

End-use Quality of Upland *NERICA* Rice (*Oryza sativa* L) as Affected by the Addition of Sweet Cassava (Low cyanide, *Manihotesculenta*) Flour

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Abstract End-use quality of upland *NERICA* 1 (WAB-450-1-B-P38-HB) rice flour as affected by the addition of 5 to 20% sweet cassava flour were evaluated. Functional characteristics, viscosity profile, proximate composition and consumer acceptability test of ‘*Tuwonlaushi*’ prepared from the blends were determined. Results indicated that WAI varies between 28.77 and 63.54%, while OAI were significantly ($p=5\%$) lowered when cassava flour was added and ranged between 4.96 at 20% cassava flour to 9.21% in 100% rice flour. GI significantly ($p=0.5$) ranges from 0.11 in 10% cassava flour formulations to 0.86 in 5% cassava flour formulations. PT for 100% cassava flour and rice flour were 54.38 and 56.33°C respectively. The PV value increase with increase cassava flour substitution between 116.75 and 134.75 RVU for 5% and 20%. FV ranged between 182.08 RVU (5% cassava flour) and 199.33 RVU (20% cassava flour). Moisture content of the different formulations were not significantly different ($p=0.05$) ranging from 0.16% to 0.28% with an average of 0.23%. The protein content of the rice-cassava blends were significantly ($p=5\%$) lower than the whole rice flour, ranging from 10.90% in 100% rice flour to 5.49% in 20% substitution. Consumer ratings indicated high ranking for 10, 15 and 20% formulation in this order indicating detectable effect of cassava flour addition in ‘*tuwonlaushi*’ production. Correlation studies indicated a significant ($p=5\%$) negative correlation between moisture content and emulsion capacity (-0.96^{**}) and bulk density (-0.97^{**}) of the blends and positive correlation (0.96^{**}) between protein and caloric value, indicating positive contribution of protein to overall metabolizable energy value of the formulations. The variation in functional and pasting properties and nutritional properties is an indication of possible multi-dimensional end-use which rice flour mixed with cassava flour could be subjected to at different ratios that could be of benefit for both domestic and industrial applications.

Keywords Rice, Cassava, Pasting viscosity, Proximate composition, Functional characteristics, End-use

1. Introduction

Nigeria has experienced rapid growth in per capita rice consumption during the last few decades, increasing from 5kg in the 1960s to 25kg in the late 1990s and currently stands at 30kg and 40kg among rural and urban dwellers respectively. Although, rice ranks fourth behind major staples like sorghum, maize and cassava in terms of the overall volume of food consumed in Nigeria, it is the fastest growing source of food consumed in the country. From 1980 to date, Nigeria has immersed to become the highest producer of rice in West Africa and third in Africa, after Egypt and Madagascar. The trend has made Nigeria to attain 2.103 and 3.46 million metric Tons (MMT) of milled rice

production in 2005 and 2008 respectively. Rice is used in different forms for the preparation of diverse recipes in Nigeria. However, one of the challenges facing the rice sector is poor post-harvest technical system. Significant quality losses are recorded during rice processing due to poor processing techniques and machineries. Experts suggested value addition to low quality broken rice as a strategy for improvement in the short term and upgrading local mills for the long term.

During rice milling, broken rice is produced which reduced the quality of the resulting product and therefore used for the production of flour. Rice flour (also called *Michiko* in Japanese and *Pirin çunu* in Turkish) is a form of flour made from finely ground milled rice [29]. There has been increased industrial application of rice flour as ingredients in gels, puddings, ice cream and baby formulations because of their nutritional, hypoallergenicity, colorlessness and bland taste [30]. But native rice flour has been reported to have low resistance to shearing force and

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poor elastic gel-forming abilities and therefore have marked tendency to loss their viscosity and thickening power during cooking [24]. Rice flour obtained from high amylose, low gelatinization temperature and high gel consistency varieties have been shown to be suitable for pastry production. While low amylose varieties has low potential for extruded products [20, 26, 27].

In commercial practices rice flour is either chemically modified or combined with other flours to improve its end-use qualities and this practice is attracting significant research effort [24, 25]. Viscosity is one of the major characteristics of rice flour that is important in determination of its processing behavior. Vast information exists on the behavior of rice starch during processing into different food products. Lopez *et al.*, [28] reported on the mixture of rice flour, corn and cassava starch in the production of gluten-free white bread; Tiboonbun *et al.*, [23] investigated the effect of replacing rice flour with unripe banana flour for noodle production; while Surojanametakul and others [22] investigated the effect of partial replacement of rice flour with other crop starch on the physicochemical and sensory characteristics of some *SenLek* noodles; but little or no information exist on the properties of *NERICA* (*New Rice for Africa*) rice flour especially those produced in Nigeria and these properties when blended with sweet cassava flour. Cassava, also called *yuno*, *mogo*, *manioc*, *mandioca* is popular root crop in the tropics and plays a significant role in food security of the poor. Nigeria is the World's highest producer and is classified as either sweet or bitter depending on the levels of anti-nutritional or cyanide factors [9]. The bitter variety has received greater attention over the years because of its versatile application and adaptation to marginal climate conditions, while the sweet type received little attention. Nevertheless, cassava flour is low in protein, which is a disadvantage in its wide scale use in bakery and snack foods. Fortification with protein sources, cereals and legumes will certainly expand the spectrum of cassava flour utilization in the food industry.

The *New Rice for Africa* has been spreading rapidly since its introduction in 1996 and has been reported to be responsible for significant growth in yield in several countries in sub Saharan Africa. But further spread is being hampered by lack of readily available scientific literatures on its nutritional characteristics, food applications as well as the recommended production practices. To facilitate information dissemination the African Rice Center (AfricaRice) compiled available information in 2008 and publish as *NERICA*: a compendium. But little or no information are available on flour behavior and related effect with other flour. Accordingly, this study was designed to evaluate the end-use quality in terms of functional and viscosity profiles of *NERICA* rice flour blended with sweet cassava flour. Results of this study we believe will be useful in understanding quality attributes of food prepared from the blends and improve on the utilization of *NERICA* in value-added product development.

2. Materials and Methods

2.1. Materials

NERICA 1 (WAB-450-1-B-P38-HB) released in Nigeria as FARO 55 was obtained from the Breeding unit of the National Cereals Research Institute (NCRI), Badeggi, Nigeria. 5kg of paddy rice was dehulled with laboratory test sample Sheller (Satake Corporation, Japan) and the brown rice milled in McGill No. 2 Mill. Milled rice was then grounded in an attrition mill (locally manufactured in Nigeria) and flour sieved (30 mesh size) to obtain fine rice flour. While sweet cassava was obtained from the Bidamodern market Niger State. Edible grade cassava flour was prepared by washing, peeling and slicing into 0.5cm chips, followed by sun drying and powdering. The flour was sieved (30 mesh size) to obtain fine grade sample. Flour was sealed in a polyethylene packs and stored in a refrigerator until required for analysis. Composite flour was obtained by mixing rice flour with cassava flour at different proportions. The blending ratios were 95%, 90%, 85%, and 80% of rice flour to 5%, 10%, 15% and 20% cassava flour. All the analysis was conducted at the Rice Grain Quality Laboratory of NCRI and Analytical Laboratory of the International Institute of Tropical Agriculture (IITA), Ibadan Nigeria.

2.2. Methods

2.2.1. Water and Oil Absorption Capacity

The water and oil absorption capacities were determined by the method described by Jisha *et al.*, [10]. 1.0g of the blended flour was mixed with 10 ml distilled water (for water absorption) or refined vegetable oil (for oil absorption), at ambient temperature ($30 \pm 4^\circ\text{C}$) for 30 min and centrifuged (REMI 412 LAG) for 10 min at 2000rpm. Water or oil absorption capacity was expressed as percent water or oil bound per gram of the sample.

2.2.2. Bulk Density

The bulk density was determined according to the method described by Jisha *et al.*, [11]. 50g of flour was measured into a 100 ml graduated cylinder and tapped 20-30 times on a laboratory desk. The bulk density was calculated as weight per unit volume of sample.

2.2.3. Foaming Capacity

Forming capacity was determined as described by with Jisha *et al.*, [11] slight modifications. 1.0 g was measured and added to 50 ml distilled water at room temperature in a graduated cylinder. The suspension was mixed and then shaken for 5 min to foam. The volume of foam after whipping for 30 sec was expressed as foaming capacity.

2.2.4. Emulsion Activity

1 g sample, 10 ml distilled water, and 10 ml soybean oil was used to form emulsion in a calibrated centrifuge tube.

The emulsion was centrifuged (REMI 412 LAG) at $2000 \times g$ for 5 min. The ratio of the height of the emulsion layer to the total height of the mixture was calculated as the emulsion activity expressed in percentage [11].

2.2.5. Pasting Viscosity

Viscosity of rice-cassava flour blends were measured using Rapid Visco Analyzer (RVA) (Newport Scientific Pty Limited, Australia). 3g of sample and approximately 25g distilled water was used to mixed the flour and the temperature was gradually increased to 50°C after immersing the spindle and held at this temperature for 1 min, then increased further to 95°C in 3.5 minutes; held for 2.5 min; cooled back to 50°C in 3.5 min; and held for 5 min. The instrument provides the following parameters; peak viscosity (PV) (highest viscosity during heating process), trough viscosity (TV) (hold) (the lowest viscosity during heating, and final viscosity (FV) (the viscosity at the completion of the heating circle) and the breakdown viscosity (BV) calculated as PV minus TV, while setback viscosity (SV) determined by subtracting PV from FV. Peak time (PT) (the time at which peak viscosity was recorded) and the Pasting temperature (PT °C) (the temperature at which starch granules begin to swell and gelatinize due to water uptake). The viscosity was expressed in terms of Rapid Visco Units (RVU), which is equivalent to 10 centipoises [17].

2.2.6. Proximate Composition Determination

The proximate composition of rice-sweet cassava flour blends for moisture and total ash was determined by the method described by Kadan et al. [21]. Nitrogen was determined by the micro Kjeldahl method and the nitrogen content (N %) was converted to protein by multiplying by a factor of 6.25. Crude lipid content was determined using Soxhlet apparatus and carbohydrate content was determined by difference. Energy (caloric value) was calculated by the method described by FAO [9]. All the proximate composition values were reported in percentage.

2.2.7. Sensory Evaluation

Acceptability test was conducted on cooked thick dough (*tuwonlaushi*) prepared from the various formulations by 20 untrained panelists. They were asked to evaluate the samples according to their liking in terms of terms of color, texture, smell, taste, consistency, moldability and overall acceptability using a 9-point hedonic scale: score 9-extreme like and score 1-extreme dislike.

2.2.8. Statistical Analysis

Data generated in all the determinations were subjected to analysis of variance (ANOVA) using CROSTAT for window (Version 7.2.2007.3, International Rice Research Institute, Manila). The significant means were compared using Least Significant Difference (LSD) test at 5% level of probability as described by Gomez and Gomez [18]. While graphs were plotted using Microsoft Excel version 2010

(Microsoft Cooperation, USA).

3. Results and Discussions

3.1. Functional Characteristics

End-use quality methodology can be categorized as those procedures that determine product physical, functional, chemical and sensory properties. Functional properties of food largely determine the end-use quality of particular formulation as food ingredients [12]. Functional properties of food material may be classified according to the mechanism of action on three main groups. These groups are (1) properties related with hydration (absorption of water/oil, solubility, thickening, wettability); (2) properties related with the protein structure and rheological characteristics (viscosity, elasticity, adhesiveness, aggregation and gelling), and (3) properties related with the protein surface (emulsifying and foaming activities, formation of protein-lipid films, whippability) [15]. In this study, functional properties related to hydration of rice starch are water and oil absorption indices. Water absorption capacity (WAC) varies between 28.77% and 63.54% (Fig.1). The highest value was recorded at rice-cassava flour blend of 85:15. Kinsella [15] and Jideani [12] reported that WAC is an important functional attributes considered in the development of ready-to-eat food from cereal grains, since high WAC might improve product cohesiveness. The higher WAI observed in the 85:15 formulations could be attributed to the presence of higher amount of hydrophilic constituents as a result of the addition of cassava starch [2]. The result of this study is slightly lower than the 65-78% range reported by early workers on complementary blend of soybean and cowpea with malted maize.

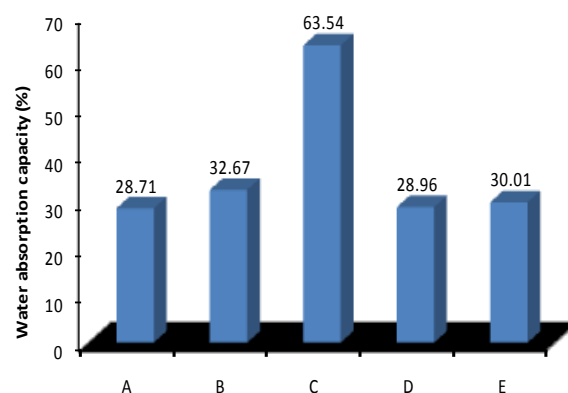


Figure 1. Effect of the addition of cassava flour on WAC of rice flour

Oil absorption capacity (OAC) is another critical functional attributes of a flour formulation. In this study, the values were significantly lowered when cassava flour was added (Fig. 2) and ranged between 4.96% at 20% cassava flour to 9.21% in 100% rice flour. This result is higher than water melon, cassava and wheat flour blends that could hold

1.3-2.17%/g dry sample as reported by Ubbor and Akobundu [6]. This attribute relates to the lipophilic character of cassava starch flour that is used for the stabilization of rice flour. High OAC of the flour suggest its usefulness in food preparations that involve oil mixing, such as in bakery products where oil is an important ingredient. Absorption of oil by food product also improves mouth feel and flavor retention. The higher OAC recorded in the 100% rice flour may be attributed to the presence of more hydrophobic proteins which show superior binding to lipids [15].

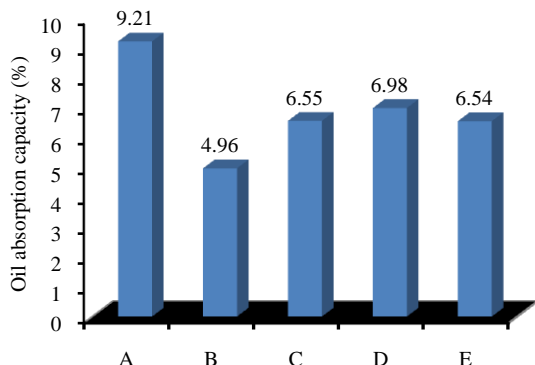


Figure 2. Effect of the addition of cassava flour on OAC of rice

The gelation index (GI) is functional property related to structure of proteins in foods [12]. It significantly ($p \leq 0.5$) ranges from 0.11 in 10% cassava flour formulation and highest value of 0.86 in 5% cassava flour formulations. A highly soluble protein is required in order to obtain optimum functionality required in gelation [6]. The ability of food protein to form gels and provide a structural matrix for holding other food ingredients, such as water, flavoring agents and sugars is useful in food applications and new product development. Gelling property is important in comminuted sausage products [12]. Bulk density ranged between 0.62 g/m^3 (100% rice flour) and 0.69 g/m^3 in 10% rice-cassava flour blend. The significantly ($p \leq 0.5$) low bulk density recorded in this study be attributed to the addition of cassava flour. Low bulk density in food is an advantage if the food is to be used in complementary feeding [3]. This therefore, suggests that the addition of cassava flour to rice flour is advantageous as it lower the bulk density and improving complementary feeding attributes. BD decreases with increasing level of cassava flour substitutions, with 100% rice flour being denser than all the substituted samples (Fig. 4). Bulk density of flour is generally affected by the particle size and it is an important factor in determining the packaging requirement, handling and utilization in wet processing in the food industry [3, 4]. This result indicate less packaging requirement with increase cassava flour substitution.

The emulsion capacity (EC) and foaming ability (FC) of the various rice-cassava flour blends are presented in Fig.5 and 6 respectively. EC was significantly ($p \leq 0.05$) high in 5%

blend (633.08%) and lowest at 20% (286.87%). While foaming capacity ranged from 8.02% to 14.75%, with 20% blend recording the highest score and the lowest recorded in 5% blend. EC and FC are two phase systems commonly found in food systems, whose formation is significantly affected by protein surface activity [12, 15].

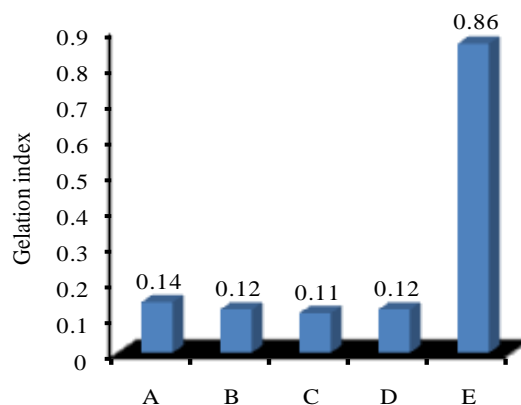


Figure 3. Effect of cassava flour on gelation of rice flour

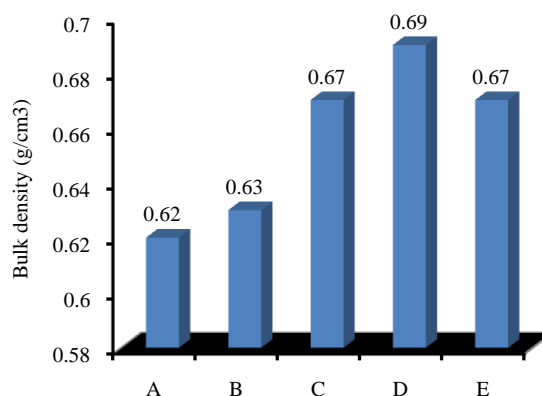


Figure 4. Effect of addition of cassava flour on bulk density of rice flour

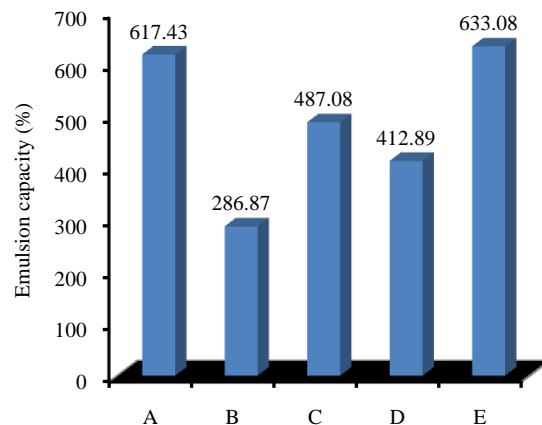


Figure 5. Effect of addition of cassava flour on emulsion capacity of rice flour

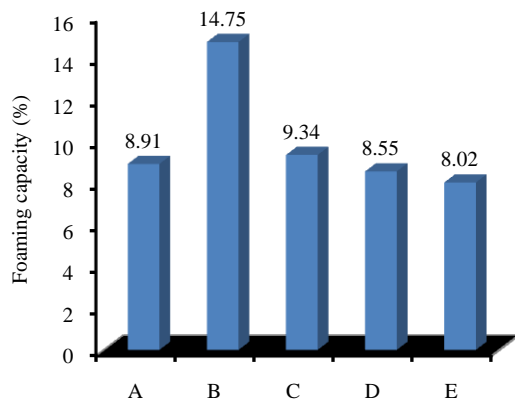


Figure 6. Effect of the addition of cassava flour on foaming capacity of rice flour

3.2. Pasting Viscosity

The Rapid Visco Analyzer (RVA) is a recording viscometer that measures pasting viscosity of flour-water suspension during heating and cooling and all the viscosities measured in Rapid Visco Unit (RVU) which is equivalent to 10 centipoise. The classification of cereal-based flour on its viscosity profile (Fig. 7-12) is important in categorizing the flour for end-use recommendation [17] and considered an important attributes of food as it affect mouth feel (Regina and Chen, 2009). The pasting viscosity of sole sweet cassava flour and rice flour are presented in Fig. 7 and 8 respectively. Peak viscosity (PV), trough (hold) viscosity (HV) and final viscosity (FV) for cassava flour is 147.63, 121.89 and 230.63RVU respectively, while rice values are 139.58, 118.50 and 211.08 RVU respectively. In general, root and tuber flour and starches exhibit high viscosity profile than cereals, although, their starch retrograde easily [13]. Similar trend are reported in this study. These tendencies may be as a result of weaker associative intra-granular forces between root and tuber starch or flour granules which result in gelatinization at relatively low temperature, with rapid and uniform swelling of granules. Pasting temperature (PT) for 100% cassava flour and rice flour were 54.38 and 56.33°C respectively. PT is one of the pasting properties of flour or starch which provide an indication of the minimum temperature required for sample gelatinization. It is also an indication of energy costs involved and other component stability [17]. High PT is an indication of starch granule resistance to swelling. In this study, the PT gradually decreases as cassava flour percentage substitution increases (Fig. 7-12). This is in agreement with the findings of Craig *et al.* (1989). Akinwande *et al.*, [32] reported that food materials with lower pasting temperature value are generally considered to be easier to cook. However, Newport scientific [14] reported that low pasting temperature is often associated with low paste stability, which is usually considered to be undesirable end-use property. On the contrary, Bhattacharya, *et al.*, [19] reported variability in pasting temperature of different rice cultivars, suggesting that variation is varietal

specific and probably less dependent on the starch or flour modification.

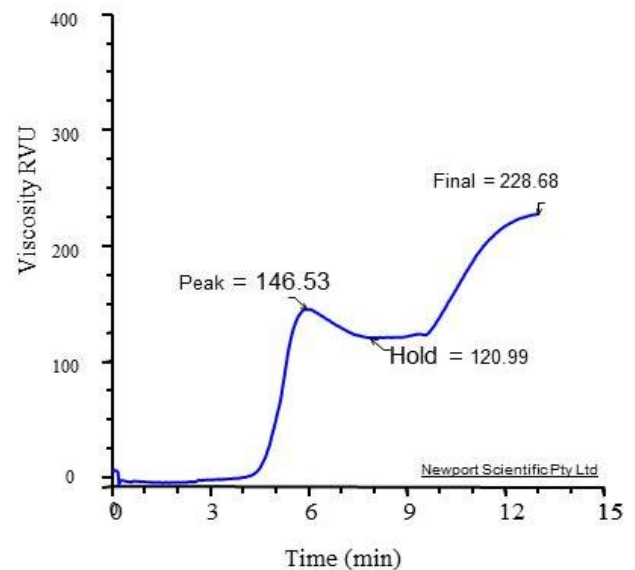


Figure 7. Viscosity profile of sweet cassava flour

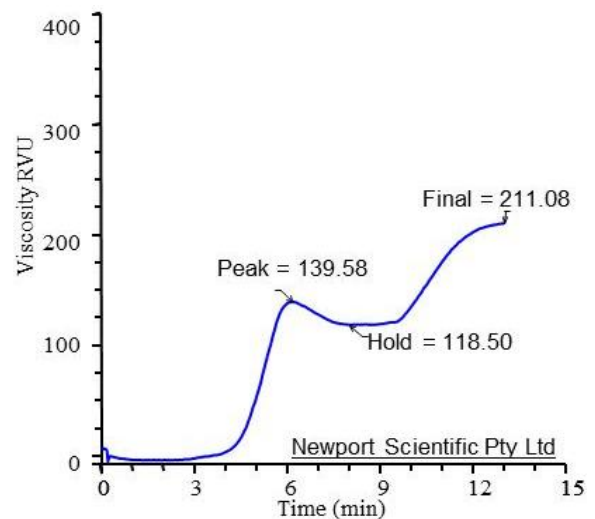


Figure 8. Viscosity profile of NERICA cassava flour

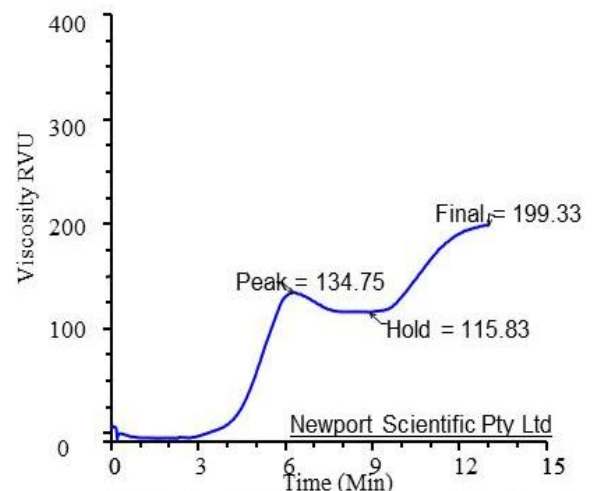


Figure 9. Effect of 20% cassava flour on viscosity profile of NERICA rice flour

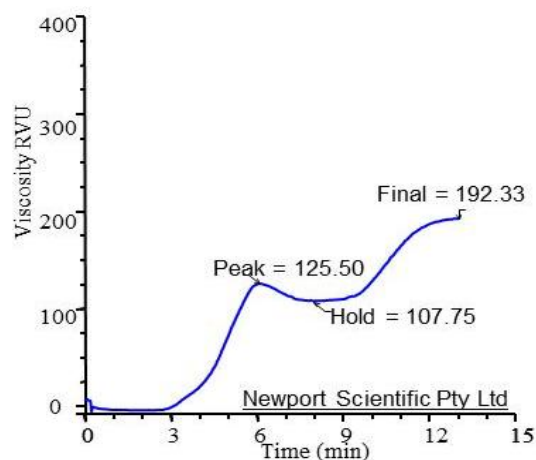


Figure 10. Effect of 15% cassava flour on viscosity profile of NERICA rice flour

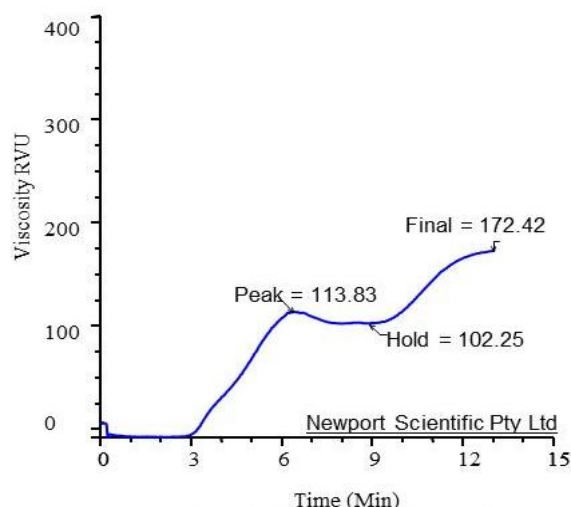


Figure 11. Effect of 10% cassava flour on viscosity profile of NERICA rice flour

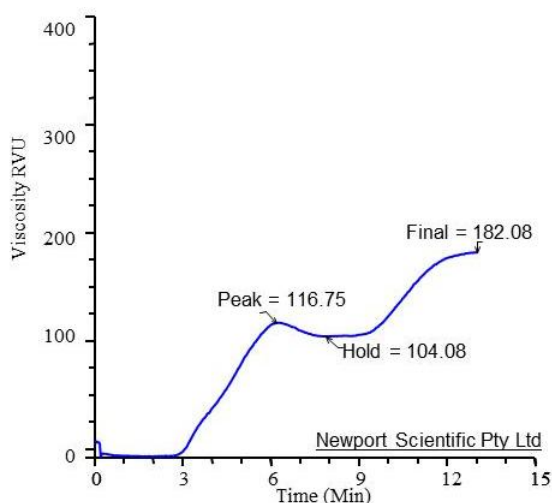


Figure 12. Effect of 5% cassava flour on viscosity profile of NERICA rice flour

PV which is the ability of flour to swell freely before their physical breakdown ranged between 116.75 and 134.75 RVU for 5% and 20% cassava flour substitution (Fig.9-12).

The PV value increase with increase cassava flour substitution (Fig.9-12). High PV indicates water binding capacity of flour and is an indicative that the flour may be suitable for products requiring high gel strength and elasticity [16, 17]. Increase in PV value noted in this study as the proportion of cassava flour increases is of processing advantages. Regina and Chen [16] explained that high PV is significance in connection with manufacturing of stiff dough from flour products like 'tuwo'. The hold viscosity is the minimum viscosity value in the constant temperature phase of the RVA profile and measures the ability of the flour paste to with stand breakdown during cooling. In this study, it decreases from 118.50 RVU (Fig. 7) in 100% rice flour to 104.08 RVU (Fig. 12) in 5% cassava flour substitution. At 20% substitution, the HV was 115.83 and gradually fall to 104.08 RVU as the percentage cassava flour increases. Madsen and Christensen (1996) observed a similar trend in potato starch. High paste stability is a frequent requirement for industrial application of starch products [34]. FV is the change in the viscosity after holding cooled starch at 50°C. It ranged between 182.08 RVU (5% cassava flour) and 199.33 RVU (20% cassava flour) (Fig. 9 to 12). These values are lower than 230.63 RVU (Fig. 7) and 211 RVU (Fig. 8) recorded for 100% cassava and rice flours respectively.

3.3. Proximate Composition

The proximate composition which is an indication of nutritive value of food matrix is presented in Table 1. This include, moisture, protein, fat, ash, fiber, carbohydrate and caloric values. The moisture content of any food substance to a greater extend determined its keeping and end-use quality. In rice, moisture content of a whole grain has been reported to affect cooked rice palatability. In this study, the moisture content of the different rice flour-cassava starch formulation was not significantly different ($p \leq 0.05$) ranging from 0.16% to 0.28% with an average of 0.23%. Though no significant difference was observed among the blends in terms of moisture contents, a slight increase may be observed as the ratio of cassava starch increase. This may be due to equilibration of flour moisture content and the atmospheric moisture.

The protein content of the rice-cassava starch blends were significantly ($p=5\%$) lower than the whole rice flour, ranging from 10.90% in 100% rice flour to 5.49% in 20% substitution (Table 1). The low level of protein may be attributed to supplementation by cassava starch. The protein content is higher in this study than the protein values of cassava varieties. The protein content of cassava based composite flour could be elevated through the incorporation of legume or cereals flour, justifying the rice-cassava flour blending for improved end-use.

Ash, fat and caloric values are not significant different ($p=5\%$) (Table 1). Ash content is generally taken to be a measure of the mineral content of the original food material. The non-significant ($p=5\%$) observed in this study may be attributed to the fact that little change was made to the rice

flour ash as a result of cassava starch substitution. Fat content of the flour blends were generally low ranging from 0.08 to 0.10% with mean value of 0.09%. These results are not far from the fact that both rice and cassava are not oil seeds and the rice used is milled rice where the bran has been removed. This is of practical importance in the keeping quality of the product as fat has been implicated in the development of rancidity in food materials. An increased in fat content Moorthy [31] observed may improve starch textural properties and lead to viscosity stability, hence improving the quality of starch. The high significant ($p=5\%$) carbohydrate contents (87.44% (100% rice flour) to 92.71% (20% rice-cassava flour)) of the flour might as result of high proportion of rice which is carbohydrate rich food as well as starch from cassava. This reveals that the composite flour is a good source of energy. Metabolizable energy (ME) was not significantly ($p=5\%$) different (Table 1) but is greater than 390 kcal/100g in all the formulations. ME is the potential

energy available to the human body when food is ingested.

3.4. Consumer Acceptability Test

Mean consumer rating of 'liking' for taste, texture, smell, color, consistency, moldability and overall acceptability of 'tuwonlaushi' a common traditional stiff porridge made from rice flour are presented in Table 2. All the sensory characteristics evaluated showed significant difference ($p \leq 0.05$) between whole rice flour products and rice-cassava blend. Overall, consumer liked all the samples (rating greater than 6 on the average. Phang and Chan [7] reported that rating higher than 6 (like slightly) for hedonic ratings based on 9-point hedonic scales implies that the product tested is well-liked by the consumers. Consumer ratings indicated high ranking for C, D and E in this order in terms of overall ranking (Table 2), indicating detectable effect of cassava flour addition in 'tuwonlaushi' production.

Table 1. Proximate composition of different proportions of rice-cassava flour blends

Formulation	Proximate composition (%)					
	Moisture	Protein	Ash	Fat	CHO	Energy (kcal/100g)
Rice flour (100%)	0.25 \pm 0.01	10.90 \pm 1.01	1.33 \pm 0.01	0.08 \pm 0.01	87.44 \pm 0.03	394.08 \pm 0.06
Rice flour + Cassava flour (95:5)	0.19 \pm 0.03	10.16 \pm 0.07	1.26 \pm 0.04	0.10 \pm 0.00	88.29 \pm 0.02	394.70 \pm 1.01
Rice flour + Cassava flour (95:10)	0.16 \pm 0.05	8.87 \pm 0.16	1.32 \pm 0.05	0.09 \pm 0.04	89.56 \pm 0.01	394.53 \pm 0.08
Rice flour + Cassava flour (95:15)	0.28 \pm 0.04	6.81 \pm 1.21	1.77 \pm 0.04	0.08 \pm 0.06	91.06 \pm 0.02	392.86 \pm 0.03
Rice flour + Cassava flour (95:20)	0.26 \pm 0.02	5.49 \pm 0.59	1.46 \pm 0.02	0.08 \pm 0.03	92.71 \pm 0.01	392.52 \pm 0.08
Means	0.23 \pm 0.01	8.45 \pm 0.02	1.43 \pm 0.02	0.09 \pm 0.01	89.81 \pm 0.11	393.74 \pm 0.02
LSD (%)	NS	3.23	NS	NS	3.29	NS

Results are mean of three determinations. Means in the same column followed having difference greater than LSD are significantly different at 5% level of probability. NS = Not significant

Table 2. Consumer preference analysis of stiff dough (tuwonlaushi) made from rice-cassava flour blends

Formulation	Sensory attributes						
	Taste	Texture	Smell	Color	Consistency	Moldability	Overall acceptability
A	6.16 \pm 0.11	6.44 \pm 0.12	6.46 \pm 0.21	6.26 \pm 0.15	7.08 \pm 0.06	6.67 \pm 0.07	6.33 \pm 0.03
B	6.61 \pm 0.12	6.15 \pm 0.12	6.31 \pm 0.11	5.61 \pm 0.13	6.56 \pm 0.25	6.77 \pm 0.22	6.78 \pm 0.08
C	6.23 \pm 0.17	6.76 \pm 0.18	5.89 \pm 0.18	6.70 \pm 0.15	7.33 \pm 0.21	6.83 \pm 0.15	6.98 \pm 0.22
D	6.79 \pm 0.21	6.46 \pm 0.06	6.49 \pm 0.26	6.08 \pm 0.24	6.78 \pm 0.07	6.88 \pm 0.21	6.11 \pm 0.23
E	6.51 \pm 0.05	6.59 \pm 0.05	5.41 \pm 0.35	6.98 \pm 0.65	6.99 \pm 0.23	6.90 \pm 0.11	6.12 \pm 0.33
Means	6.46 \pm 0.26	6.48 \pm 0.22	6.11 \pm 0.46	6.33 \pm 0.54	6.95 \pm 0.29	6.81 \pm 0.09	6.46 \pm 0.40
Standard Error	0.127	0.100	0.206	0.239	0.131	0.042	0.177
LSD (%)	1.35	0.86	1.22	1.26	1.29	1.20	1.59

Results are mean of three determinations. Means in the same column followed having difference greater than LSD are significantly different at 5% level of probability. A= Rice flour (100%), B= Rice flour + Cassava flour (95:5), C= Rice flour + Cassava flour (95:10), D= Rice flour + Cassava flour (95:15), E= Rice flour + Cassava flour (95:20). NA = Not applicable

3.5. Correlation Studies between Chemical Composition and Functional Qualities of Flour Blends

Correlation studies between proximate composition and functional characteristics of rice-sweet cassava flour formulation are presented in Table 3. There was a significant ($p=5\%$) negative correlation between moisture content and emulsion capacity (-0.96^{**}) and bulk density (-0.97^{**}) of the blends. This indicates significant reduction in the two properties with increasing moisture value. Significant positive correlation (0.96^{**}) was observed between protein and caloric value, indicating positive contribution of protein to overall ME value of the formulations. While negative correlation (-0.96^{**}) was seen between fat and OAC (Table 3).

Table 3. Correlation coefficients among chemical and functional characteristics of rice-sweet cassava flour blends

	Moisture	Protein	Ash	Fat	CHO	Energy	WAC	OAC	ECA	BDT	FOC	DIS	GLC
Moisture	1.00												
Protein	-0.63	1.00											
Ash	0.69	-0.98**	1.00										
Fat	0.44	0.32	-0.14	1.00									
CHO	0.61	-1.00	0.97**	-0.35	1.00								
Energy	-0.78	0.96**	-0.99**	0.05	-0.95*	1.00							
WAC	0.72	-0.98**	0.94*	-0.27	0.98**	-0.94	1.00						
OAC	-0.27	-0.55	0.40	-0.96**	0.57	-0.30	0.47	1.00					
ECA	-0.96**	0.81	-0.86	-0.24	-0.80	0.92*	-0.87*	0.03	1.00				
BDT	-0.97**	0.44	-0.49	-0.52	-0.42	0.59	-0.57	0.42	0.87*	1.00			
FOC	-0.03	-0.24	0.03	-0.70	0.26	-0.02	0.35	0.58	-0.02	-0.04	1.00		
DIS	0.47	0.39	-0.29	0.88*	-0.41	0.17	-0.26	-0.94*	-0.22	-0.65	-0.30	1.00	
GLC	-0.74	0.19	-0.15	-0.34	-0.18	0.26	-0.38	0.37	0.60	0.88*	-0.40	-0.67	1.00

CHO=Carbohydrate, WAC=Water absorption capacity, OAC=Oil absorption capacity, ECA = Emulsion capacity, BDT = Bulk density, FOC = Foaming capacity, DIS = Dispensability, GLC = Gel consistency. df = n-2, where n is the sample size. 5% =0.878, 1% = 0.959

4. Conclusions

This study has revealed that the addition of up to 20% cassava flour to rice flour significantly improves its functional attributes. The differences record in the proximate composition, functional characteristics, pasting properties and sensory attributes of rice-cassava flour mix indicate that nutritional variation may occur when food is prepared from the two blends. The significant variation in functional and pasting properties indicated possibilities of multi-dimensional use which rice flour mixed with modified cassava flour could be subjected to at different blend ratios that could be of benefit for both domestic and industrial applications. Consumer liking also improves with addition of cassava flour to rice flour in the preparation of stiff dough. End-use quality of the rice flour blended with cassava flour therefore is enhanced and we recommend that economic loss due to high broken rice resulting from poor milling operations could be improve through flour production and substitution with cassava flour.

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