COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH-FOOD RESEARCH INSTITUTE

CSIR-FRI/CASSAVA G-MARKETS PROJECT

A Report on the Assessment of HQCF as an Ingredient in flour blends for the preparation of two Ghanaian local diets (*Banku* and *Tuo Zaafi*)

Technical Report

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Summary

This report presents the findings of an assessment of HQCF as an ingredient in the processing of two Ghanaian local diets. The aim of this study was to determine the suitability of HQCF as an ingredient in *banku* and *tuo zaafi*. This was geared towards finding alternative uses of HQCF in a bid to expand its range of usage as a raw material for food processing. HQCF was incorporated, at different inclusion levels, into the traditional formulation for preparing *banku* and *tuozaafi*. Some physicochemical and viscometric properties of the resulting flour blends were determined using standard methods. The flour blends were used to process the local diets and these were evaluated in a sensory session by a 15-member untrained panel. The results showed some similarities in physico-chemical and pasting behavior of flour blends and their controls (which did not contain HQCF). For the *banku* mix, water absorption capacity was 2.0 % for all the blends and the control. Addition of HQCF at 30% did not affect the peak viscosity and setback ratio significantly. Addition of HQCF to the *banku* mix, however prolonged the pasting time. In the case of *tuo zaafi*, addition of HQCF reduced pasting time significantly ($p<0.05$) and did not affect water and oil absorption capacities. Sensory evaluation revealed similarities in the rating of attributes and overall acceptability on the two local diets and their controls (which did not contain HQCF).

1.0 Introduction

Cassava roots a regarded as an important source of energy in most parts of Africa, serving as food for more than 1 million people. The roots are bulky and contain more than 60% moisture making it susceptible to spoilage within a few days after harvest. This makes processing into dry and more stable forms attractive. Recent attempts in Ghana to add more value to the root crop and make it a useful raw material for both domestic and industrial applications has led to production of unfermented flour from the crop. This flour, also termed High Quality Cassava Flour (HQCF), is quite versatile in its use and applicable in a wide range of products.

The use of HQCF in the production of two Ghanaian staples (*Banku* and *Tuo zaafi*), in a bid to make this raw material more visible, is explored in this study. These foods are originally prepared with cassava, in the form of a fermented dough or fermented flour and maize flour. In this activity HQCF is used to replace the other forms of cassava in varying proportions. Physico-chemical, functional and rheological properties of different blends are compared. Sensory evaluation of the two food products is also conducted to ascertain the performance of HQCF in these local dishes.

2.0 Methodology

2.1 Materials

HQCF, fermented cassava flour, cassava dough and fermented maize meal procured from the commercialization division of the CSIR-Food research Institute were used in this activity.

2.2 Methods

2.2.1 pH

pH of the flour blends was measured with a pH meter (Jenway, 3330, England) by AACC, 2000. Five grams of flour was mixed with 20 mL of distilled water to form a suspension which was stirred for 5 min and allowed to settle for 10 min. The pH of the water phase was then measured with the calibrated pH meter.

2.2.2 Color

Color of the flour formulae was determined using a Minolta Chroma meter (CR-310 Minolta, Japan). The device was calibrated with a reference white porcelain tile (L_0=97.63, a_0=0.31 and b_0=4.63) before the determinations. Color of the various flours was described using the L a b system, where L* is a measure of lightness, a* defines components on the red-green axis and b* defines components on the yellow-blue axis. All determinations were done in triplicates and the means and standard error reported. Colour difference, using color of the "control" samples as the set reference, was calculated as: $\Delta E = (\Delta L^2+\Delta a^2+\Delta b^2)^{1/2}$

2.2.3 Water and oil absorption capacity

The method described by Beuchat (1977) was used to determine the water and oil absorption capacities of the flours blends. One gram of flour was mixed with 10ml of distilled water for 30 seconds. The samples were allowed to stand at room temperature (28 ºC) for 30 min after which they were centrifuged at 3000 rpm (Remi Research, R23) for 30 minutes. The volume of the supernatant was recorded and water absorption capacity (mg/ml) calculated as the difference between the initial volume of water added to the flour and the volume of the supernatant. For oil absorption capacity, the same procedure was carried out using vegetable oil (Frytol®) instead of distilled water

2.2.4 Bulk density

Bulk density was determined by Ashogbon and Akintayo (2012). A graduated measuring cylinder was weighed and filled to 10 mL with flour. This was done by gently tapping the bottom of the cylinder on the laboratory bench several times until there was no further diminution of the sample level after filling to the 10 mL mark. The bulk density of flour samples was thereafter calculated by the following relation:

$$Bulk\ density = \frac{Weight\ of\ sample\ (g)}{Volume\ of\ sample\ (ml)}$$

2.2.5 Pasting properties of flour

The pasting properties of the various flours were determined on an 8% slurry of flour using a Brabender Viscoamylograph (Viskograph-E, Brabender Instrument Inc., Duisburg, Germany) equipped with a 1000 cmg sensitivity cartridge. The suspension was heated from 50 °C to 95 °C at a rate of 1.5 C/min, held at this temperature for 15 min, cooled to 50 °C at a rate of 1.5 °C/min and held at this temperature for 15 min. The viscosity profile indices recorded included the following: pasting temperature, peak viscosity, viscosity at 95 °C, viscosity after 30 min hold at 95 °C (95 °C-hold), viscosity at 50 °C and viscosity after 15 min hold at 50 °C (50 °C-hold), breakdown and setback.

2.2.6 *Banku* and *Tuo zaafi* preparation

Banku and *Tuo Zaafi*, which are usually prepared with maize meal and cassava dough (for *banku*) or fermented cassava flour (in the case of *tuo zaafi*), had their cassava component replace with HQCF in this study. The two local staples were prepared using the formulations provided in Table A.

Table A: Proportions of ingredients in the various flour blends

Banku formula	Proportions	*Tuo Zaafi* formula	Proportions

Control	70% Fermented maize meal and 30% cassava dough (*agbelima*)	*Control*	70% maize meal and 30% fermented cassava flour
F70:H30	70% Fermented maize meal and 30% HQCF	*M70:30*	70% maize meal and 30% HQCF
F60:H40	60% Fermented maize meal and 40% HQCF	*M50:H50*	50% maize meal and 50% HQCF
F50:H50	50% Fermented maize meal and 50% HQCF	*M40:H60*	40% maize meal and 60% HQCF

2.2.7 Sensory Evaluation

Fifteen untrained panelists, who are familiar with *banku* and *tuo zaafi* and have previous experience in sensory evaluation, were made to assess common attributes of the two staples such as appearance, color, aroma, taste, texture and overall acceptability. A 9-point hedonic scale (Stone and Sidel, 2004), with 1 representing dislike extremely and 9 representing like extremely was used for the evaluation. Panelists were also given the option to make general comments about the samples. Panelists were instructed to rinse their mouths with water before tasting subsequent samples. Individual scores from the panelists were averaged and data analyzed (SPSS 17.0.1, 2008).

2.2.8 Statistical Analysis

Data was analyzed for differences using ANOVA, and where present these differences separated by Duncan's Multiple Range Tests (SPSS 17.0.1, SPSS Inc USA). Statistical significance was set at a level of 95% confidence interval. Results were reported as means ± standard deviation.

3.0 Results and discussion

3.1 Physico-chemical and functional properties

Table 1: Colour of flour blends for *banku* preparation

Composite	Colour			ΔE
	L	a	b	
Control	90.75 ± 0.16^{b}	-0.73 ± 0.04^{a}	7.22 ± 0.07^{c}	-
F70:H30	90.63 ± 0.03^{a}	-0.73 ± 0.02^{a}	6.78 ± 0.16^{b}	0.46 ± 0.15^{a}
F60:H40	91.30 ± 0.04^{c}	-0.72 ± 0.04^{a}	6.62 ± 0.12^{b}	0.82 ± 0.10^{b}
F50:H50	91.64 ± 0.05^{d}	-0.67 ± 0.06^{a}	5.78 ± 0.13^{a}	1.70 ± 0.13^{c}

Means along the same column with different superscripts are significantly different ($p<0.05$)

Table 2: pH and functional properties of flour blends for *banku* preparation

Composite	pH	BD (g/ml)	WAC (%)	OAC (%)
Control	3.65±0.02^{b}	0.78±0.00^{c}	2.0±0.0^{a}	1.7±0.1^{b}
F70:H30	3.63±0.01^{a}	0.78±0.00^{c}	2.0±0.0^{a}	1.4±0.0^{a}
F60:H40	3.71±0.00^{c}	0.77±0.01^{b}	2.0±0.0^{a}	1.5±0.1^{ab}
F50:H50	3.79±0.00^{d}	0.74±0.01^{a}	2.0±0.0^{a}	2.0±0.2^{c}

Means along the same column with different superscripts are significantly different (p<0.05)

Table 1 presents some physico-chemical properties of different proportions of ingredients for *banku* preparation. Color has been described by Wrolstad and Smith (2010) as having a far-reaching influence on consumer opinion about food, and in flours it is considered critical, since it affects marketing and acceptability of products made from them (Van Hal, 2000). Generally, colour of the ingredients is shown to be white, with a slight shade of yellow. Whiteness and yellowness was significantly different ($p<0.05$) among the different composites, with F50:H50 being the whitest and least yellowy. Among the new composites, whiteness increased with an increase in the proportion of HQCF while yellowness decreased. The control was more yellow than all of the new formulae and lighter than only the formulae with 30% HQCF. The red-green index of the new composites was comparable to the control, since DMRT showed no significant differences ($p>0.05$) among them. Colour difference between the "control" and new formulations was pronouncedly affected by HQCF and ranged from 0.46 to 1.70. F50:H50 was the most different from the control (Table 1)

A trend of marked increase in pH (Table 2) was observed among the newly developed composites, when the proportion of HQCF in the mix was increased from 30 through 50%. This observation is due to the fact that pH of the HQCF is higher than that of the ingredients in the control formula. The developed composites generally had a higher pH than the control except for F70:H30, which had a slightly acrid pH than the control formulation.

Some functional properties (Table 2) of the new formulae were comparable to that of the control composite. A reduction in bulk density was noticed when the proportion of HQCF was increase because HQCF is lighter in weight compared to the fermented maize meal and cassava dough. The composite with the lowest proportion of HQCF had the same bulk density as the control but those with 40 and 50% HQCF proportion had a considerably lower bulk density. Water absorption capacity of the new blends was the same as the control formulation. Considerable differences were noticed in the oil absorption capacity of the different mixes, but F60:H40 was comparable to the control. F50:H50 had the highest oil absorption capacity, possibly because of the effect of the HQCF.

Table 3: Colour of flour blends for *tuo zaafi* preparation

	Colour			ΔE
	L	a	b	
Control	88.98±0.14^{a}	-0.78±0.08^{a}	9.16±0.16^{d}	-
M70:H30	90.06±0.20^{b}	-0.67±0.07^{b}	6.35±0.16$_{c}$	3.01±0.21^{a}
M50:H50	91.11±0.19^{c}	-0.68±0.02^{b}	5.60±0.05^{b}	4.15±0.10^{b}
M40:H60	91.85±0.11^{d}	-0.65±0.04^{b}	5.10±0.12^{a}	4.98±0.06^{c}

Means along the same column with different superscripts are significantly different (p<0.05)

Table 4: pH and functional properties of flour blends for *tuo zaafi* preparation

	pH	BD (g/ml)	WAC	OAC
Control	5.99±0.01^{d}	0.81±0.01^{c}	2.1±0.0^{a}	1.9±0.2^{a}
M70:H30	5.85±0.00^{c}	0.82±0.01^{c}	2.2±0.0^{a}	2.1±0.2^{a}
M50:H50	5.70±0.01^{a}	0.74±0.01^{b}	2.1±0.0^{a}	1.9±0.1^{a}
M40:H60	5.63±0.01^{b}	0.71±0.00^{a}	2.2±0.0^{a}	2.1±0.2^{a}

Means along the same column with different superscripts are significantly different (p<0.05)

Physico-chemical and functional properties of the different ingredients for TZ preparation are summarized in Table 3. Colour parameters of the new formulae differed significantly from that of the control formula. The influence of HQCF is made manifest in the increasing whiteness of the newly developed blends. Increasing HQCF proportion correlated negatively with the yellow-green index. Mean colour difference ranged between 3.01 and 4.98 and was highest for M40:H60, which incidentally had the highest proportion of HQCF.

pH and functional properties of the flour blends for *Tuo zaafi* preparation is presented in Table 4. pH of the three different formulations differed considerably from the control mix, with higher proportions of HQCF having a pH lowering effect on the blends. All of the newly formulated blends had higher pH values compared to the control. Bulk density of the formulations ranged between 0.71 and 0.72 with a general trend of a reduction observed with an increase in amount of HQCF. M50:H50 and M40:H60 had significantly lower bulk densities compared to the control but M70:H30 did not show considerable difference from the control. Water and oil absorption capacities of the newly developed blends were comparable to that of the control. As such there was no significant differences (p>0.05) between the formulations and the control, with respect to the two functional properties.

3.2 Visco-elastic properties of ingredients for the two local diets

Table 5 presents the visco-elastic properties of flour blends for producing *banku*. Generally, substituting *agbelima* with HQCF was found to have a marked effect on pasting characteristics of flour blends, since these were different from the control sample (Figure 1). That notwithstanding, similarities were found between the peak viscosity, trough and breakdown viscosities of the control and F70:H30. As well, pasting time for F50:H50 and that of the control was also comparable. Pasting temperature, which is indicative of the onset of gelatinization, was observed to reduce when the proportion of HQCF was increased. Primarily, starches with lower pasting temperatures are easier to cook (Afoakwa and Sefa-Dedeh, 2002) and therefore, addition of HQCF would facilitate the cooking of *banku*. This is also reflected in the pasting time, which, among the new blends is lowest in the blend with high amounts of HQCF, but pretty much the same as that of the control. An increase in the proportion of HQCF resulted in an increase in peak viscosity of the blends, which had significantly higher peak viscosity than the control (Table 5). At 30% however, peak viscosity was akin to that of the control since no significant difference was established between these two.

The viscosity attained after holding at a constant temperature of 95 for 30 min during cooking indicates the ease of breakdown of the hot cooked paste. This index is similar to the stability ratio, which also explains paste stability under the influence of shearing forces. As summarized in Table 5, this property was improved with the introduction of HQCF. Statistical analysis indicated a considerably ($p<0.05$) improved gel strength conferred on the blends by higher amounts of HQCF. Similarly, a positive correlation was noticed between peak viscosity and amount of HQCF. Meanwhile, the new blends had significantly lower ($p<0.05$) peak viscosity compared with the control *banku* blend. Peak viscosity ranged from 128.0 to 140.0 BU for the new formulae and was 154.0 BU for the control. Setback ratio shows retrogradation tendency of starch pastes after gelatinization (Sefah Dedeh and Sackey, 2002) and its reduction in the new blends is ascribed to the quantity of HQCF added (Table 5). Higher setback ratio indicates higher retrogradation tendency, which is not a pleasant phenomenon in cooked pastes.

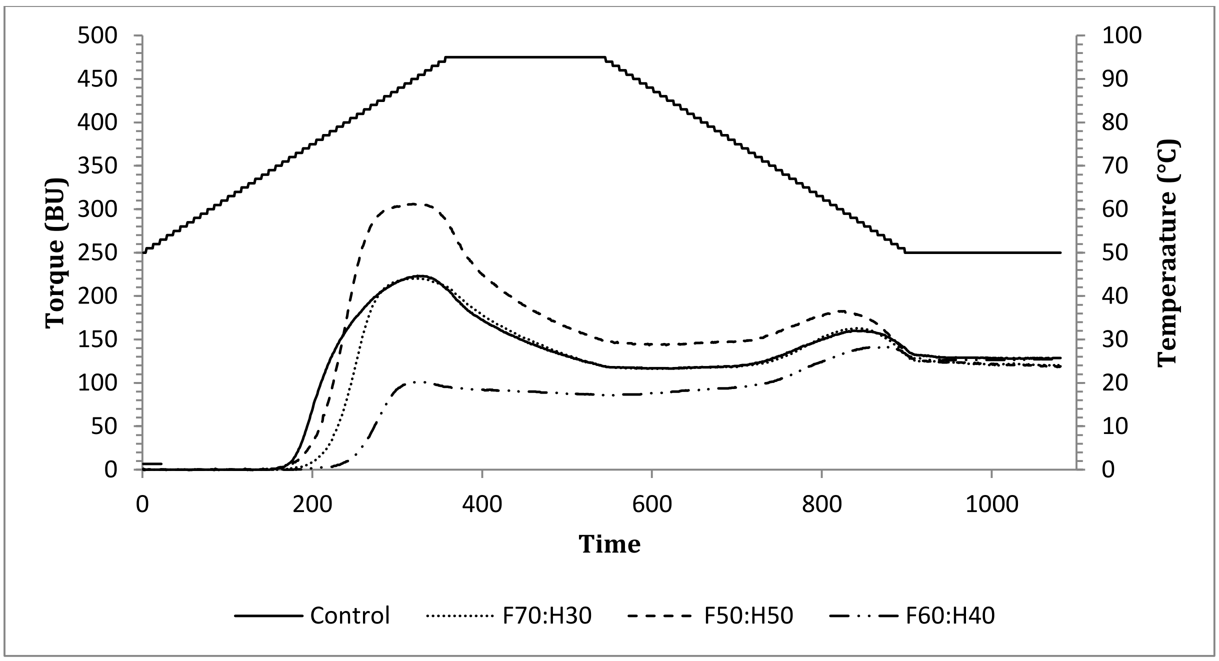

Figure 1. Pasting profile of flours for *banku* preparation

Table 5: Pasting properties of flour blends for *banku* preparation

Index	Control	F70:H30	F60:H40	F50:H50
Pasting Temp(°C)	70.7±0.1^{a}	74.0±0.1^{c}	79.0±0.0^{d}	71.5±0.2^{b}
Pasting time (min)	14.4±0.0^{a}	16.2±0.0^{b}	20.0±0.0^{c}	14.8±0.4^{a}
Peak Viscosity	223.5±0.7^{b}	220.5±0.7^{b}	100.5±0.7^{a}	306.0±10.0^{c}
V Hold (90C)	119.5±3.5^{b}	120.0±0.0^{b}	86.5±0.7^{a}	149.0±5.7^{c}
Final Viscosity	154.0±0.0^{d}	128.0±0.0^{a}	143.0±0.0^{c}	140.0±0.0^{b}
Stability ratio	0.53±0.02^{b}	0.54±0.02^{b}	0.86±0.0^{c}	0.49±0.0^{a}
Setback ratio	1.07±0.01^{c}	1.00±0.03^{b}	1.47±0.25^{d}	0.80±0.23^{a}

Means along the same row with different superscripts are significantly different ($p<0.05$)

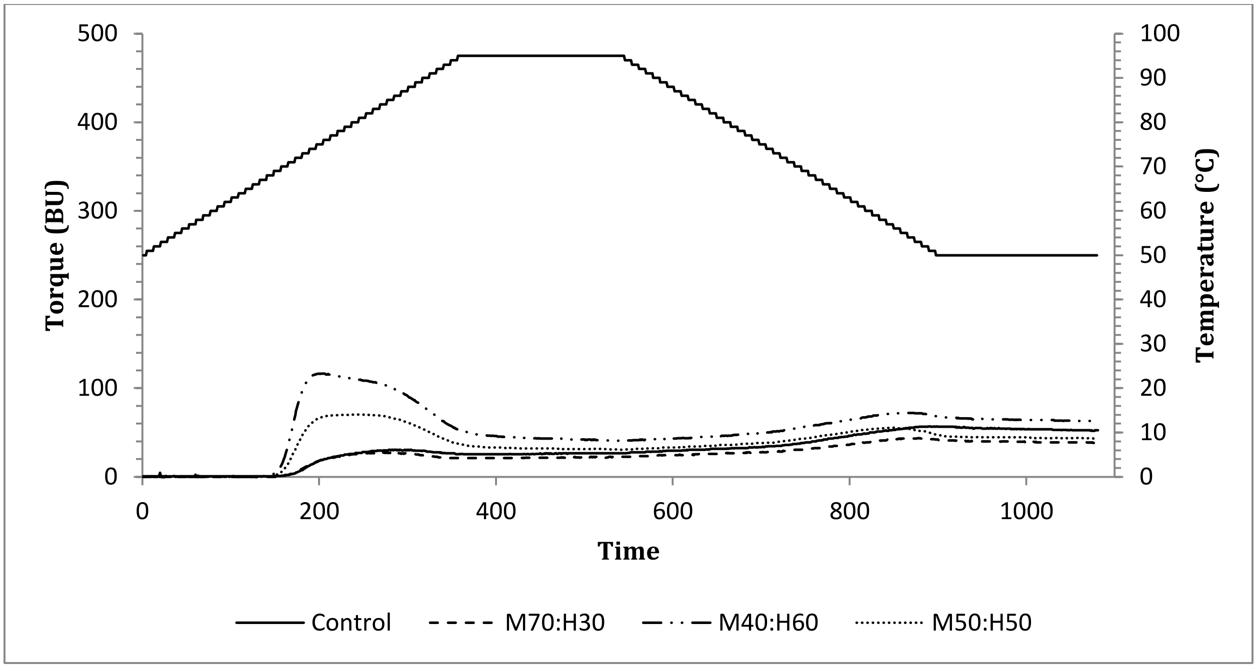

Figure 2. Pasting profile of flour blends for *Tuo zaafi* preparation

Visco-elastic profile of three flour blends and the control blend for *tuo zaafi* preparation is shown in Figure 2. A seemingly different profile is noted for the blends with higher amounts (50 and 60 %) of HQCF and low proportions of maize flour. A similar profile is however observed for the control blend and the new formula containing 30% HQCF. This trend may be attributed to the influence of maize flour which forms the majority of ingredients in these two blends.

Details of the visco-metric properties of the different flour blends are presented in Table 6. Overall, the effect of HQCF in the blends either caused a steady increase or a decrease in the various indicators of flour rheological properties. Pasting temperature and time saw a steady decrease when more HQCF was added to the flour blends. Similarities in pasting temperature was however observed between the control and M70:H30, possibly because of the influence of maize flour while the impact of higher amounts (50% or more) of high quality cassava flour explains the relation between M50:H50 and M40:H60. As shown in Table 6, pasting temperature and time were highest in the control flour formula and this inferentially indicates a slight difficulty in cooking, with higher energy costs, compared to the newly developed formulae.

Table 6: Pasting properties of flour blends for *tuo zaafi* preparation

Index	**Control**	**M70:H30**	**M50:H50**	**M40:H60**
Pasting Temp(°C)	73.2 ± 2.4^{b}	71.5 ± 0.3^{ab}	69.0 ± 0.4^{a}	68.1 ± 0.1^{a}
Pasting time (min)	15.2 ± 0.1^{c}	15.1 ± 0.1^{c}	13.3 ± 0.1^{b}	12.8 ± 0.3^{a}
Peak Viscosity	30.5 ± 0.7^{b}	27.5 ± 0.7^{a}	70.5 ± 0.7^{c}	116.5 ± 0.7^{d}
V Hold (90C)	26.5 ± 0.7^{b}	22.5 ± 0.7^{a}	30.5 ± 0.7^{c}	41.0 ± 0.0^{d}
Final Viscosity	$52.5\pm0.7b^{c}$	38.5 ± 3.5^{a}	44.0 ± 2.8^{ab}	62.5 ± 6.3^{c}
Stability ratio	0.87 ± 0.00^{d}	0.82 ± 0.00^{c}	0.43 ± 0.01^{b}	0.35 ± 0.00^{a}
Setback ratio	1.98 ± 0.03^{b}	1.71 ± 0.03^{ab}	1.44 ± 0.12^{a}	1.52 ± 0.16^{ab}

Means along the same row with different superscripts are significantly different ($p<0.05$)

As in the case of the flour formulation for *banku*, an increase in the proportion of HQCF resulted in an increase in peak viscosity of the blends for TZ preparation. The trend in peak viscosity also depicts the ability of unfermented cassava flour to increase the viscosity of flours at higher proportions. It ranged between 27.5 and 116.5 for M70:H30 and M40:H60. Incidentally, M70:H30 had the least peak viscosity among all the flour blends (control inclusive).

The viscosity attained after holding at a constant temperature of 95 for 30 min during cooking indicates the ease of breakdown of the hot cooked paste. This index is similar to the stability ratio, which also explains paste stability under the influence of shearing forces. V-Hold (90) was nearly 27 BU for the control and ranged from 22.5 to 41.0 BU for the new blends, with higher values corresponding to higher proportions of HQCF. Stability ratio on the other hand reduced as the proportion of HQCF in the blends increased and was highest in the control sample. This seems to suggest that HQCF negatively impacts on paste stability, since a high stability ratio usually indicates relatively stable viscosity (Sefah-Dedeh and Sackey, 2002). Compared to the control, peak viscosity was generally lower in the HQCF blends, apart from the mix with 60% HQCF. An increase in twice the amount of HQCF, from 30% to 60%, resulted in an increase in final viscosity of more than 1.5 fold. Multiple range analysis conducted indicated significant some similarities in peak viscosity between the control and M40:H60 as well as between M70:H30 and M50:H50. Setback ration reduced with the introduction of HQCF into the mix and further reduced as the proportion of HQCF in the mixture was raised. Setback ratio indicates the retrogradation tendency in cooked pastes, a phenomenon which is attributed to high degree of association of starch molecules as a result of hydrogen bonding. Setback ratio has been found to be associated also with starch concentration and measuring methods (Chen et al., 2005)

3.3 Sensory evaluation

Sensory evaluation rating of attributes commonly used to assess *banku* and *tuo zaafi* by consumers of these diets are illustrated in Figures 3 and 4.

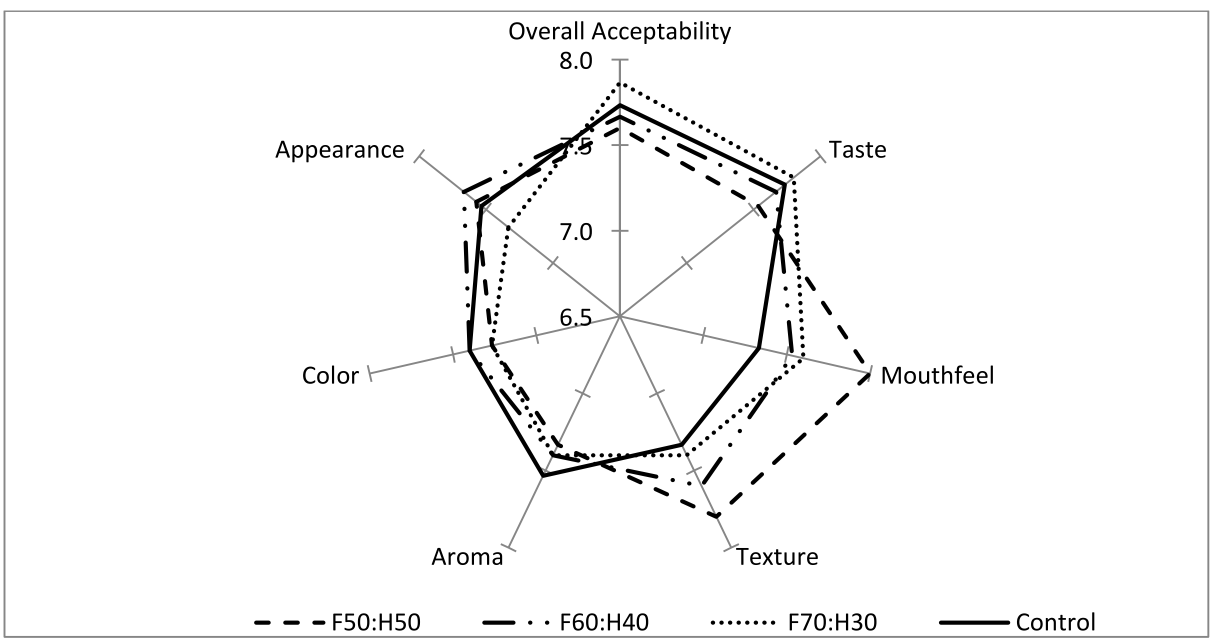

Figure 3: Sensory profile of *Banku* from different flour blends

For *banku* (Fig. 3), the new blends were generally rated in a similar pattern as the control, except for texture and mouth-feel. The result of using HQCF led to scores for the new *banku* mix being significantly much higher (p<0.05) for these attributes than the control. F70:H30 attained the highest score for taste while those with higher amounts of HQCF (>30%) were rated lowly. This might be due to the drastic reduction in the slightly acrid feeling which is typical of *banku*, when HQCF is added in high proportions. This same reason may have accounted for all the blends being rated lower than the control *banku* in terms of aroma.

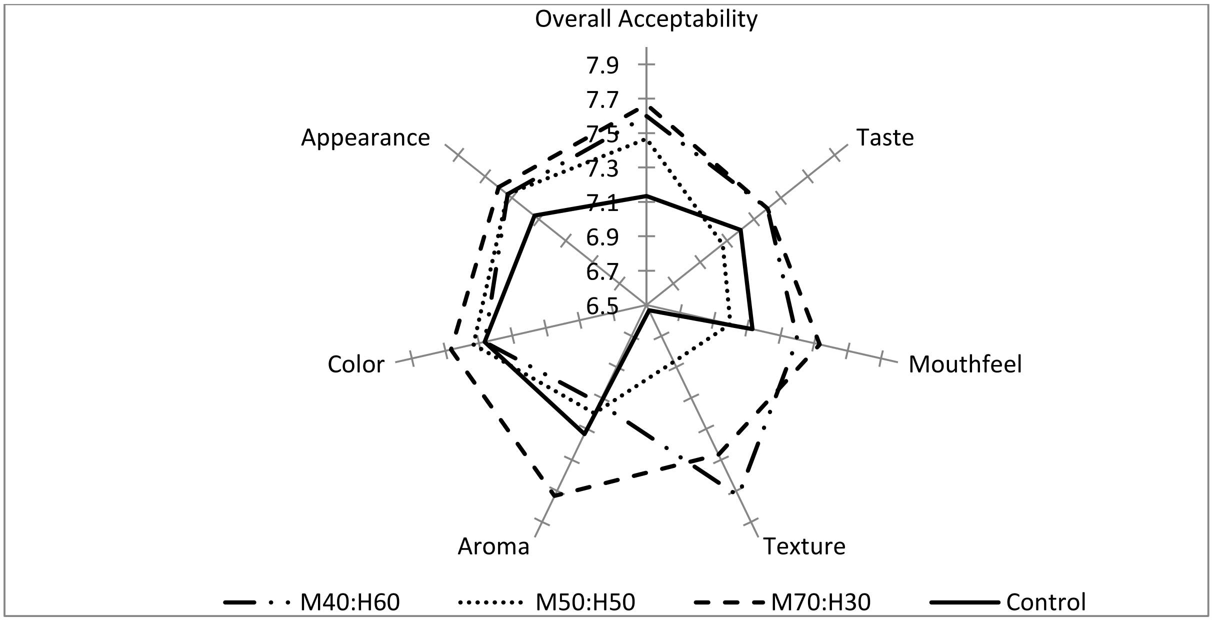

Figure 4: Sensory profile of *Tuo Zaafi* from different flour blends

In the case of t*uo zaafi*, the rating profile was quite dissimilar for the new blends and the control specifically because of the scoring for colour and aroma. As shown, the fairly circular nature of the profile of the control is somewhat truncated because of the comparatively lower score the attribute received. M40:60, which incidentally had the highest texture rating, also show a deviation from the circular nature of the rest of the profiles because its score for aroma was quite low. Higher proportions of HQCF resulted in high rating for taste and overall acceptability, while *tuo zaafi* containing intermediary level of HQCF received a lower rating for most of the attributes assessed.

Table 7 summarizes the overall acceptability of the two local diets as rated by the 25-member sensory panel. The findings of the sensory evaluation suggest that the two products were well accepted by panelists since they generally rated them similarly as they did their control samples. Acceptability scores ranged from 7.3 to 7.6 for *Banku* and 7.1 to 7.6 for *Tuo Zaafi*. For all two products, no significant differences (p>0.05) were observed among the control samples and the blends and also among the new formulae.

Table 7: Acceptability of *Banku* and *Tuo zaafi* from HQCF

Banku formula	Acceptability	Tuo Zaafi formula	Acceptability
Control	7.5^a	*Control*	7.1^a

F70:H30	7.3[a]	*M70:30*	7.7[a]
F60:H40	7.6[a]	*M50:H50*	7.5[a]
F50:H50	7.6[a]	*M40:H60*	7.6[a]

*Means with the same superscripts are not significantly different (p>0.05)

Although the inclusion of HQCF generally resulted in an increased acceptability rating for *banku* and *tuo zaafi*, this increment was not statistically considerable. The implication is that HQCF could be successfully used in the preparation of *banku* and *tuo zaafi* without significant changes in acceptability of these diets, even at varying proportions as used in this study.

4.0 Conclusion

The study has shown comparable properties between new blends and control flour blends for the preparation of two indigenous Ghanaian diets. This observation suggests the possibility of using blending HQCF and flour from cereal grains (mainly maize) for the preparation of *Banku* and *Tuo zaafi*. Sensory evaluation showed similarities in the rating of attributes as well as comparable overall acceptability in the two diets and their controls. This shows that HQCF could be adopted in preparing these staples without compromising essential product attributes.

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