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Production and quality evaluation of bread from wheat and pregelatinized cassava flour blends incorporated with carboxyl methylcellulose

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Abstract

The quality of bread from wheat and pregelatinized cassava flour blends was investigated. Cassava flour was produced from cassava roots and pregelatinized. The pregelatinized cassava flour was used to substitute 10, 20, 30 and 40% wheat flour in bread. The bread samples were evaluated for the physical and sensory properties. Carboxyl methyl cellulose (CMC) at 2% and 3% levels were incorporated into the bread containing 20% pregelatinized cassava flour and the breads were assessed for the proximate composition, physical and sensory properties. The moisture, protein, fat, ash, crude fibre and carbohydrate contents of the pregelatinized cassava flour were 6.12, 29.94, 9.71, 3.95, 2.64 and 47.63% respectively. The bread containing carboxyl methyl cellulose contained 24.42% moisture, 35.94% protein, 1.89% fat, 3.59% ash, 1.52% crude fibre and 32.65% carbohydrate. The weight, loaf volume and specific volume of the breads increased with the level of CMC incorporation in the bread. The breads containing CMC had higher loaf volume and specific volume but less weight than the bread that did not contain CMC. The scores for colour, taste, flavour, texture and overall acceptability of the breads containing CMC were significantly ($p<0.05$) higher than those of the control. The scores for all the sensory attributes increased with the level of CMC in the bread. The incorporation of CMC improved the physical and sensory properties of bread containing 20% pregelatinized cassava flour.

Keywords: Bread, Cassava flour, Pregelatinization, Carboxyl methylcellulose, Bread quality.

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Introduction

Bread is a fermented baked confectionery product prepared predominantly from white wheat flour with the addition of water, yeast, salt and other optional ingredients such as fat, milk, egg, etc (Adebato-Oyetoro *et al.,* 2016). Bread is an indispensable staple food consumed by all categories of people all over the world including Nigeria, where it provides dietary energy, proteins, vitamins B and E as well as minerals (Dewenttinck *et al*,. 2008). Indeed, Shittu et al. (2007) reported that bread is the second most popular staple food in Nigeria after rice.

The increasing popularity of bread as a major staple in different parts of the world, especially in Africa is partly due to increasing population and urbanization, and its convenience (Olaoye *et al.,* 2006). However, wheat importation represents a major burden on the economy of the importing countries (Ohimain, 2014). In this regard, attempts have been made to use indigenous non- wheat plant food commodities to substitute wheat flour in bread making (Ameh *et al*., 2013). The objective was to alleviate some of the problems associated with the use of 100% wheat flour which include cost, celiac disease and loss of nutrients during the milling process (Ohimain, 2014). In addition, this will boost agriculture and create jobs for the teeming populations, especially in Africa. One of such flours that have been used for this purpose is cassava flour. The inclusion of cassava flour as composite for the production of foods such as noodles, breakfast cereals, cookies, breads, cakes, pastries, muffins and doughnuts among others have reduced the costs of wheat importation and increased the production of these products locally (Oyewole, 2002; Akubor and Ukwuru, 2003; Falade and Akingbala, 2009). In 2003, Nigeria established a policy to use 10 % cassava flour in bread making. Following this development, a number of studies have been conducted to use cassava flour in bread making. Most of the studies showed that wheat flour can be replaced by 5 to 10 % cassava flour without significant effects on the processing and the quality of bread (Defloor *et al.,* 1994; Eddy *et al.,* 2007). However, bread from wheat flour containing 10% cassava flour has low volume and high rate of syneresis. Some of the factors that influence the quality of bread prepared from wheat-cassava composite flours have been studied and were reported to include variety of cassava (Eggleston *et al.,* 1993; maturity of cassava of the same variety (Defloor *et al..* 1995), the time and temperature of baking (Shittu *et al.,* 2007) and lack of use of fertilizer on cassava roots (Shittu *et al.,* 2007).

However, Cassava flour does not contain gluten. Thus, the incorporation of 10% of cassava into wheat flour presents considerable technological difficulties because the proteins of composite flour lack the ability to form the necessary gluten network for holding the gas produced during the fermentation (Onimawo and Akubor, 2012). The dough formed is difficult to handle, and the bread has poor loaf volume and crumb softness (Okoye and Ezengwu, 2019). Several studies have been carried out to improve the quality of bread from composite flours. Defloor *et al.,* (1995) showed that emulsifiers such as glycerylmonostearte could be used to improve air incorporation during mixing and gas retention during fermentation. The use of prehydrated extruded starch to increase batter viscosity was also recommended for producing high quality bread (Pasqualone *et al.,* 2010). Bread improvers are widely used in the bread making industry to improve dough handling properties and bread quality. Hydrocolloids are used in baked food to increase moisture retention and to improve viscoelastic properties of the dough in order to improve bread volume. In gluten-free breads based on rice flour and corn starch, Lazaridou *et al.,* (2007) showed that addition of hydrocolloids improved dough strength and bread volume. High specific volume, soft crumb and improved moisture retention were obtained in wheat bread with addition of hydroxypropyl methylcellulose (HPMC) and high methoxyl (HM)-pectin (Rosell *et al.,* 2001). Shittu *et al.,* (2007) documented improved specific volume and crumb softness in bread made from composite cassava-wheat flour incorporated with xanthan gum.

Cassava flour contains native starch which is not suitable for industrial applications due to its low shear stress resistance and thermal decomposition, high retrogradation and syneresis in addition to poor processability (Onimawo and Akubor, 2012). Hence, there is need to modify cassava starch to improve the functional and physicochemical properties for use in bread production. Starch could be modified by physical and chemical methods. The physical methods of starch modification such as moist-heat treatment, annealing and pregelatinization were identified to be more acceptable for the production of food products (Chung *et al*., 2009, Akubor and Igba, 2019). They are chemical-free and thus, considered safe for human consumption. Modified cassava starch could be used in bread as stabilizers or emulsifiers to modify and stabilise the texture of bread (Onimawo and Akubor, 2012). This could be achieved by improving some of the physicochemical properties of the dough such as viscosity, gel formation and water retention capacity (which decreases syneresis) (Chung *et al.*, 2009). Therefore, the objective of the study was to determine the chemical composition, physical and sensory properties of bread from wheat and pregelatinized cassava composite flour incorporated with carboxyl methyl cellulose.

Materials and Methods

Procurement of raw materials: Freshly harvested cassava roots, wheat flour, carboxyl methyl cellulose (CMC) and other bread ingredients used for the study were purchased from Wukari main market, Taraba state, Nigeria. They were taken to the Department of Food science and Technology laboratory, Federal University Wukari and used for the study.

Preparation of high quality cassava flour: The High quality cassava flour was prepared following the method described by Dziedzoave *et al.*, (2003). The fresh cassava roots were peeled manually using a stainless knife. The peeled cassava roots were washed in tap water, grated using a manual grater, pressed, disintegrated manually and then oven dried at 60^0C to constant weight. The powder was then milled in attrition mill and sieved through a 60 mesh sieve (0.10mm) to obtain the high quality cassava flour. The flour was packaged in high density polyethylene bag prior to use.

Preparation of pregelatinized cassava starch: The cassava flour was pregelatinized as described by Akubor and Igba(2019). The cassava flour (500g) was suspended in 1,000 ml distilled water and heated to 800C for 15 min with slow mixing. The pregelatinized cassava flour was spread on a stainless steel tray and dried in an oven at 400C for 48 h, milled and sieved using 60 mesh. The pregelatinized flour was then packaged in high density polyethylene bag and stored at ambient temperature (30±20C) prior to use.

Preparation of wheat flour: The commercial wheat flour was sieved through 60 mesh sieve and packaged in a high density polyethylene (HDPE) bag prior to use.

Flour blending: The modified cassava flour was used to substitute 10, 20, 30 and 40 % of wheat flour in a food blender that was operated at full speed (1200 rpm) for 10 min. The flour samples were packed in HDPE bags and stored in a refrigerator at 4^0C prior to use.

Preparation of bread Samples: The wheat and pregelatinized cassava flour blends were used to prepare breads using the recipe which consisted of flour (50 g), water (25 ml), margarine (8 g), sugar(4 g), powdered milk(10 g), salt (2 g) and yeast (1g) (Akubor and Obiegbuna, 2014). The breads were prepared following the procedures described by Akubor and Obiegbuna (2014). The rubbing method was used for the dry ingredients where the ingredients were weighed and the yeast was creamed in a basin with the milk-water mixture. A hole was made in the centre of the flour blend and the dissolved yeast was added and mixed. This was then covered with cheese cloth and fermented at 35^0C. The remaining milk – water mixture, butter, sugar and salt were added and kneaded manually until smooth dough free from stickiness was formed. The remaining dough was returned to the basin, covered with cheese cloth and proofed at 35^0C for 10 min. This was then knocked down and kneaded again for proper uniformity of spread of the ingredients. Thereafter, the dough were moulded and carefully brushed with egg and transferred into fat greased pans and proofed for 2h. The dough was baked at 220^0C for 10 min in a baking oven. The bread samples were cooled to ambient temperature and packaged in low density polyethylene bags prior to use.

Determination of proximate composition: The moisture, crude fat, ash, crude protein and crude fibre contents of the bread samples were determined using the AOAC (2012) methods. The carbohydrate content was calculated by difference.

Evaluation of the physical properties of the bread: The weight of the bread was determined using electronic weighing balance. The loaf volume was determined by seed displacement method as described by Akubor and Obiegbuna(2014). The specific volume was calculated as loaf volume/ loaf weight.

Evaluation of Sensory Properties of breads: The bread samples were evaluated for colour, taste, odour and texture by twenty trained panellists as described Ihekoronye and Ngoddy (1985). The panellists were randomly selected from staff and students of the Department of Food Science and Technology, Faculty of Agriculture and Life sciences, Federal University Wukari, Taraba state, Nigeria based on their familiarity with bread. The bread samples were presented in 3-digit coded white plastic plates at 29 ± 3^oC. The samples were evaluated on a 9 point Hedonic scale where 1 = disliked extremely and 9= like extremely. The order of presentation of the samples to the panellists was randomized. The panellists were provided with bottled water to rinse their mouths in between evaluations. The sensory evaluation was carried out at mid-morning (10am) in the sensory evaluation laboratory under adequate lighting and ventilation. The 100% wheat flour bread served as control. Based on sensory evaluation, the most preferred bread was incorporated with 2 and 3% CMC and the bread samples were used further studies.

Experimental design and statistical Analysis: The experiment was carried out in completely randomized design. The data were analysed by one way analysis of variance using Statistical Package for Social Science software version 20, 2007. Means where significantly different were separated by the least significant difference (LSD) test. Significance was accepted at $p < 0.05$.

Results and discussion

Proximate composition of flours and bread samples

The proximate composition of wheat flour, pregelatinized cassava flour and the bread supplemented with pregelatinized cassava flour are shown in Table 1. The moisture contents of the wheat flour and pregelatinized cassava flour (PCF) were 8.6 and 7.12%, respectively. Enwere (1998) reported that moisture content above 15% caused mould growth in foods. The moisture contents of both wheat flour and the pregelatinized cassava flours were within the limit of not more than 11% for storage stability of flours (Enwere, 1998). This makes the wheat flour and PCF suitable for long term storage. The incorporation of CMC probably slowed down the hydration process of the dough which decreased the moisture content of the bread containing CMC. Based on moisture content, the bread containing CMC would have longer shelf life than the control. This corroborated the findings of Eddy *et al*., (2007) but sharply contrasted those of Olaoye *et al.*, (2006) who reported that the moisture content of the composite flour breads increased with increasing level of non-wheat flour. The protein contents of the wheat flour and the pregelatinized cassava flour were

10.54 % and 2.94 %, respectively. The protein contents increased to 15.25 and 16.94% for the 100% wheat flour bread and the bread containing 2% CMC, respectively. The bread containing 2% CMC had higher protein content than the 100% wheat flour bread which was in agreement with the reports of Zannini *et al*,. (2012) that CMC is used to improve the protein content of food. The pregelatinized cassava flour contained lower amount of fat (1.71%) than the 100% wheat flour (2.75%). The fat content of bread containing CMC (7.89%) was significantly ($p<0.05$) higher than the 6.26% for the 100% wheat flour bread. The low fat contents of the flours and breads would enhance their keeping quality by reducing the development of rancidity (Akubor and Ukwuru, 2003). The pregelatinized cassava flour (3.95%) had higher content of ash than the wheat flour (0.30%). The ash content of bread containing pregelatinized flour was 3.59% which was significantly ($p < 0.05$) higher than that of the 100% wheat flour bread (2.58%). Ash is a measure of mineral content of a food. The high amount of ash in the pregelatinized cassava flour and the bread is an indicative of high mineral content. Ash also influences colour by impacting dark colour to finished products. Some specialty products requiring particularly white flour call for low ash content while other products require high ash content (Lund and Smith, 1982). The crude fibre contents of the flours (1.51 – 2.64%) were significantly higher than those of the bread samples (1.38 – 1.52%). The therapeutic effects of soluble fibres in prevention of heart diseases, colon cancer and diabetes and their role in the treatment of digestive disorders (diversticulosis) and constipation are widely documented (Lund and Smith, 1982). The moderate crude fibre contents of both the flours and bread samples are of importance as fibres aid in easy faecal movement (Lund and Smith, 1982). 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 (Zannini et al., (2012). The carbohydrate contents of the wheat flour and the pregelatinized cassava flour were 76.36 % and 81.64 %, respectively. The carbohydrate contents of the breads (45.65 – 47.77%) were significantly lower than those of the flours. Carbohydrates are good sources of energy and high concentration of it is desirable in breakfast meals and weaning formulas (Eddy *et al.*, 2007).

Physical Properties of breads

The physical characteristics of bread supplemented with pregelatinized cassava flour are presented in Table .2. The weight of the 100% wheat flour bread was 203.80g. The weight of the bread containing pregelatinized cassava flour varied from 180.30 – 205.80g. The weight of the loaf after baking is important as it is linked to the water holding capacity of the flour. The significant ($p<0.05$) decrease in the loaf weight with the level of the pregelatinized cassava flour in the bread was probably due to retention of the carbon dioxide produced during fermentation in the gelled matrix of the composite flour dough. This produced less dense bread (Akubor, 2016). The high weight of the 100% wheat flour bread may be related the high water absorption capacity of the wheat flour. The composite flour absorbed water but during baking, it probably lost more than the wheat flour water. The loaf weight is determined by the amount of moisture and carbon dioxide diffused out of the loaf during baking (Shittu *et al.*, 2007). Higher loaf weight and volume have positive economic value on the bread at the retail end.

Table 1: Proximate composition (%) of wheat flour, pregelatinized cassava flour and bread supplemented with pregelatinized cassava flour

Sample	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Crude fibre (%)	Carbohydrate (%)
Wheat flour	$8.60^{c} \pm 0.01$	$10.54^{c} \pm 0.02$	$2.75^{c} \pm 0.01$	$0.30^{d} \pm 0.01$	$1.51^{b} \pm 0.01$	$76.30^{a} \pm 0.01$
Pregelatinized cassava flour	$7.12^{d} \pm 0.01$	$2.94^{d} \pm 0.01$	$1.71^{b} \pm 0.01$	$3.95^{a} \pm 0.01$	$2.64^{a} \pm 0.01$	$81.64^{b} \pm 0.01$
100% wheat flour bread	$26.76^{b} \pm 0.01$	$15.25^{b} \pm 0.01$	$6.26^{a} \pm 0.01$	$2.58^{c} \pm 0.01$	$1.38^{d} \pm 0.01$	$47.77^{d} \pm 0.01$
Bread containing CMC	$24.41^{a} \pm 0.01$	$16.94^{a} \pm 0.01$	$7.89^{d} \pm 0.01$	$3.59^{b} \pm 0.01$	$1.52^{c} \pm 0.01$	$45.65^{c} \pm 0.01$

Values are means ± standard deviation of 3 replications. Means within a column with the same superscripts were not significantly different (p>0.05). CMC = Carboxyl methyl cellulose

Table 2: Physical properties of bread supplemented with pregelatinized cassava flour (PCF)

WF	PCF	Weight (g)	Loaf Volume (cm^3)	Specific Volume (cm^3)
100	0	$203.800^{b} \pm 0.10$	$1000.33^{e} \pm 0.58$	$2.463^{a} \pm 0.02$
90	10	$180.300^{e} \pm 0.10$	$1104.67^{c} \pm 0.58$	$2.200^{c} \pm 0.01$
80	20	$205.800^{a} \pm 0.10$	$1030.33^{d} \pm 0.58$	$2.280^{b} \pm 0.01$
70	30	$188.300^{d} \pm 0.10$	$1135.33^{b} \pm 0.58$	$1.940^{d} \pm 0.01$
60	40	$200.800^{c} \pm 0.10$	$1295.00^{a} \pm 0.58$	$1.030^{e} \pm 0.01$

Values are means ± standard deviation of 3 replications. Means within a column with the same superscripts were not significantly different (p>0.05)
WF = Wheat flour

Table 3: Effects of incorporation of carboxyl methyl cellulose (CMC) on the physical properties of bread supplemented with pregelatinized cassava flour

Level of CMC in the bread	Weight (g)	Loaf Volume (cm^3)	Specific Volume (cm^3)
0	$205.800^{a} \pm 0.10$	$1030.33^{c} \pm 0.58$	$2.280^{b} \pm 0.02$
2	$203.180^{b} \pm 0.10$	$1494.67^{a} \pm 0.58$	$7.340^{a} \pm 0.01$
3	$200.020^{c} \pm 0.10$	$1472.00^{b} \pm 1.00$	$7.353^{a} \pm 0.01$

Values are means ± standard deviation of 3 replications. Means within a column with the same superscripts were not significantly different (p>0.05).
The bread was supplemented with 20% pregelatinized cassava flour.

Table 4: Mean sensory scores of bread supplemented with pregelatinized cassava flour (PCF)

WF : PCF	Colour	Taste	Flavour	Texture	Overall acceptability
100 : 0	$7.95^{a} \pm 0.759$	$7.85^{a} \pm 0.933$	$7.30^{a} \pm 1.218$	$7.85^{a} \pm 1.040$	$8.05^{a} \pm 0.759$
90 : 10	$7.35^{a} \pm 1.137$	$6.15^{b} \pm 1.785$	$6.35^{a} \pm 1.268$	$6.90^{b} \pm 0.968$	$7.30^{ab} \pm 1.302$
80 : 20	$7.35^{a} \pm 0.875$	$6.20^{b} \pm 1.322$	$6.40^{a} \pm 1.314$	$6.35^{b} \pm 1.461$	$7.60^{ab} \pm 0.995$
70 : 30	$7.30^{a} \pm 1.490$	$7.00^{b} \pm 1.170$	$6.45^{a} \pm 1.731$	$7.10^{ab} \pm 1.586$	$6.80^{b} \pm 2.067$
60 : 40	$7.15^{a} \pm 1.496$	$6.80^{b} \pm 1.281$	$6.75^{a} \pm 1.372$	$6.95^{b} \pm 1.146$	$6.40^{b} \pm 2.113$

Values are means ± standard deviation of 10 replications. Means with the same superscripts within a column were not significantly different ($p>0.05$).
WF= wheat flour.

Table 5: Effect of incorporation of carboxyl methyl cellulose on the sensory properties of bread supplemented with pregelatinized cassava flour

Level of carboxyl methyl cellulose on the bread	Colour	Taste	Flavour	Texture	Overall acceptability
0	$6.90^{a} \pm 1.373$	$6.20^{b} \pm 1.056$	$5.45^{b} \pm 1.538$	$5.75^{b} \pm 1.888$	$6.10^{b} \pm 1.252$
2	$7.00^{a} \pm 0.918$	$6.75^{ab} \pm 0.910$	$6.60^{a} \pm 1.046$	$6.65^{ab} \pm 0.988$	$6.90^{a} \pm 0.788$
3	$6.95^{a} \pm 1.395$	$6.85^{a} \pm 0.745$	$6.60^{a} \pm 1.142$	$6.95^{a} \pm 1.538$	$7.10^{a} \pm 0.968$

Values are means ± standard deviation of 10 replications. Means with the same superscripts within a column were not significantly different ($p>0.05$)

Reduction of loaf weight and volume during baking is unacceptable economic quality to bakers as the people prefer bread with high loaf weight which is believed to have more value (Akubor and Obiegbuna, 2014). The loaf volumes of the breads containing pregelatinized cassava flour (1030.33 – 1295.00 cm^3) were significantly ($p<0.05$) higher than that of the 100% wheat flour bread (1000.33 cm^3).The pregelatinized cassava flour provided the matrix for the composite flour which caused the retention of carbon dioxide and consequently increased the loaf volume (Akubor and Igba, 2019). A decrease in loaf volume of bread fortified with barley beta-glucan was reported (Knucles *et al.,* 1997). Similar results were reported for bread fortified with wheat fibre and psyllium husk fiber which reduced the loaf volume of bread (Nindjin *et al*., 2011).

Loaf volume is regarded as one of the most important baked good characteristics, since it provides a qualitative measurement of baking performance (Akubor, 2016). Loaf volume is affected by the quantity and quality of protein in the flour (Okoye and Ezengwu, 2019). The specific loaf volume of the 100% bread was 2.463 cm^3. The specific loaf volume decreased from 2.200cm^3 for the bread containing 10% pregelatinized cassava flour to 1.030cm^3 for the bread containing 40% pregelatinized cassava flour. The low specific loaf volume of the composite breads was probably due to the dilution effects on gluten with addition of pregelatinized cassava flour to the wheat flour. The Gluten fraction is responsible for the elasticity of the dough by causing it to extend and to trap the carbon dioxide generated by yeast during fermentation. When gluten coagulates under the influence of heat during baking, it provides 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 (Tajudeen, 2012). A minimum protein content of 11.0% in wheat flour is necessary for the production of yeast-leavened bread (Halverson and Zeleny, 1988). Flours with high gluten content have ability to extend and trap CO_2 produced during fermentation (Onimawo and Akubor, 2012).

Effect of incorporation of carboxyl methyl cellulose on the physical properties of bread

The effect of incorporation of 2.0% and 3.0%) carboxyl methyl cellulose (CMC) in the bread containing 20% pregelatinized cassava flour on the physical properties of bread are shown in Table .3. The weight of the bread decreased from 205.80g in the control to 200.02g for the bread containing 3 % CMC. The loaf volume of the control was 1030.33 cm^3 and increased from 1472 for the bread containing 2% CMC to 1494.67 cm^3 for the breads containing 3% CMC. The specific volume of the control was 2.280 cm3. The specific volume increased from 7.340 cm^3 for the bread containing 2% CMC to 7.353 cm^3 for bread containing 3% CMC. The Incorporation of CMC improved the physical properties of the breads supplemented with pregelatinized cassava flour. The CMC probably caused gas retention by the dough during fermentation .Gums were reported to improve loaf volume, overall loaf appearance, bread yield and texture by limiting water loss in baked bread (Zannini *et al.,* 2012). High specific volume is a desirable index of bread quality .Specific volume and loaf count, however, are dependent not only on the leavening activity but also on the ability of the dough to retain gas (Carbon dioxide) generated (as a result of fermentation) during the baking which influences the Visco-elasticity power of the dough (Onimawo and Akubor, 2012). Specific volume is used as one of important parameters to evaluate quality of bread which corresponds to softening of crumb on bread (Akubor, 2016). Specific volume is an important parameter to analyze the quality of bread which involves loaf volume and loaf weight. The China Grain Products Research and Development Institute reported that specific volume of standard bread is $6cm^3/g$, and should not be less than $3.5cm^3/g$ (Lazaridou *et al*., 2007). The specific volumes of the breads incorporated with 2 % and 3% CMC were higher the Chinese standard for bread. On the contrary, Zannini et al., (2012) reported that specific volume below $4cm^3/g$ affected quality of bread. The specific loaf volume for standard bread was also reported to range from 3.5 to 6.0cm3/g in which variation in loaf volume was attributed to different rates of gas evolution and the extent of starch gelatinization (Lazaridou *et al*., 2007).

Sensory properties of breads

The sensory properties of bread supplemented with pregelatinized cassava flour are shown in Table 4. The scores for all the sensory attributes of the 100% wheat flour bread were higher than those of the breads containing pregelatinized cassava flour (PCF). The scores for colour decreased, though, not significantly (p>0.05) with increased level of PCF in the bread. Similarly, the scores for taste, flavour, texture and overall acceptability decreased with the level of PCF in the bread. Table 5 shows the effect of incorporation of carboxyl methyl cellulose on the sensory properties of breads. The breads containing CMC had higher scores for all the sensory attributes than the control. The scores for all the sensory attributes except colour increased with the level of CMC.

Conclusion

Based on the results of the study, it is concluded that 20% pregelatinized cassava flour could be used to substitute wheat flour in bread without affecting the quality of the bread. However, incorporation of 2 and 3 % carboxyl methylcellulose (CMC) into the bread containing 20 % pregelatinized cassava flour improved the physical and sensory properties of the bread over the control.

Recommendation

Based on the results of this study, it is recommended that:

- Pregelatinized cassava flour should be incorporated into wheat flour at 20% level for bread production.
- Carboxyl methyl cellulose at 2% should be added to bread containing 20% pregelatinized cassava flour.
- The performance of pregelatinized cassava flour in other food products should be evaluated.
- The storage stability of bread containing pregelatinized cassava flour and carboxyl methyl cellulose should be investigated.

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