
CCB_2	17.79 ^c	1.31 ^c	11.78 ^c	1.18 ^c	0.92 ^b	67.33 ^c
CCB_3	17.31 ^d	1.61 ^d	9.04 ^d	1.54 ^d	0.54 ^d	70.49 ^d

Mean values with different superscript in the same column are significantly different (p<0.05)

WWB, CCB 1, CCB 2 and CCB 3 are 0, 10%, 20% and 30% cocoyam-wheat composite breads, respectively.

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