

Production and Evaluation of Bread Made from Modified Cassava Starch and Wheat Flour Blends

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Abstract

Starches obtained from five selected improved cassava species (NR 93/0199, TMS 96/0304, TMS 98/0581, TMS 92/10326, TMS 98/12123) were chemically modified by oxidation, acetylation and acid-thinning. Baking potentials of these starches were investigated. Acetylated starches significantly ($p < 0.05$) gave the highest values in specific volume (10.25 ml/g). Acid-thinned starches significantly ($p < 0.05$) yielded the lowest values in specific volume (2.92 ml/g). Oxidized starches maintained the least positions in some sensory properties – aroma (6.60), and general acceptability (6.62). TMS 96/0304 significantly ($p < 0.05$) had the lowest value in specific volume (5.54 ml/g). Highest values were obtained in specific volume (6.82 ml/g) for NR 93/0199 as well as for TMS 98/12123 among the cassava species. Although the different modification methods and cassava species showed no significant ($p > 0.05$) effects on the sensory properties of the wheat/cassava starch bread samples, the native starches and TMS 98/0581 had the highest scores for general acceptability.

Keywords: Cassava starch; Wheat flour; Baking; Cassava species; Acid-thinning

Introduction

Starch is abundant in such staple foods as potatoes, wheat, cocoyam, yam, maize, rice and cassava [1-4]. Cassava starch is easy to extract using a simple process with limited capital. Advantages of cassava starch includes high level of purity, excellent thickening characteristics, neutral (bland) taste, desirable textural characteristics and relative cheap source of raw material that can surpass the properties offered by other starches from wheat, maize, potatoes and rice [5]. Many improved cassava cultivars with relatively high dry matter and starch contents have been developed in Nigeria by the National Root Crops Research Institute (NRCRI) Umudike and the International Institute of Tropical Agriculture (IITA) Ibadan [6-8]. Native or unmodified starches have limited usage [9-11], due to their inherent weakness of hydration, swelling and structural organization. To enhance viscosity, texture and stability among many food and non-food industrial applications, starches and their derivatives are modified by chemical, physical and biotechnological means. Modified starches are prepared by physically, chemically or enzymatically treating native starches thereby changing properties of the starches [12-14].

Modified starches are used, in practically all starch applications such as in food products as a thickening agent, stabilizer or emulsifier; in pharmaceuticals as a disintegrant or in paper and textiles as a binder [15,16]. Widely used prepared foods containing modified starches includes bread, pancakes, beverages, flavouring agents, cakes, cereals, noodle, pasta, porridge and tortilla [15,17-19]. According to Ibe [20], developing cassava starches with good physico-chemical and baking potentials will help to realize the vision of expandable utilization of

cassava in Nigeria, promoting food security, increasing employment and contributing to economic growth.

Baking with cassava starch instead of flour shows that bread making potential of cassava flour is determined both by the starch and non-starch fraction [21,22]. Starches from different origins have different compositional and structural properties and such variance can affect the properties of bread dough [23-26]. According to Ciaceo and D'Appolonia [27], acceptable bread could be produced with up to 15% level of substitution of cassava starch or flour. Regardless of the type of bread-making procedure, blends containing cassava starch show a better baking response than those with cassava flour [28]. Modification of starches from five available improved cassava species (NR 93/0199, TMS 98/0581, TMS 96/0304, TMS 92/0326 and TMS 98/12123) using acetylation, oxidation and acid-thinning methods in order to investigate their baking potentials is the focus of this study.

Materials and Methods

Materials

Fresh tubers from five new cassava species (NR 92/0199, TMS 98/0581, TMS 96/0304, TMS 92/0326 and TMS 92/12123) were obtained from the National Root Crops Research Institute (NRCRI) Umudike, Nigeria.

Methods

Starch extraction: Starch was extracted from cleaned, peeled and macerated tubers using the method of Onabolu et al. [29].

Starch modification: A portion of oven-dried starch from each cassava species was chemically modified through acetylation, oxidation and acid-thinning processes. For acetylation, the method of

Sathe and Salunkhe [30] was used. The method of Forssel et al. [31] was adopted for oxidation. Acid-thinning was determined using the method described by Lawal [4].

Baking of bread using composite cassava starch/wheat flour: A composite flour of cassava starch and wheat flour in the ratio of 10% and 90% respectively was used to bake bread for each starch sample. The No-time dough method was used. The recipe for each bread sample was 50 g flour, 3 g sugar, 0.5 g salt, 1.5 g yeast, 5 g margarine and water (variable) [29]. All the ingredients and flour blends were placed in the dough mixer and mixed thoroughly for approximately 5 min. The dough was left in bowls to prove and covered with damp clean muslin cloth for approximately 55 min at room temperature (29°C). Two kneading's of 30 s each were afterwards performed at 60 and 120 min. The dough was divided in two pieces which were moulded into a loaf, placed in a loaf tin and further proved in a proving cabinet for 30 min at 30°C. The samples were introduced into the oven and baked at 180°C for 35 min.

Determination of specific volume: A 10% cassava starch/90% wheat flour formulation was used. The method of Demiate et al. [32] was adopted. First, 12.0 g of the starch samples was partially cooked by addition of 10 ml of de-ionised water. The partially cooked starch was homogenized to produce dough and the dough was moulded and baked on an electric oven at 200°C for 25 min. After baking, the dough was weighed and made impermeable by using paraffin and their volume determined on graduated cylinder as the volume of water displaced. The expansion was obtained by dividing volume by weight and was expressed as specific volume (ml/g).

Sensory Analysis

Samples of bread produced were subjected to sensory analysis on a nine point Hedonic scale (1 and 9 representing extremely dislike and

extremely like respectively) [9,33,34] using twenty-five untrained panelists (students and staff of the Department of Food Science and Technology, Michael Okpara University of Agriculture, Umudike, Nigeria). The quality attributes assessed were appearance, aroma, taste, mouthfeel and general acceptance.

Experimental Design

The experiments were fitted into 2-way anova/classical model of 4 x 5 factorial designs and the resultant of any variation due to main effect and their interaction were established. The main effects included modification method [4] and selected cassava species [5].

Statistical Analysis

Analyses were done in triplicates. Data obtained from the analyses were subjected to analysis by variance [9,33-36]. Fishers Least Significant Difference (LSD) ($p < 0.05$) was used to separate the means that have significant difference [33,37].

Results and Discussions

Effect of chemical modification and cassava species on the specific volume of cassava starch/wheat flour bread

The results of specific volumes of bread samples produced from composite flour (90% wheat flour and 10% cassava starch) as affected by cassava species and chemical modification methods are shown in Table 1.

Cassava Species	Native	Oxidation	Specific Volume Acetylation	Acid-thinning	Mean \pm SD	LSD
NR 93/0199	4.45	7.73	12.02	3.07	6.82 \pm 3.98 ^a	1.17
TMS 96/0304	3.56	7	8.91	2.68	5.54 \pm 2.92 ^c	1.17
TMS 98/0581	3.05	7.15	10.12	2.86	5.60 \pm 3.50 ^{abc}	1.17
TMS 92/0326	2.92	6.59	10.3	2.99	5.70 \pm 3.51 ^{abc}	1.17
TMS 98/12123	3	7.04	9.9	3	5.74 \pm 3.37 ^{abc}	1.17
Mean \pm SD	3.40 \pm 0.64 ^c	7.10 \pm 0.41 ^b	10.25 \pm 1.13 ^a	2.92 \pm 0.15 ^a	-	-
LSD	0.97	0.97	0.97	0.97	-	-

Table 1: Effects of chemical modification and cassava species on the specific volume (ml/g) of cassava starch/wheat flour bread sample.

Means with different superscripts in the same row or column differ significantly ($p < 0.05$).

Acetylation and oxidation treatments conferred much better volume development properties within the modification process against the native and acid-thinned blended samples. This suggests that these forms of modification increase the hydrophilic and hydrophobic potentials of the starch which are inherent properties that support volume increase [4,38]. Acetylation and oxidation enhanced the re-association of size-reduced starch molecules of

amylose and/or amylopectin in amorphous regions and thus enhanced the baking expansion [26,39,40]. According to Vatanasuchart et al. [25], introduction of acetyl moiety, carbonyl and carboxyl functional groups which enhance depolymerization of the starch dough would cause low viscosity of the bubble wall and low viscosity resistance for the bubble growth, thus baking expansion was effected by forming amorphous matrix structure with hydrogen bond.

Results for acid thinning ranged from 2.68 (TMS 96/0304) to 3.07 (NR 93/0199). Acid-thinning was observed to have the greatest

reducing effect on volume development in baked cassava starch/wheat flour bread. This was due to extensive acid degradation of cassava starch which made the bubble walls lose their integrity earlier, thus rupturing at lower strains causing no expansion of the starches when baked [41,42]. Acetylation produced significantly ($p < 0.05$) highest and most desirable specific volume (10.25 ml/g) than other chemical modification methods while acid-thinning performed significantly ($p < 0.05$) poorly with undesirable value of 2.92 ml/g.

Specific volume was significantly ($p < 0.05$) highest (6.82 ml/g) in NR 93/0199 and lowest (5.54 ml/g) in TMS 96/0304 within the cassava species. This varietal difference could be as a result of amylose content of the starch granules which varies with botanical source of the starch, climatic conditions and soil type during growth [43,44]. Thus, it may be deduced that NR 93/0199 has better packing of amylose and amylopectin within the granules as this vary among starches from different species [45] and this may be the reasons for its improved volume when thermally cooked.

Effect of chemical modification and cassava species on the sensory properties of cassava starch/wheat flour bread

Reduction in sensory values after acid-thinning is as a result of retrogradation tendency [40,46]. The leaching of the amorphous region during acid hydrolysis enhances interactive bond formation between the amylopectin molecules; thus facilitating retrogradation of acid-thinned cassava starch thus explaining reduction in sensory parameters when compared with the native and other modified starches. Species of cassava also influenced sensory properties

evaluated. This is in agreement with the report of Steve [11] that the physicochemical properties and functional characteristics that are impacted by the starches to the aqueous system and their uniqueness in various food applications vary with the biological origin. According to Narpinder et al. [45] packing of amylose and amylopectin within the granules has been reported to vary among the starches from different species. The amylose content of the starch granules varies with the botanical source of the starch and is affected by the climatic conditions and soil type during growth [4,26,40,43,44]. TMS 98/0581 relatively performed better in all the sensory properties.

However, native starch maintained superior scores in most sensory properties showing that modification processes will create no significant ($p > 0.05$) difference on the baking properties of the starches. Results of the sensory scores of cassava starch/wheat flour bread as affected by cassava species and chemical modification processes are presented in Tables 2-6. Results obtained show that there were no significant differences ($p < 0.05$) due to variation in chemical modification methods and cassava species.

Appearance

Bread sample from native starch had the highest score (7.62) in appearance followed by acetylated starch (7.16) while acid-thinned starch scored lowest (6.46). This shows that the modification process led to decrease in the appearance of bread samples. TMS 92/0326 was scored highest (7.15) while TMS 98/12123 was scored lowest (6.65) within the cassava species. No significant ($p > 0.05$) difference existed due to variations in both cassava species and modification methods.

Cassava Species	Native	Appearance Oxidation	Acetylation	Acid- thinning	Mean \pm SD
NR 93/0199	7.7	6.4	8	6	7.03 \pm 0.97
TMS 96/0304	8	7.5	7	6	7.13 \pm 0.85
TMS 98/0581	8	7	6.2	7.3	7.08 \pm 0.83
TMS 92/0326	7.4	7.2	8	6	7.15 \pm 0.84
TMS 98/12123	7	6	6.6	7	6.65 \pm 0.47
Mean \pm SD	7.62 \pm 0.43	6.82 \pm 0.61	7.16 \pm 0.82	6.46 \pm 0.46	-

Table 2: Effects of chemical modification and cassava species on the appearance of cassava starch/wheat flour bread sample.

Values are means of nine determinations \pm SD.

Aroma

No significant difference ($p < 0.05$) was observed in the aroma of the bread samples as a result of variation in modification processes and within the cassava species (Times). The sensory scores for the aroma ranged from 7.00 in acid-thinned sample to 6.60 in oxidized sample. Within the cassava species, it ranged from 7.50 in TMS 98/0581 (as the most improved in aroma) to 6.50 in both TMS 96/0304 and TMS 92/0326. No significant difference ($p > 0.05$) existed due to variations both in cassava species and modification methods.

Mouth feel

Results obtained for the sensory scores of the mouth feel (Table 4) of the cassava starch/wheat flour bread samples indicates that there was no significant difference ($p < 0.05$) due to variation in both modification methods and cassava species [47]. The value of the mouth feel decreased after modification processes from 7.32 for native starch to 6.50 for acetylated starch. Within the cassava species, the value ranged from 7.57 in TMS 98/0581 to 6.29 in TMS 98/12123. No significant ($p > 0.05$) difference existed due to variations both in cassava species and modification methods.

Taste

Sensory scores for the taste (Table 5) of the bread samples indicated that no significant difference ($p < 0.05$) exists due to variations in both modification processes and cassava species.

Cassava Species	Native	Aroma Oxidation	Acetylation	Acid- thinning	Mean ± SD
NR 93/0199	7	7	6	7	6.75 ± 0.50
TMS 96/0304	7	6	7	6	6.50 ± 0.58
TMS 98/0581	8	7	7	8	7.50 ± 0.58
TMS 92/0326	6	6	7	6	6.50 ± 0.58
TMS 98/12123	6	7	7	7	6.75 ± 0.50
Mean ± SD	6.80 ± 0.84	6.60 ± 0.55	6.80 ± 0.45	7.00 ± 0.71	-

Table 3: Effect of chemical modification and cassava species on the aroma of cassava starch/wheat flour bread sample; Values are means of nine determinations ± SD.

Cassava Species	Native	Mouth Feel Oxidation	Acetylation	Acid- thinning	Mean ± SD
NR 93/0199	6	7.6	6.3	6.2	6.53 ± 0.73
TMS 96/0304	8.7	7.4	6.4	7.41	7.50 ± 0.94
TMS 98/0581	8.1	6.3	7.5	8.36	7.57 ± 0.92
TMS 92/0326	7	7	6.19	6	6.55 ± 0.53
TMS 98/12123	6.8	6	6.09	6.25	6.29 ± 0.36
Mean ± SD	7.32 ± 1.08	6.86 ± 0.69	6.50 ± 0.57	6.84 ± 1.01	-

Table 4: Effects of chemical modification and cassava species on the mouth feel of the cassava starch/wheat flour bread sample; Values are means of nine determinations ± SD.

Values ranged from 7.12 in native starch to 6.46 in acid thinning. Within the species, TMS 98/0581 scored highest (7.04) while TMS 98/12123 had the lowest score (6.01). No significant ($p>0.05$) difference existed due to variations both in cassava species and modification methods.

Cassava Species	Native	Oxidation	Acetylation	Acid- thinning	Mean ± SD
NR 93/0199	6.28	6.35	7.15	7.00	6.70 ± 0.44
TMS 96/0304	8.31	6.11	6.17	6.22	6.70 ± 1.07
TMS 98/0581	7.08	7.05	6.06	7.04	6.81 ± 0.50
TMS 92/0326	7.00	6.00	7.34	6.03	6.59 ± 0.68
TMS 98/12123	6.98	7.00	6.00	6.01	6.50 ± 0.57

Mean ± SD	7.13 ± 0.73	6.50 ± 0.49	6.54 ± 0.65	6.46 ± 0.52	-
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Table 5: Effects of chemical modification and cassava species on the taste of cassava starch/wheat flour bread sample; Values are means of nine determinations ± SD.

General acceptability

Results obtained for general acceptability (Table 6) placed native starch/wheat bread as the most acceptable (7.59) and oxidized starch/wheat bread as the least acceptable sample (6.62). Within the species of cassava, TMS 98/0581 maintained the lead with a value of 7.95 while TMS 98/12123 had a value of 6.75. No significant ($p>0.05$) difference existed due to variations both in cassava species and modification methods.

Cassava Species	Native	General Acceptability Oxidation	Acetylation	Acid- thinning	Mean ± SD
NR 93/0199	7.23	6.07	7.00	6.80	6.78 ± 0.50
TMS 96/0304	8.14	6.06	7.16	6.30	6.92 ± 0.94
TMS 98/0581	8.08	7.43	7.37	8.90	7.95 ± 0.71
TMS 92/0326	7.51	6.31	7.40	6.31	6.88 ± 0.66
TMS98/12123	7.00	7.24	6.29	6.46	6.75 ± 0.45
Mean ± SD	7.59 ± 0.51	6.62 ± 0.66	7.04 ± 0.45	6.95 ± 1.11	-

Table 6: Effects of chemical modification and cassava species on the general acceptability of the cassava starch/wheat flour bread sample; Values are means of nine determinations ± SD.

Conclusion

Specific volume of the bread samples was improved by acetylation and oxidation treatments against the native and acid-thinned blended samples. Modification processes did not lead to any significant difference on the baking properties of the starches and this is reflected in the superior scores obtained for native starch in most of the sensory properties especially in general acceptability. Bread samples from native starch/wheat flour blends were the most acceptable (7.59) and bread samples from oxidized starch/wheat flour blends were the least acceptable (6.62).

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