Quality characteristics of wheat- cassava composite bread as affected by cassava flour pre-treatment

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Abstract - **This study was carried out to investigate the effects of cassava pre-treatment on the baking and organoleptic properties of wheat-cassava composite bread. High quality cassava flour produced from three different cassava varieties (Ampong, Broni and Otuhia) which were pre–treated in five different ways (chipping, toasting, chipping and steeping in citric acid solution, grating and dewatering, and steeping in citric acid solution and toasting) were used to produce wheat–cassava composite bread at 20% substitution level of wheat flour with cassava flour. The resulting bread samples were evaluated for their specific volume and sensory attributes of appearance, aroma, colour, texture, crust, mouth feel, taste, and overall acceptability. The results of the evaluation indicate that the specific volume of the composite bread samples from Otuhia and Broni varieties was not statistically different ($p \leq 0.05$) from the control sample for all the pre-treatment methods except for toasting pre-treatment of Broni variety while all the samples from Ampong variety were statistically lower ($p \leq 0.05$) than the control with the exception of samples from citric acid pre-treatment. The sensory properties of the composite bread samples were not statistically different ($p \leq 0.05$) from that of the control sample for all the varieties and pre-treatment methods. Toasting and grating however enhanced the taste and overall acceptability of samples from Otuhia and Broni varieties.**

keywords **- pre-treatment, composite bread, specific volume, sensory evaluation, cassava**

I. Introduction

II. Bread which is an important staple food among the urban dwellers in most West African countries is traditionally produced by a mixture of wheat flour, yeast, salt and water.

III. Wheat does not grow well in tropical climate and hence these countries rely on the importation of this product leading to a huge drain of their scarce foreign exchange [1]. The Food and Agricultural Organization introduced the concept of composite flour technology with a primary purpose of encouraging the use of indigenous crops such as cassava, yam, maize and other cereal crops which will eventually lead to the reduction of fund outflow towards the temperate countries. Since the introduction of this concept, there have been growing interests in the use of composite flour for bread baking in many developing nations. Previous researchers [2] reported that in order to reduce the nations expenses, the government of Mozambique mandated the use of composite flour in bread making The government of the federal Republic of Nigeria also gave a policy directive for relevant stake holders to include 10% cassava flour in bread, biscuit and other confectioneries in order to sustain cassava production and reduce fund outflow for import of wheat [3].

IV. However, the partial substitution of wheat flour by flour from other plant sources present some technological difficulties since the protein from these other sources lack the ability to form the needed gluten network for holding the gas produced during fermentation [2,4]. Some of the problems encountered in the use of the non-wheat flour for bread making are difficulties in the dough handling, poor loaf volume and crumb softness [5].

V. Bread baked with cassava wheat composite flour has been evaluated by various researchers and the general observation were reduced loaf volume, crust colour and impaired sensory qualities as the level of substitution with other flours increased [2,6,7,8]. Nweke [9] in his work on the new challenges in cassava transformation in Nigeria and Ghana emphasized the need for standardisation of cassava varieties, age of cassava roots and its growing environment as a means of enhancing its use in food industries. Various studies on wheat-cassava composite flour have investigated the influence of baking processes, effect of added hydrocolloids and other viscosity enhancers on bread quality [2,10,11] but very little attention has been paid on the investigation of pre-treatment methods as a vital factor in the production of high quality cassava flour as ingredient in composite flour for bread production. The objective of the present study is therefore to investigate the effect of five different pre-treatment methods on some important quality attributes of wheat-cassava composite bread from three new cassava varieties in Ghana.

2.0 Materials and Methods

2.1 Materials

The materials used for the baking were wheat flour (hard wheat), granulated sugar, refined iodide salt, instant dry yeast, margarine, nutmeg, milk, flavour and cassava flour. All these ingredients were purchased from standard shops that supply baking materials keeping the same specification in all experiments.

The cassava flour was produced from 300kg of 12months old cassava roots of *Ampong*, *Broni* and *Otuhia* varieties harvested from the cassava plots of Crop Research Institute Fumesua, Kumasi, Ghana.The nutritive values and drying characteristics of these samples were investigated in previous research works [12,13].

2.2 Methods

2.2.1 Experimental Design

Completely Randomised design (CRD) was used in the study with the principal factor as the bread type (AT1 to AT5, BT1 to BT5, and OT1 to OT5). The samples were evaluated for specific volume and various sensory attributes. The data generated were statistically analysed using Genstat 12th edition. The significance of the treatment means was tested at 5% probability level using Duncan's Multiple Range Test (DMRT)

Processing of cassava flour

The cassava tubers were processed into flour at the food and post-harvest laboratory of Agricultural Engineering Department, Kwame Nkrumah University of Science and Technology Kumasi, Ghana.

Tubers from each of the three cassava varieties were divided into five portions, then washed and peeled. Each portion was subjected to a unique pre-treatment before drying in a mechanically ventilating cross flow dryer pre-set to a temperature of 70°C. The pre-treatment was carried out in the following ways. For the first pre-treatment, the tubers were chipped to a size of 10× 10 ×50mm as recommended by Romeo and Bruno[14].

The second pre-treatment involved grating the tubers with mechanical grater, dewatering by placing under a load for about 15h, screening and then toasting in a toasting pan for 6min [15]. The third samples were chipped to size of 10 × 10 × 50mm and steeped in citric acid solution (20%m/v) for 12h [16].

For the fourth samples, the cassava tubers were grated, dewatered and kept under load for 15h. The fifth samples were sliced and steeped in citric acid solution (20%m/v) before grating, dewatering, screening and toasting for 6min using a toasting pan. The pre-treated samples were dried to a constant weight in a mechanically ventilating cross flow dryer.

The dried samples were ground into fine flour with a laboratory mill and the excess fibres were removed by passing the flour through a 250μm sieve in accordance with the recommendations of the African Organization for Standardization [17].

2.2.2 Bread making procedure

Bread dough was formed using 20% substitution of wheat flour with the pre-treated cassava flour. The dough samples were therefore prepared according to the following formula:

480g wheat flour (hard wheat), 120g pre-treated cassava flour, 100g margarine, 40g sugar, 4g yeast, 3g salt, 1g nutmeg, 30ml milk and 2.5 ml flavour. It should be noted that in order to obtain equal consistency of the dough from each of the composite flour samples, the amount of water added varied slightly from 320ml to 360ml. All the ingredients were mixed in a *Kenwood* dough mixer (fig.1) for 10min. The dough was then divided into two parts after kneading. The first part was formed into mini loafs of 30g weight for sensory evaluation while the second part was formed into larger loafs of 350g weight (fig.2) for the specific volume evaluation.

The dough was covered with kitchen cloth in a greased pan and proofed for 2 h in a warm chamber at 35°C.The proofed dough was transferred into a preheated oven at 190°C where it was baked for 25 min. The baked bread was cooled for one hour and then wrapped in cellophane bags ready for the volume and sensory evaluations. A control wheat bread (100% wheat flour) was prepared simultaneously in the same oven under identical conditions with those of composite flour.

Fig.1 *Kenwood* dough mixer

Fig.2 A set of the composite bread samples for sensory and specific volume evaluation

2.2.3 Sensory Evaluation

The sensory evaluation was carried out using fifteen trained panelists who are staff members and graduate students at Food Research Institution, Accra who are familiar with the sensory attributes of local bread. The bread samples were first coded with random 3-digits numbers before serving them to the panelist. The fifteen panelists were independently served with the samples for evaluation. Crackers and water were provided for each panelist to rinse the mouth after testing each sample so as to remove the residual test of the sample before going for the next sample.

The bread samples were scored based on appearance, colour, aroma, taste, crust, texture, mouth feel and overall acceptability using a 9-point hedonic scale according to Ihekoronye and Ngoddy [18], with 9 as the highest score representing extremely liked, followed by 8 (likes very much) and the lowest 1 which stands for dislike extremely.

2.2.4 Evaluation of the specific volume of the samples

The specific volume of the bread samples was determined by a modification of the rapeseed displacement method [8,19,20,21]. Millet grains were used in this method instead of the conventional rapeseed. The bread loaf was first weight using a Metler Toledo Precision Top-loading balance (PL 1501-S model). The weight of the bread sample was noted as W_b. A metal box of fixed dimension was placed on a tray and filled with millet grains till it was slightly overfilled.

A straight edge was used to press across the top of the box once to give a level surface. The grains were decanted from the box into a bowl. The weighed loaf was placed in the metal box and the decanted grains were used to refill the box and levelled off as before. The overspill which is the volume displaced by the bread was collected, measured and recorded as V_b.

The specific volume was then calculated by dividing the volume displaced by the bread VB by the weight of the bread, W_b as indicated in equation 2.1

$$S_v(cm^3/g) = V_b/W_b \qquad 2.1$$

Where S_v = specific volume, V_b = volume of bread, W_b = weight of bread

Results and Discussions

3.1 Specific Volume

The specific volume is a very important quality characteristic of bread especially for the commercial baker who is very much concerned with the rising ability of the bread dough. The mean values of the specific volume of the composite bread produced from 80% wheat and 20% cassava flour from three cassava varieties pre-treated in five different ways are presented in table 3.1 below.

Table 3.1 Means values of specific volume of cassava wheat composite bread as affected by cassava varieties and pre-treatment.

Variety	Treatment	Specific volume (cm3/g)
	Control	3.24^{a}
AMPONG	AT_1	2.79^{bcdef}
	AT_2	2.66^{ef}
	AT_3	3.05^{abcd}
	AT_4	2.53^{f}
	AT_5	2.68^{cef}
BRONI	BT_1	3.02^{abcde}
	BT_2	2.52^{f}
	BT_3	3.13^{ab}
	BT_4	3.09^{ab}
	BT_5	2.61^{f}

OTUHIA	OT1	3.27^{a}
	OT_2	3.13^{ab}
	OT_3	3.35^{a}
	OT_4	3.24^{ab}
	OT_5	3.06^{abc}

Means with common superscript letters of alphabets within the column are not statistically different at p < 0.05

The specific volume of the control sample (100% wheat bread) is 3.24cm^3/g while the composite bread produced from Otuhia cassava variety pre-treated by soaking in citric acid solution (OT_3) and chipping (OT_1) has specific volume values of 3.35 cm^3/g and 3.27cm^3/g respectively. Although these pre-treatments resulted to the production of composite bread with improved specific volume, the difference between their values and that of the control was not statistically different as is indicated in table 3.1. It can also be observed from the table that the specific volume of all the bread samples produced from Otuhia cassava variety are not statistically different from the control sample irrespective of the pre-treatment method. The composite bread samples produced from Broni variety also have acceptable values of the specific volume relative to the control sample with the exception of the samples from toasting pre-treatment (BT_2 and BT_5) whose specific volume values are lower ($p \leq 0.05$) than the control sample. The situation is however different with the Ampong cassava variety which produced bread samples from all the pre-treatment methods that have lower ($p \leq 0.05$) specific volume than the control, with the exception of only AT_3 (citric acid pre-treatment) which is statistically equal ($p \leq 0.05$) to the control sample.

3.2 Sensory evaluation

The result of scores obtained from the sensory evaluation of the composite bread samples generally indicates that the samples from the three varieties and five pre-treatment methods are within the acceptable range since all the mean scores are above 6 and they are not significantly different from the control sample. Details of the scores of various sensory attributes of the bread are as presented in the following subsections.

3.2.1 Appearance, colour and aroma

The mean values, of the scores obtained from the sensory evaluation of the composite bread samples for appearance, colour and aroma are presented in table 3.2 below.

Table 3.2: Mean values of sensory evaluation scores for Appearance, colour and aroma

Variety	Treatment	Appearance	Colour	Aroma
Ampong	Ctrl	7.30^{abc}	7.40^{ab}	7.13^{ab}
	AT_1	7.60^{abc}	7.67^{ab}	7.33^{ab}
	AT_2	6.93^{bc}	7.40^{ab}	6.80^{ab}
	AT_3	7,53^{abc}	7.33^{ab}	6.67^{b}
	AT_4	7.13^{abc}	7.13^{b}	6.93^{ab}
	AT_5	7.67^{ab}	7.47^{ab}	6.87^{ab}
	BT_1	7.80^{ab}	8.07^{a}	7.6^{a}
Broni	BT_2	6.93^{bc}	7.07^{bc}	7.6^{a}
	BT_3	7.80^{ab}	8.00^{a}	7.00^{ab}
	BT_4	7.33^{abc}	7.47^{ab}	7.47^{ab}
	BT_5	7.07^{bc}	7.47^{ab}	7.53^{ab}
	OT_1	7.80^{ab}	7.67^{ab}	7.40^{ab}
	OT_2	6.87^{c}	7.12^{b}	7.27^{ab}
Otuhia	OT_3	7.87^{a}	8.00^{a}	7.53^{ab}
	OT_4	7.80^{ab}	7.40^{ab}	7.47^{ab}
	OT_5	7.6^{abc}	7.40^{ab}	7.20^{ab}

Means with common superscript letters of alphabets within the column are not statistically different at p ≤0.05

The score values for appearance, colour and aroma of the control sample (100% wheat flour bread) are 7.20, 7.40 and 7.13 respectively. These values are not statistically different ($p \leq 0.05$) from the composite bread samples as can be seen in table 3.2 above. It was observed that the mean score values of appearance for BT_5, AT_2, BT_2 and OT_2 (which are composite bread samples from toasted cassava flour) have the lowest score values relative to the rest of the samples. The differences are however not statistically significant ($p \leq 0.05$) except for OT_2 (6.87) which is lower ($p \leq 0.05$) than OT_1 (7.80), OT_3 (7.87), OT_4 (7.80), BT_1 (7.80), BT_3 (7.80) and AT_4 (7.80). The implication of this observation is that bread samples from toasted cassava flour have inferior appearance than samples from other pre-treatment. The score values for the colour of AT_4 (7.13), OT_2 (7.13) and BT_2 (7.07) are significantly lower ($p \leq 0.05$) than BT_1 (8.07), BT_3 (8.00) and OT_3 (8.00) even though they are not significantly different from the mean values of the control sample. This implies that citric acid pre-treatment positively affected the samples relative to toasting pre-treatment of *Otuhia* and *Broni* varieties. The score values for the aroma of the bread samples from T_2 (6.50) and T_3 (6.67) pre-treatment of *Ampong* cassava varieties is significantly lower than the scores for samples from T_1 (7.60) and T_2 (7.60) of Broni variety. The score values of the bread samples fomrT_4 (6.93) and T_5 (6.87) pre-treatment of *Ampong* cassava variety are lower than the scores from the other samples even though they are not significantly different. The aroma of the bread samples produced from the *Ampong* cassava variety is therefore not as appealing as those from *Broni* and *Otuhia* varieties.

3.2.2 Texture and crust

The mean score values of the composite bread samples for texture and appearance are as presented in Table 3.3 below.

Table 3.3. Mean score values of sensory evaluation of bread samples for texture and crust

Variety	Treatment	Texture	Crust
	Control	7.00^{ab}	7.00^{ab}
Ampong	AT1	6.73^{ab}	7.07^{ab}
	AT2	6.60^{b}	7.07^{ab}
	AT3	6.83^{ab}	7.13^{ab}
	AT4	6.67^{ab}	6.73^{b}
	AT5	6.60^{b}	6.80^{b}
	BT1	7.07^{ab}	7.13^{ab}
Broni	BT2	6.93^{ab}	7.13^{ab}
	BT3	7.13^{ab}	7.13^{ab}
	BT4	6.93^{ab}	7.13^{ab}
	BT5	6.87^{ab}	7.4^{ab}
Otuhia	OT1	7.60^{a}	7.60^{a}
	OT2	6.67^{ab}	7.40^{ab}
	OT3	7.4^{ab}	7.60^{a}
	OT4	6.74^{ab}	7.40^{ab}
	OT5	6.60^{b}	7.530^{ab}

Means with common superscript letters of alphabets within the column are not statistically different at $p < 0.05$.

The mean score value for the texture of the control bread sample is 7.00 while that of the composite bread produced for *Otuhia* cassava variety pre-treated by chipping (OT_1), and steeping in citric acid (OT_3) are 7.60 and 7.40 respectively. These pre-treatment methods produced bread samples from *Otuhia* and *Broni* cassava variety with enhanced texture relative to the control sample even though the difference is not significant at $p \leq 0.05$. The mean score values for the rest of the bread samples even though lower than the control value are not statistically different from the value of the control sample.
The mean score value for the crust of the control bread sample is equally not different ($p \leq 0.05$) from the score values of the rest of the bread samples even though pre-treatment enhanced the crust of all the composite bread samples relative to the control sample with the exception of AT_4 of the *Ampong* variety.

3.2.4 Mouth feel, taste and overall acceptability

The mean score values for mouth feel, taste and overall acceptability are presented in table 3.4 below.

Table 3.4: Mean score values for mouth feel, taste and overall acceptability

Variety	Treatment	Mouth feel	Taste	overall acceptability
	Control	7.07^{abc}	7.27^{ab}	7.33^{ab}
Ampong	AT1	6.33^{c}	6.47^{c}	7.00^{ab}
	AT2	6.80^{abc}	7.20^{ab}	7.13^{ab}
	AT3	6.73^{abc}	6.47^{c}	6.73^{b}
	AT4	6.20^{c}	6.47^{c}	7.00^{ab}
	AT5	6.33^{c}	6.67^{c}	6.93^{ab}
Broni	BT1	7.13^{abc}	7.33^{ab}	7.47^{ab}
	BT2	7.47^{a}	7.73^{a}	7.47^{ab}
	BT3	6.87^{abc}	7.07^{abc}	7.33^{ab}
	BT4	7.00^{abc}	7.20^{ab}	7.40^{ab}
	BT5	7.00^{abc}	7.33^{ab}	7.60^{a}
Otuhia	OT1	7.53^{a}	7.67^{a}	7.67^{a}
	OT2	7.33^{ab}	7.33^{ab}	7.47^{ab}
	OT3	7.27^{ab}	7.27^{ab}	7.47^{ab}
	OT4	7.00^{abc}	7.73^{a}	7.53^{ab}
	OT5	7.67^{a}	7.67^{a}	7.67^{a}

Means with common superscript letters of alphabets within the column are not statistically different at $p \leq 0.05$.

The control sample has mean score values of 7.07, 7.27 and 7.33 for month feel, taste and overall acceptability respectively. These values are not significantly different from the values obtained for all the composite bread samples. It was however observed that the bread samples produced from Ampong Cassava variety have the lowest score values for overall acceptability, mouth feel and taste relative to composite bread produced from other cassava varieties as well as the control sample, even though the difference is not significant at P≤0.5 for most of the samples as can be seen in table 3.4 above. The overall acceptability and taste of the composite bread samples were however enhanced by Toasting and grating pre-treatment of Otuhia and Broni cassava varieties.

4.0 Conclusion and Recommendation

1) Varietal differences and pre-treatment methods significantly affected the specific volume of composite bread samples produced by 20% substitution of wheat flour with cassava.
2) The specific volume of bread samples produced from Otuhia and Broni cassava varieties was enhanced by grating and citric acid pre-treatment while that of Broni and Ampong varieties was negatively affected by toasting pre-treatment.
3) Results of the sensory evaluation for appearance, colour, aroma, texture, crust, taste, mouth feel and overall acceptability of the composite bread samples indicates that they are not significantly different from the control sample for all the varieties and pre-treatment.
4) Wheat flour can be effectively substituted with 20%cassava flour for Otuhia and Broni cassava varieties in production of composite bread with similar qualities as those from 100% wheat flour.
5) The production of cassava flour from these varieties is a huge opportunity for commercial production of composite bread and very appropriate for cassava growing regions as alternative value addition to reduce the high post-harvest losses associated with cassava.

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