ELSEVIER

Food Chemistry 79 (2002) 479–483

Food Chemistry

www.elsevier.com/locate/foodchem

Influence of hydrothermal treatment of maize grains on the quality and acceptability of *Tuwon masara* (traditional maize gel)

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Received 8 November 2001; received in revised form 14 May 2002; accepted 14 May 2002

Abstract

The influence of hydrothermal treatment of maize grains, meant for flour production, on the quality and acceptability of *tuwon masara* (traditional maize gel) was investigated. The grains were variously hydrothermally-treated at 65±1 °C for 30, 45 and 60 min, respectively, as well as at 75±1; 85±1 and 95±1 °C for the same aforementioned time intervals, respectively. The pasting characteristics of traditionally-produced maize flour (control) in terms of apparent gelatinization temperature, peak viscosity, final viscosity when held for 15 min at 50 °C, consistency and setback values were 82.5 °C, 140 BU, 436 BU, 444 BU and 436 BU, respectively while the ranges for those from hydrothermally-treated grains were 72.5–87.5 °C, 194–400 BU, 212–816 BU, 252–770 BU and 190–672 BU, respectively. The peak viscosity of all the flour samples assessed, including the control, were attained at 95 °C, particularly after 15 min of holding while the stability of the paste of most of them during cooking was not affected. The functional properties of the control in terms of bulk density, water absorption capacity, oil absorption capacity and foaming capacity were 0.84 g/cm^3, 2.20 g/g, 0.89 g/g and 4.08%, respectively while the ranges for those from hydrothermally-treated grains were 0.80–0.94 g/cm^3, 2.30–3.10 g/g, 1.04–1.32 g/g and 4.08–5.20%, respectively. The sensory evaluation on the laboratory-prepared *tuwon masara* showed that none of the samples were significantly different in colour at $P \leqslant 0.05$. BC3 (grains hydrothermally-treated at 75±1 °C for 60 min) had the highest scores for aroma, texture (ease of mouldability), taste and overall acceptability though these were not significantly different from CDI and CD2 (grains hydrothemally-treated at 85±1 °C for 30/45 min, respectively) at $P \leqslant 0.05$.

Keywords: Hydrothermal; Maize grains; Gel; *Tuwon masara*

1. Introduction

Tuwon masara (traditional maize gel) is one of the numerous traditional food products obtainable from maize, particularly in West Africa. *Tuwon masara* is a Hausa phrase meaning ‘food made from maize’ and it is usually prepared from maize flour to form a gel-like food but is normally consumed along with any of the popular local soups (e.g. tafshe, kuka, kubewa). The food product is particularly popular among the Hausa-speaking communities of West Africa in general and of Nigeria in particular while its preparation and consumption have now also spread to other non-Hausa-speaking communities principally due to inter-ethno-tribal movement of people in the sub-region. The food product serves as a cheap calorific source in the diet of consumers while the acceptable quality standard of the product can be described as a non-sticky mass, easy to mould when cooled and when left overnight to store under ambient conditions, and it should be cohesive to touch with no brittleness during moulding.

The processing of cereals (e.g. maize, sorghum, millet and rice) into traditional food products has not progressed much beyond traditional techniques, particularly in West Africa (Adeyemi, 1987), causing inevitable problems of labour intensiveness, time consumption, food loss/wastage potential, and/or low quality end-product (Ihekoronye & Ngoddy, 1985; Kordylas, 1990). *Tuwon masara* production is no exception.

The problems associated with *tuwon masara* include eating quality, e.g. inability to form a highly elastic,

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PII: S0308-8146(02)00223-6

long-bodied gel, its ability to retrograde easily when cooled, thereby leading to its brittleness while consuming, and the long period of cooking during preparation, with concomitant high level of fuel consumption. The identified unattractive problems with *tuwon masara* have thus made it unattractive to the people from non-Hausa-speaking communities.

The recognition of the problems with the food product is even reflected in the attempts being made by traditional consumers (Hausa-speaking communities) to mix flour from other botanical sources (e.g. cassava) with maize flour so as to improve the eating quality. Similarly, most people prefer to consume the food product when warm because, upon cooling, its binding capacity is greatly reduced and it tends to be brittle while moulding by hand during consumption. Nevertheless, the quality and general acceptability of a cereal product is reported to be influenced by the physical and chemical properties of the cereal from which it is produced (Akingbala, Oguntimein, & Sobande, 1995) while these properties may be modified through chemical, physical and enzymic processes so as to obtain desired functional characteristics (Galliard & Bowler, 1987).

The objective of this study was to evaluate the influence of hydrothermal treatment of maize grains, meant for flour production, on the quality and acceptability of *tuwon masara*, with the aim of evolving a modified processing technique that minimizes or outrightly eliminates the identified quality problems with the food product, thereby allowing wider acceptability among the populace of West Africa.

2. Materials and methods

2.1. Materials

A cultivar of flint maize (TZPB-SR) obtained from the Agricultural Development Programme (ADP) office, Akure, Ondo State, Nigeria, was used for this study. The maize grains were not less than 3 months old after harvest.

2.2. Methods

2.2.1. Preparation of maize flour samples

Different batches (1 kg each) of dry and wholesome maize grains were first soaked separately in cold water (submerged) for 1 h after which each was drained and then subjected to hydrothermal treatment. The different grain batches were variously hydrothermally-treated at 65±1 °C for 30, 45 and 60 min, respectively; 75±1 °C for 30, 45 and 60 min, respectively, 85±1 °C for 30, 45 and 60 min, respectively, and 95±1 °C for 30, 45 and 60 min, respectively. At the end of the treatment, each batch was drained and then spread on aluminium trays for drying in an air draught oven at 60 °C for 18 h; after this the dried grains were milled into flour and then sieved using a sieve size of 250 microns and the flour was subsequently kept in an air-tight polythene container until required.

Maize flour was also produced using the traditional method to serve as the control. One kilogram of dry and wholesome maize grains was first decorticated so as to remove the hulls through manual aspiration. This was then washed thoroughly in cold water, manually, to remove other adhering particles, followed by spreading on a mat for sundrying. The sundried decorticated grains were then milled into flour and sieved using a sieve size of 250 microns, while the flour was subsequently kept in an air-tight polythene container until required.

2.2.2. Evaluation of pasting characteristics of maize flour samples

Pasting characteristics of each sample of maize flour were evaluated using a Brabender visco-amylograph. Flour slurry containing 12% solids (w/w, dry basis) was heated up from 30 to 95 °C at the rate of 2.5 °C/min, kept at this temperature (95 °C) for 15 min, then cooled down to 50 °C and held at this temperature for another 15 min.

2.2.3. Evaluation of functional properties of maize flour samples

Functional properties of some maize flour samples (selected based on their relative high final viscosity values at 50 °C after 15 mins of holding) and the control were evaluated. The bulk density of the maize flour samples was determined using the method of Narayana and Narasinga Rao (1984); water and oil absorption capacities were determined using the method of Beuchat (1977), while foaming capacity was determined by the method of Coffman and Garcia (1977).

2.2.4. Preparation and sensory evaluation of 'Tuwon masara'

Four (4) maize flour samples (selected based on their relatively high final viscosity values at 50 °C after 15 min of holding), together with that produced using the traditional method (control) were used to prepare *tuwon masara*, followed by sensory evaluation of the food product. The overall ratio of water to flour used in the preparation of *tuwon masara* was 3.5:1 (v/w). Cold maize flour slurry was first prepared by mixing 25% of the measured water with 20% of the measured maize flour. Sixty percent of the measured water was then brought to boiling, after which the initially-prepared flour slurry was gradually added to the boiling water with continuous stirring until a pap-like consistency was obtained. The remaining quantity of maize flour (80%) was then added gradually to this boiling pap-like mass, with continuous stirring, until a satisfactory gel was obtained. The last quantity of water (15%) was added to this gel (and it was then covered) followed by allowing it to cook for about 3–5 min (without stirring), after which it was vigorously stirred again and was ready to be served. The final product eventually obtained is called *tuwon masara*.

A set of five *tuwon masara* samples, consisting of a reference (control) made by the traditional process and the other four (from hydrothermal treatment processes) was subjected to sensory evaluation, after the samples were cooled down under ambient conditions. A nine-member panel was used to compare the samples with the control using a multiple comparison test, by rating them on the basis of colour, aroma, texture (ease of mouldability), taste and overall acceptability on a scale of 9 to 1 (9 = extremely superior to the control; 5 = neither superior nor inferior to the control; 1 = extremely inferior to the control). All panellists were familiar with the traditional product and were trained in the use of sensory evaluation procedures. The scores from the ratings were eventually analyzed using standard procedures of analysis of variance and multiple range testing of the significance of mean difference at 5% significant level (Amerine, Pangborn, & Roessler, 1965; Snedecor & Cochran, 1967; IFT, 1981).

3. Results and discussion

The pasting characteristics of different samples of maize flour obtained from various forms of hydrothermal treatments are shown in Table 1. The apparent gelatinization temperature (T_a) of a traditionally-prepared maize flour (control) was 82.5 °C, while that of maize flour samples obtained from hydrothermal treatments varied from 72.5 to 87.5 °C. AB2 and DE1 had the highest apparent gelatinization temperature (87.5 °C), while CD1 and CD3 equally had the lowest value (72.5 °C).

The peak viscosity (V_p) of traditionally-prepared maize flour (control) was 140 BU, while those of other samples were higher (194–400 BU). This implies that the hydrothermal treatment of maize grains prior to flour production had improved the peak viscosity values. It was also observed that the peak viscosity of maize starch from the same grain type (TZPB-SR) at 8% solids level (w/w, dry basis) was 590 BU (Adeyemi, Commey, Fakorede, & Fajemisin, 1987) higher than that of its flour counterpart (140 BU). This suggests that the presence of other components, such as fibre, fat and protein (with the starch) could lower its peak viscosity. All the flour samples, including that of the control, were

Table 1
Pasting characteristics of maize flour obtained from various hydrothermal treatments of grains

Maize flour samples	T_a (°C)	V_p (BU)	V_a (BU)	V_b (BU)	V_c (BU)	V_f (BU)	V_p-V_b (BU)	V_c-V_p (BU)	V_c-V_a (BU)	T_p (°C)
AA (control, traditionally-prepared flour)	82.5	140	132	140	576	436	0	436	444	95
AB1 (grains hydrothermally-treated at 65±1 °C for 30 min)	77.5	394	278	394	910	682	0	516	632	95
AB2 (grains hydrothermally-treated at 65±1 °C for 45 mins)	87.5	308	210	308	980	338	0	672	770	95
AB3 (grains hydrothermally-treated at 65±1 °C for 60 min)	82.5	358	258	358	764	490	0	406	506	95
BC1 (grains hydrothermally-treated at 75±1 °C for 30 min)	75.0	320	282	320	540	300	0	220	258	95
BC2 (grains hydrothermally-treated at 75±1 °C for 45 min)	75.0	310	248	310	500	212	0	190	252	95
BC3 (grains hydrothermally-treated at 75±1 °C for 60 min)	75.0	400	332	400	815	676	0	415	483	95
CD1 (grains hydrothermally-treated at 85±1 °C for 30 min)	72.5	310	310	300	890	816	10	580	580	95
CD2 (grains hydrothermally-treated at 85±1 °C for 45 min)	80.0	260	172	260	904	660	0	644	732	95
CD3 (grains hydrothermally-treated at 85±1 °C for 60 min)	72.5	340	244	340	670	372	0	330	426	95
DE1 (grains hydrothermally-treated at 95±1 °C for 30 min)	87.5	194	68	194	580	440	0	386	512	95
DE2 (grains hydrothermally-treated at 95±1 °C for 45 min)	85.0	200	82	200	676	520	0	476	594	95
DE3 (grains hydrothermally-treated at 95±1 °C for 60 min)	80.0	260	48	260	510	228	0	250	462	95
Range	72.5–87.5	194–400	48–332	194–400	500–980	212–816	0–10	190–672	252–770	95

T_a = apparent gelatinization temperature; V_p-V_b = stability during cooking; V_p = peak viscosity; V_c-V_p = setback value; V_a = viscosity at 95 °C; V_c-V_a = consistency; V_b = viscosity after 15 min at 95 °C; V_c = viscosity at 50 °C; T_p = temperature at peak viscosity; V_f = final viscosity after 15 min at 50 °C. BU, Brabender unit.

found to attain their peak viscosity at 95 °C, particularly after 15 min of holding, except CD1 which had a reduced viscosity after the period.

The viscosity (V_c) of the control when cooled to 50 °C increased to 576 BU but dropped to 436 BU (V_f) when held for 15 min at this same temperature. All other maize flour samples also showed a similar trend by their increased values in viscosity when cooled to 50 °C and these ranged from 500 to 980 BU. However, when these samples were held for 15 min at 50 °C, their final viscosities (V_f) dropped, ranging from 212 to 816 BU. The samples that had lower final viscosity (V_f) than that of the control were AB2, BC1, BC2, CD3 and DE3, while others had higher values. And since this final viscosity (V_f), attained after stirring in the Brabender amylograph for 15 min at 50 °C, is an indicator of the stability of the cooked paste in actual use (Mazurs, Schoch, & Kite, 1957), it implies that the samples having higher final viscosity values (V_f) than the control were more stable.

The hydrothermal treatments on the maize grains prior to flour production were found not to have any effect on the stability ($V_p - V_b$) of the paste during cooking, except CD1 which became even less stable as reflected in its higher V_p–V_b value.

A wide variation was observed for the index of retrogradation tendency or setback values (V_c–V_p) ranging from 190 to 672 BU while that of the control was 436 BU. The flour samples having reduced index of retrogradation tendency, as reflected in lower setback values than that of the control, were AB3, BC1, BC2, BC3, CD3, DE1 and DE3; other samples had increased values. The increase in the index of retrogradation tendency of some of the samples may be attributed to the conditions of their hydrothermal treatments which might have made the hydrogen bonding among polysaccharide molecules in the cooled paste more extensive during cooling, thereby encouraging the increase and growth of gel micellar regions; hence an increase in index of retrogradation tendency resulted (Hodge & Osman, 1976). Similarly, the tendency to reduction in the index of retrogradation of some of the samples is most probably also due to the conditions of their hydrothermal treatments. These might have caused the hydrogen bonding among the polysaccharide molecules in the cooled paste to be less extensive, thereby making the entrapped water molecules less prone to expression, resulting in reduced retrogradation in the gel.

The consistency (V_c–V_a) of the samples during cooking ranged from 252 to 770 BU, spanning that of the control (444 BU). The samples that recorded lower consistency values than the control included BC1, BC2 and CD3; others recorded higher values with AB2 having the highest. Generally, most of the results obtained were found to be consistent with an earlier observation (Schoch, 1970) that native maize starch or flour exhibits a moderate peak viscosity, little breakdown during cooking and very high setback on cooling due to retrogradation of its linear fraction.

The functional properties of some of the maize flour samples (selected based on the relatively higher final viscosity, V_d, attained when held for 15 min at 50 °C) are shown in Table 2. The bulk density of the flour samples generally increased, ranging from 0.86 to 0.94 g/cm^3 as compared with that of the control (0.84 g/cm^3), with the exception of CD1 which had a lower value (0.80 g/cm^3). The increase in the bulk density might be due to the conditions at which the hydrothermal treatments were carried out. Increase in bulk density may offer a packaging advantage as a greater quantity may be packaged within a constant volume (Fagbemi, 1999).

Hydrothermal treatment of maize grains was also found to increase the water absorption capacity of the selected flour samples, ranging from 2.30 to 3.10 g/g as compared with that of the control (2.20 g/g). Water absorption capacity is an index of the ability of the flour to associate with water, particularly in products where hydration is required to enhance handling characteristics, such as in doughs and pastes (Giami & Alu, 1994).

The hydrothermal treatment of maize grains also improved the oil absorption capacity (OAC) of the flour. The oil absorption capacity of the selected flour samples varied from 1.04 to 1.32 g/g, which was higher than that of the control (0.89 g/g). The general increase in OAC of the samples is most likely due to the hydrothermal treatment of the maize grains which enhanced the physical entrapment of the oil, attributable also to the degree of denaturation of protein component in the flour coupled with the temperature of the treatment and size of the flour particles (Richest, Morr, & Cocney, 1974). Oil absorption capacity essentially measures the ability of the flour to associate with oil and this phenomenon is particularly relevant in food preparations that involve oil mixing, such as bakery products, which have oil as an important ingredient.

The foaming capacities of the selected flour samples were generally low with CD1 and CD2 having equal value to that of the control (4.08%) while AB1 and BC3

Table 2
Some functional properties of selected maize flour obtained from various hydrothermal treatments of grains[a]

Selected maize flour sample	Bulk density (g/cm^3)	Water absorption capacity (g/g)	Oil absorption capacity (g/g)	Foaming capacity (%)
AA (control)	0.84±0.01	2.20±0.08	0.89±0.04	4.08±0.07
AB1	0.86±0.03	2.30±0.07	1.04±0.01	5.10±0.08
BC3	0.94±0.05	2.60±0.09	1.33±0.05	5.20±0.11
CD1	0.80±0.02	2.80±0.09	1.13±0.03	4.08±0.05
CD2	0.86±0.02	3.10±0.13	1.32±0.04	4.08±0.06

[a] Values are means of triplicate determinations ± standard deviation.

Table 3
Sensory evaluation ratings for laboratory-prepared *Tuwon masara*

Source of *Tuwon masara* sample	Sensory scores[a]				
	Colour	Aroma	Texture (ease of mouldability)	Taste	Overall acceptability
AB1	7.56a	6.33bc	8.11bc	6.11b	7.89b
BC3	7.89a	7.11ac	8.89a	6.89a	8.67a
CD1	8.0a	7.56a	8.44a	7.0a	8.56a
CD2	8.0a	7.67a	8.33ac	7.0a	8.56a

[a] Mean values within the same column having the same letters are not significantly different at $P \leqslant 0.05$.

had higher values (5.10 and 5.20%, respectively). Maize flour, therefore, cannot be useful as a foaming agent, particularly in foods that require aeration, due to its low foaming capacity values.

The sensory quality assessment of *tuwon masara* prepared from selected maize flour samples, is presented in Table 3. None of the *tuwon masara* samples were significantly different in terms of colour while there were significant differences in other sensory attributes. *Tuwon masara* samples, prepared from BC3, CD1 and CD2, respectively, were highly acceptable in all sensory attributes while that from AB1 obtained significantly lower scores for aroma, texture (ease of moudability), taste and overall acceptability. Nevertheless, *tuwon-masara* prepared from BC3 got the highest scores for overall acceptability, though this was not significantly different from CD1 and CD2 at $P \leqslant 0.05$.

It may therefore be concluded that hydrothermal treatment of maize grains, prior to the production of flour meant for *tuwon masara* preparation, played a significant role in the improvement of quality and acceptability of the traditional product. *Tuwon masara* of improved sensory attributes, such as colour, aroma, texture (ease of mouldability), taste and overall acceptability, was obtained from BC3 (grains hydrothermally treated at 75±1 °C for 60 min) and therefore this is recommended as an improved version over the traditionally-prepared counterpart.

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