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ORIGINAL RESEARCH ARTICLE

PROXIMATE COMPOSITION, FUNCTIONAL, AND SENSORY PROPERTIES OF *KADAL* (FERMENTED GRAIN FLOUR) PRODUCED FROM WHOLE AND DECORTICATED MAIZE AND PEARL MILLET GRAINS

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ABSTRACT

Kadals are normally prepared from fermented cereal grains and the kadal flours are usually transformed into stiff dough called tuwo and consumed as staple food in many West African countries. Pearl millet (Mi) and maize (Mz) grains were decorticated and each of them was divided into four portions. The first portion was unfermented and the other portions were soaked in water separately for 48h (K2), for 72h (K3) and 96h (K4). Four portions each of whole maize and millet were subjected to the same soaking time, respectively. At the expiration of soaking time, each portion was washed, thoroughly rinsed, sun dried, milled and sieved to produce kadal flours. The unfermented whole and decorticated millet and maize flours served as the experimental controls. The functional properties and proximate compositions of twenty samples were evaluated using standard procedures and the organoleptic properties of the tuwo (kadal dough) prepared from them were evaluated without soup, and with okro soup. Results revealed significant variations ($p<0.05$) existed in the functional properties and proximate composition of kadal flours as well as the sensory attributes of the tuwo. Wettability of the kadal flours improved with soaking time, water absorption capacities decreased with fermentation time, as well as bulk densities though marginally. Dispersibility of the kadal flours were generally high (70.50-77%) and no significant difference was observed. Ash, protein and fat contents of the whole grain kadal flours were higher than that of decorticated, and there was slight decrease in these nutrients with soaking time. Again, moisture and carbohydrate were lower in whole grain kadal flours than in decorticated counterparts. On sensory attributes of the various tuwo produced, colour improved with soaking time more in the decorticated millet kadals. Decorticated millet had greater desirable flavor, which was not significantly different from that of whole millet kadals. Texture of 4th day kadal tuwo was better, with whole millet kadal tuwo rated better than that of the decorticated, unlike the texture of maize kadal tuwo. Control tuwo in general had poorer flavour, colour, texture and taste. The overall acceptability of the kadal tuwo was generally higher than the control. Millet kadal tuwo progressively improved with soaking time. The bottom line was that nutritional values were sacrificed to the improvement of sensory properties of the prepared kadal flours.

1.0 Introduction

Kadal is flour produced from fermented maize or sorghum or pearl millet grains or the fermented liquor. The stiff dough (*tuwo*) obtained from *kadal* flour is a staple in Northern Nigeria where it is consumed along with traditional soups such as okro, *kirikashi, kuka, egusi* majorly by teaming resource poor families. The importance of *kadal* flour in nutritional wellbeing of the inhabitants of this region of Nigeria cannot be over-stressed, a region with favourable climate for large scale cultivation of diverse cereal grains. Cereals are considered the most important sources of protein, complex carbohydrates, dietary fibre, minerals and B-vitamins for humans in different climes and cultures world over, providing 45% of dietary calories (FAO, 2003; Mohammed et al., 2013), however their nutritive value in general are plagued by low lysine content and availability of anti-nutrients such as phytic acid, tannins, polyphenols (Amadou et al., 2013). Therefore, traditional technologies involving such pretreatments as dehulling/decortication, soaking, fermentation, roasting, sprouting go a long way to improve the nutritional quality of grains (Holtz and Gibson, 2007). Soaking of grains prior to cooking is among the culinary practices and is the preliminary stage to malting. Short time soaking (less than an hour) enables faster decortication of the grains especially the pulses but prolonged soaking results to fermentation, a process defined by Cheftel and Cheftel (1976) as beneficial biochemical activity induced by microorganisms and their enzymes (Kahajdova and Karovicova, 2007) on food components notably proteins, carbohydrates, lipids and mineral elements. Initial observation during soaking is rapid uptake of water by biologically inactive grains which elicits tremendous physical and biochemical changes made possible by activation of endogenous enzymes. Fermentation as practiced in the traditional food preparation utilizes mix culture of microorganisms existing in the immediate environment notably lactic acid bacteria leading to heterolactic fermentation. These microorganisms release amylolytic and proteolytic enzymes that hydrolyze grain substrates leading to the production of peptides, maltodexrins, sugars, amino acids, fatty acids etc and further sugars are transformed into organic acids and alcohols. The subsequent drop in pH or increase in the acidity of the medium favours the activation of phytase (Elyas et al., 2002) that liberate polyvalent metallic ions complexed by phytic acid (inositol hexaphosphate) including nutrients bonded to tannins, rendering them more bioavailable. Prolonged soaking or fermentation is an effective method of improving starch and protein digestibility and bioavailability (Boralkar and Reddy, 1995; Mahajan and Chauhan, 1987; Sripriya et al.,1997). Mohammed et al. (2007) reported decrease in anti-nutritional factors of millet subjected to 12-24 hour fermentation. Lestiene et al. (2005) reported leaching of iron and zinc into soak medium and significant reduction in the level of the same in maize, rice, and soybean, and concluded that soaking alone was not enough to improve mineral bioavailability. Whole grains provide wide array of nutrients and non-nutrient phytochemicals that optimize health, however removal of outer most parts of grain improves digestibility, palatability and reduction of anti-nutrient content and at the same time reduces the nutritive value of grains. Fermentation is one of the oldest biotechnologies for the production of food products with desirable properties such as extended shelf-life and good organoleptic properties (Smid and Hogenholtz, 2010; Ray and Joshi, 2014). Fermented foods usually have an improved microbial stability and safety, and some can be stored even at ambient temperature for extended storage (Nhikata et al., 2018). The present study was aimed to evaluate the double effects of grain decortication and variable grain soaking time or fermentation on the proximate composition and functional properties of *kadal* flours as well as sensory attributes of *kadal* stiff dough (*tuwo).*

2. Materials and Methods

2.1. Collection of Raw Materials

The raw materials that were used in this study were maize (*Zea mays L.),* white flint), and pearl millet *(Pennsietum glaucum)* were purchased from Maiduguri Monday market, and transferred to Food Processing Lab, Food Science Department Ramat Polytechnic Maiduguri for processing.

2.2 *Kadal* flours preparation from whole maize and millet grains.

The whole grains (maize and pearl millet), 4kg each were separately sorted to remove dirts, stones and other foreign materials. The grains were divided into four equal parts of 1kg each and transferred into clean plastic buckets. The first portion of the maize and millet grains were washed and spread on a clean mat to dry under the sun in a secluded place, later ground and sieved. Ten liters of water was added to three buckets containing 1kg each of maize and another three buckets for millet grains. Grains in K2, K3, and K4 were soaked /fermented for 2, 3, and 4 days respectively at ambient temperature 30±2°C At the end of each fermentation, the grains were washed, spread on clean mats and sun dried for 6-8 hours. The dried grains were milled using the commercial Hammer mill, sieved using a 400µm mesh screen, packaged in already coded plastic buckets with lids and kept at ambient storage until needed.

2.2.1 Production of *Kadal* Flours from Decorticated Maize and Millet Grains

Four (4) kg each of maize and millet grains were separately sorted to remove stones, dirts and other foreign materials, and decorticated using a local attrition milling machine. The decorticated grains were spread on clean mats to dry in order to ease winnowing of the chaff from the grains. The chaffs were removed and the grains were divided into four portions. The first portions of the decorticated maize and millet grains were washed and spread on a clean mat to dry under the sun. The remaining portions were fermented in a similar manner as was done with the whole grains, for two, three and four days, and dried at the end. The dried grains were milled separately, sieved using a 400µm mesh screen, packaged in already coded plastic buckets with lids and kept at ambient condition until needed.

2.3 Physicochemical Analysis of *Kadal* Flours and the Controls

2.3.1 Functional Properties of Kadal Flours and the Controls

Water absorption capacity was determined using the method described by Beuchat et al. (1977). About, 1g of *kadal* flour was mixed with 10ml of distilled water in a centrifuge tube, stirred and rested for 30 minutes and later centrifuged at 3,500 rpm for 30 minutes. The volume of free water was read on the graduated centrifuge tube directly and expressed as percentage of water absorbed per gram of sample.

Bulk density was determined using the method described by Onwuka (2005) and expressed in g/ml.

Dispersibilty was determined using the method described by Kulkarni et al. (1991). Ten (10) grams of sample was dispersed in distilled water in a 100ml measuring cylinder filled to the 100 mark. The mixture was stirred vigorously and allowed to settle for 3h., the volume of the settled particles was subtracted from 100 and the difference reported as % dispersibility.

Wettability of the flours was determined using a modification of the method described by Okezie and Bello (1988). A plastic spatula containing 1.0g (dwb) of the sample was suspended from a retort stand 15cm above a beaker containing 500ml distilled water. The spatula containing the sample was gently tilted to drop the sample unto the surface of the water and the time taken for complete disappearance or wetting of the sample was taken as the wettability in seconds.

2.4 Proximate Composition Analysis

The proximate composition (moisture, crude protein, crude fat, total ash), of the raw materials (maize and millet), and the products (*kadal* flours) were determined according to the standard methods of AACC (2000). Moisture was determined by oven drying of 5g of each sample at 105°C for 1h; protein (%Nx6.25) was determined using micro-Kjeldhal method and 200mg of samples; fat was determined using solvent extraction of 1g of sample in a soxhlet extractor with petroleum ether, and ash was determined by incineration of 1g of the sample in muffle furnace at 550°C for 5h. Carbohydrate contents were obtained by 'difference'.

2.5 Evaluation of the sensory attributes of kadal stiff dough or tuwo

A slurry of a given *kadal* flour was introduced into boiling water and stirred to cook and gelatinize the starch, and the remaining *kadal* flour was added and repeatedly stirred until the homogeneous mass obtained was further allowed to cook until done exuding well known unmistaken flvour. It was scooped onto tray and allowed to cool. Sensory evaluation of cooled *tuwo* was carried out by 20 semi-trained panelists who were indigenous consumers of *kadal tuwo*, comprising some of the staff and students of the Department of Food Science, Ramat Polytechnic Maiduguri. *Tuwo* made with the *kadal* flours were served to the panelist firstly and later the same were served along with okra soup. A 9-point Hedonic scale with 9 representing like extremely, and 1-dislike extremely was used to evaluate the *kadal tuwo* in terms of colour, taste, flavor, texture and overall acceptability as described by Ihekoronye and Ngoddy (1985). Warm water was provided for intermittent mouth gargling.

2.6 Statistical Analysis

Data obtained were subjected to one-way analysis of variance (ANOVA), using SSPS version 16. Means were separated using the Duncan Multiple Range test and significance was accepted at 5% probability ($p<0.05$). Results were expressed as mean±SD (n=3).

3. Results and Discussion

3.1 Functional Properties of *Kadal* Flours and Controls

The water absorption capacities (WAC) of whole (W) maize *kadals* varied from 91.27% to 126.32%, the unfermented control had the highest and 4th day (k4) whole maize *kadal* (WMzK4) the least, indicating WAC decreased with increase in fermentation period, the same scenario was repeated in WAC of decorticated (D) maize (Mz) *kadals*, a range of 60.20% and 101.50%, again DMzK4 the least and the unfermented DMz flour the highest (Table 1). Also for the whole millet *kadals*, the unfermented millet flour recorded the highest (102.72%) yet lower than WAC of unfermented whole maize *kadal* counterpart, again 4th day whole millet kadal had the least WAC of 51.09%, lower than 91.17% of whole maize *kadal*. Unlike decorticated maize *kadal*, WAC of decorticated millet *kadal* (78.40-101.18) was higher than that of whole millet counterpart (51.09-101.72%). The decrease in WAC of *kadal* flour with increase in fermentation period might be linked to partial hydrolysis of protein and starch molecules into shorter chains by both endogenous and exogenous enzymes elaborated by invading microorganisms. This is the reason why unfermented controls of both whole and decorticated maize and millet had the highest WAC because the macro molecules remained intact and unaffected by amylolytic and proteolytic enzyme hydrolysis. Decorticated maize *kadal* had lost outermost fibrous cellulosic materials during decortication and these are known for high water absorption. Hydrophillic groups in protein and starch are responsible for binding with water molecules in a water stressed environment (Singh, 2001). Higher WAC is needed for *kadal* dough formation; it also increases yield, product cohesiveness and decreases *tuwo* stiffening with storage. Decreased WAC of the *kadal* with soaking time suggests suitability for thinner gruels needed for complementary feeding. Onweluzo and Nwabugwu (2009); Elkhalifa et al. (2006) also reported decrease in water binding capacity of sorghum four (4.69-4.37g/g) with increase in fermentation.

Table 1: Functional Properties of Differently Produced Kadal Flours from Maize and Millet Grains (Whole and Decorticated), and the Unfermented Controls

Sample Code	Water Absorption Capacity (%)	Bulk Density (g/ml)	Dispersibility (%)	Wettability (sec)
UWMz	115.66±5.81[b]	0.77±0.04[c]	75.00±1.41[a]	74.50±0.71[a]
WMzK2	126.32±2.28[a]	0.76±0.04[c]	74.50±0.71[a]	57.00±1.41[b]
WMzK3	101.88±1.81[c]	0.74±0.04[c]	73.50±0.01[a]	40.00±0.71[c]
WMzK4	91.17±1.91[d]	0.73±0.04[c]	73.00±1.41[a]	39.00±1.41[c]
UDMz	101.50±3.25[c]	0.89±0.04[a]	77.00±1.41[a]	72.00±1.41[a]
DMzk2	92.37±1.91[d]	0.85±0.10[a]	76.50±0.71[a]	71.50±0.71[a]
DMzK3	88.83±1.66d	0.82±0.04[b]	74.50±0.71[a]	53.50±0.71[b]
DMzk4	60.20±5.03[e]	0.63±0.06[d]	73.00±1.41[a]	44.50±0.71[c]
UWMi	102.72±0.79[a]	0.74±0.11[a]	74.50±0.71[a]	74.00±1.41[a]
WMiK2	80.38±1.22[b]	0.70±0.02[b]	73.50±0.71[a]	68.00±0.71[b]
WMik3	59.94±0.25[d]	0.68±0.06[b]	72.50±1.41[a]	59.00±1.41[c]
WMik4	51.09±1.53[e]	0.64±0.01[c]	70.50±0.71[a]	44.00±1.41[c]
UDMi	101.18±1.67[a]	0.75±0.03[a]	73.50±0.71[a]	59.00±1.41[c]
DMiK2	98.11±2.40[a]	0.72±0.06[a]	72.50±0.71[a]	57.00±1.41[c]
DMiK3	97.81±3.10[b]	0.70±0.10[b]	71.50±0.71[a]	54.00±1.41[d]
DMik4	78.40±1.81[c]	0.62±0.10[c]	70.50±0.71[a]	50.50±0.71[d]

Results are Mean±SE(n=2). Mean values bearing different superscripts are significantly different at p-value of 5% ($p<0.05$). WMz: whole maize flour; WMzK: Whole maize kadal; DMz: Decorticated maize flour; DMzK:Decorticated maize kadal; WMi: whole millet flour; WMiK: Whole millet kadal; DMi:Decorticated millet flour; DMiK: Decorticated millet kadal, and 2,3,4 represents fermentation days

Bulk density of the *kadal* flours decreased marginally with fermentation time, therefore 4th day whole and decorticated *kadals*, for both maize and millet, had the least bulk density and the unfermented controls had the highest. There was no significant variation ($p>0.05$) in the bulk density of the whole maize *kadals* (0.73-0.76), and as for the decorticated maize *kadals*, bulk density decreased from 0.89g/ml (control) to 0.69g/ml (DMzK4), and for whole millet *kadals*, bulk density decreased from 0.74 to 0.64 g/ml and from 0.75g/ml to 0.62g/ml for DMiK4. Smaller bulk densities were recorded for 3rd to 4th day *kadals* and this implied increase in cost of packaging, handling, storage and distribution (Kulkarni et al., 1991) and significant implications on wet processing in food industry (Karuna et al., 1996). Bulk density inversely correlates with flour particle size. Fermented *kadals* whether decorticated or whole had higher particle size than the control hence lower bulk density (higher flour porosity or voluminuosity) implying that

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a smaller amount of *kadal* flour occupies a bigger unit volume as observed in 4-day *kadals* of both cereals. On the other hand, reduced bulk density of the 3rd or 4th *kadals* implies reduced paste thickening during hydration and mixing (Padmashree et al., 1987). Elkhalifa et al. (2006), similarly, observed decrease in bulk density (0.73-0.66g/ml) of sorghum four with increase in fermentation period.

Dispersibility is the ease with which a powdered material is dispersed or suspended in aqueous medium, it is the ease of reconstitution (Kulkarni et al., 1991), the extent to which it will form a true uniform suspension without phase separation, and therefore it is correlated with water solubility index. Dispersibility was generally high and there was no significant difference in the dispersibility values of both cereals whether whole or decorticated, however there was slight increase with fermentation period. The values obtained ranged from 73.00 to 76.50% and 70.50 to 73.50% for maize and millet *kadal* flours, respectively. The 4th day *kadals* had the least dispersibility meaning that reconstitution tendency of the *kadals* decreased with increase in soaking time. Onwueluzo and Nwabugwu (2009) had earlier observed a decrease in the reconstitutionability of fermented millet or pigeon grain flour with fermentation time. According to Igene et al. (2005), the ease of dispersiblity is an important flour property in food formulation.

Wettability is also a parameter indicating the reconstitutionability of a powdered material and also it is particle size dependent. A significant difference was observed in the wettability of *kadal* flours from both maize and millet grains. All the unferrmented controls, both whole and decorticated cereals had greater wettability than the treated samples. For whole *kadals*, it varied from 39 sec to57sec for maize, 44 sec to 68 sec for millet, greater in whole millet *kadals* than in whole maize *kadals* meaning it is easier to reconstitute whole maize *kadal* than millet counterpart. Wettability decreased with increase in soaking or fermentation time collaborating earlier observation that *kadals* have bigger flour particles especially the whole maize and millet *kadals*. For decorticated grain *kadals* wettability values of maize *kadal* varied from 44.50sec to 60.50secs and millet from 50.50 to 57sec implying that higher soaking time improved wettability of flour. Onweluzo and Nwabugwu (2009) reported 57-75 secs and 51-57sec for fermented millet and pigeon pea grains subjected to varying fermentation period (25-96 h).

3.2. Proximate Composition of the grains used for kadal preparation.

The proximate composition of whole and decorticated maize and millet grains is presented in Table 2. These were different from those used as controls because they were not subjected to milling and sieving processes. As Table 2 reveals, whole grain had slightly lower moisture content than decorticated counterpart, both whole and decorticated had moisture that ranged between 11.5% (whole maize grain, WMzG) and 14.70% (decorticated maize, DMzG), indicating decortication increases the moisture content of cereal grains or the resulting flours due to removal of outer protecting layers and greater surface area exposure to the environment. Millet grain had higher protein content whole or decorticated, 12.54% in whole and 11.71% in decorticated millet against 9.62% and 8.67% in whole and decorticated maize respectively. Significant variation was not observed in the fat contents (2.91% DMzG and 3.67% WMiG) of the two cereals, although the whole had slightly higher fat than the decortcated especially in the maize grain due to greater loss of maize germ during decortication. It also influenced ash or mineral contents which decreased with decortication, more reduction was observed in maize

(1.32-0.89%) than in millet (1.62%-1.05%). Awolu et al. (2017) noted pronounced protein and slight fat reductions with debranning of pearl millet. Chaves-Lopez et al. (2013) reported that 80% of cereal grain mineral is located in the branny layer leaving paltry 20% in the endosperm. The bottom line is: decortication decreased the fat, ash and protein but slightly increased the moisture and carbohydrate content of grains. Comparable results were reported by Kulthe et al. (2016) for proximate composition of three pearl cultivars: ash 2.05-2.72%, crude fibre 2.07-2.63%, fat 5.14-5.96%, protein 10.97-11.65%, and carbohydrate 66.49-68.85%; but higher protein and fat contents were reported by Abah et al. (2020). Balbiker et al. (2018) made the same observation that decortication decreased ash, protein, oil and crude fibre and increased moisture and carbohydrate contents of two pearl millet cultivars. According to Marta et al. (2017) Indonesian maize hybrids contains protein 7.13-11.84%db, fat 2.58-7.17%db, carbohydrate 69.67-79.84%db, crude fibre 1.43-3.69%db, ash 0.95-1.56%db, this results accord with the proximate composition of maize used in the study as shown in Table 2.

Table 2: Proximate Composition (%) of Whole and Decorticated Maize and Millet Grains

Sample Code	Moisture	Ash	Protein	Fat	Carbohydrate
WMzG	11.05±0.09^{c}	1.32±0.01^{b}	9.62±0.13^{c}	3.57±0.53^{a}	72.83±0.15^{ab}
DMzG	14.70±0.18^{a}	0.89±0.11^{d}	8.67±0.23^{cd}	2.91±0.05^{b}	74.51±0.21^{a}
WMiG	13.25±0.04^{b}	1.62±0.29^{a}	12.54±0.34^{a}	3.67±0.27^{a}	68.79±0.17^{b}
DMiG	13.71±0.34^{ab}	1.05±0.11^{c}	11.71±0.30^{b}	3.60±0.23^{a}	69.92±0.46^{b}

Results are Mean±SE(n=2). Mean values bearing different superscripts are significantly different at p-value of 5% ($p<0.05$). WMzG: whole maize grain; DMzG: Decorticated maize grain; WMiG: whole millet grain; DMiG: Decorticated millet grain.

3.3 Proximate Composition of Kadal (fermented grain) flours

The proximate compositions of the treated samples and the controls are presented in Table 3. The general pictures is the decrease in fat, ash, protein though marginal, and increase in moisture and noticeable increase in carbohydrate (for maize *kadal* flours) for both whole and decorticated *kadal* flours with increase in soaking time. It is reasonable to say that the nutrient content of the two cereals behaved differently during the soaking period. This goes to buttress the conflicting reports concerning nutritive value of grains subjected to varying period of fermentation (Nkhata et al., 2018; Tsafrakidou et al., 2020). For whole maize *kadals*, moisture marginally increased from 7.08% (WMz, control) to 7.87% (WMz K4), carbohydrate increased from 82.92% in control to 87.29% (WMz K4), and there were linear decrease in ash (1.41-0.57), protein (6.41-5.63%), and fat (1.39-0.65). For decorticated maize *kadals*, the same variation pattern occurred with soaking time as follows: moisture (6.68-7.94%), carbohydrate (86.46-88.86%), ash (0.88-0.40%), protein (4.15-3.50%) and fat (0.57-0.36%). The decrease in proximate composition as a result of prolonged soaking time was slight in millet grain, and generally pronounced in maize *kadal* flours, perhaps due to millet's corneous endosperm. On the contrary, Banigo and Muller (1972) reported poorest recovery of ogi from pearl millet than from corn and sorghum because of extensive rupture of millet grains during steeping. For whole millet the variation was as follows: moisture (5.58-6.84) %, protein (10.09-9.43 %), ash (0.93-0.40 %), fat (1.21-1.82 %), carbohydrate also increased (81.44-82.19 %), different from variations observed in decorticated millet *kadals* with the following variations: moisture (6.03-8.31%), protein (8.59-8.01%), ash (1.41-0.35%), fat (1.42-1.21%) and carbohydrate (81.22-82.65%). The decorticated *kadals* were starchier than the whole *kadals*, however significant increase was not observed in the carbohydrate content of millet *kadals* with increase in soaking time. The decrease in protein with soaking time was hardly noticeable in majority of cases and the increase in carbohydrate contents of *kadals* was not statistically significant. Onweluzo and Nwabugwu (2009) reported 8.90-9.46% as protein of flour from fermented millet and the protein of unfermented was reported to be higher. Ene-Obong and Ohizoba (1996) did not observed any significant change in total protein and amino acid composition of substrate with fermentation time. The bottom line is that the longer the fermentation time the greater the reduction in nutritive value although slight and the observed increases in carbohydrate contents were insignificant.

Table 3: Proximate Composition (%) of Differently Produced Kadal Flour from Maize and Millet Grains (Whole and Decorticated), and the Unfermented Controls

Sample	Moisture	Ash	Protein	Fat	Carbohydrate
WMz	$7.08{\pm}0.06^{b}$	$1.41{\pm}0.12^{a}$	$6.41{\pm}0.18^{a}$	$1. 39{\pm}0.23^{b}$	$82.92{\pm}0.10^{b}$
WMzK2	$7.19{\pm}0.06^{b}$	$1.38{\pm}0.08^{a}$	$6.30{\pm}0.13^{a}$	$1.31{\pm}0.18^{b}$	$82.83{\pm}0.60^{b}$
WMzk3	$7.68{\pm}0.04^{a}$	$0.48{\pm}0.09^{b}$	$5.68{\pm}0.25^{a}$	$1.91{\pm}0.09^{a}$	$84.25{\pm}0.26^{a}$
WMzK4	$7.87{\pm}0.15^{a}$	$0.41{\pm}0.09^{b}$	$5.63{\pm}0.06^{a}$	$1.15{\pm}0.06^{b}$	$85.62{\pm}0.13^{a}$
DMz	$6.68{\pm}0.19^{a}$	$0.88{\pm}0.11^{b}$	$4.15{\pm}0.11^{b}$	$0.57{\pm}0.06^{c}$	$86.46{\pm}0.28^{a}$
DMzK2	$7.33{\pm}0.17^{ab}$	$0.57{\pm}0.11^{b}$	$4.16{\pm}0.23^{b}$	$0.65{\pm}0.16^{c}$	$87.29{\pm}0.23^{a}$
DMzK3	$7.59{\pm}0.08^{a}$	$0.53{\pm}0.04^{b}$	$3.91{\pm}0.04^{b}$	$0.56{\pm}0.01^{c}$	$87.60{\pm}0.13^{a}$
DMzK4	$7.94{\pm}0.17^{a}$	$0.40{\pm}0.11^{c}$	$3.50{\pm}0,12^{bc}$	$0.36{\pm}0.05^{c}$	$88.86{\pm}0.23^{a}$
WMi	$5.58{\pm}0.19^{d}$	$0.93{\pm}0.09^{a}$	$10.09{\pm}0.04^{a}$	$1.21{\pm}0.06^{b}$	$82.19{\pm}0.04^{a}$
WMiK2	$6.38{\pm}0.05^{c}$	$0.57{\pm}0.10^{b}$	$9.71{\pm}0.09^{a}$	$1.32{\pm}0.04^{b}$	$82.02{\pm}0.06^{a}$
WMik3	$6.58{\pm}0.04^{b}$	$0.48{\pm}0.03^{b}$	$9.81{\pm}0.23^{a}$	$1.56{\pm}0.06^{a}$	$81.54{\pm}0.40^{a}$
WMiK4	$6.84{\pm}0.09^{b}$	$0.40{\pm}0.01^{b}$	$9.43{\pm}0.13^{ab}$	$1.82{\pm}0.06^{a}$	$81.44{\pm}0.10^{a}$
DMi	$6.03{\pm}0.18^{c}$	$1.41{\pm}0.12^{a}$	$8.59{\pm}0.23^{c}$	$1.42{\pm}0.04^{a}$	$82.55{\pm}0.04^{a}$
DMiK2	$7.18{\pm}0.08^{b}$	$0.46{\pm}0.09^{b}$	$8.52{\pm}0.09^{c}$	$1.39{\pm}0.03^{b}$	$82.63{\pm}0.04^{a}$
sDMiK3	$7.84{\pm}0.08^{a}$	$0.40{\pm}0.13^{b}$	$8.62{\pm}0.06^{c}$	$1.34{\pm}0.09^{b}$	$81.22{\pm}0.06^{a}$
DMiK4	$8.31{\pm}0.11^{a}$	$0.35{\pm}0.21^{c}$	$8.01{\pm}0.03^{c}$	$1.21{\pm}0.06^{b}$	$82.12{\pm}0.11^{a}$

Results are Mean±SE (n=2). Mean values bearing different superscripts are significantly different at p-value of 5% ($p<0.05$) WMz: Whole maize flour; WMzK: Whole maize kadal; DMz: Decorticated maize flour; DMzK: Decorticated maize kadal; WMi: Whole millet flour; WMiK: Whole millet kadal; DMiK: Decorticated millet kadal, 2, 3, 4 represent fermenting days.

3.4 Sensory properties of *kadal* stiff dough (*tuwo*)

The sensory evaluation of the kadal stiff dough was evaluated on the basis of 9- point Hedonic scale. On Taste, the scores ranged from 7.25 to 8.60 and 7.35 to 8.70 for maize and millet *tuwo* respectively. The fermentation process imparted on the flavor of the *tuwo,* the flavor of millet *tuwo* was preferred most. Among the pearl millet *kadals*, taste scores of whole millet *kadal* stiff doughs were better than the decorticated as shown in Table 4. Contrarily, decorticated maize *kadal* doughs were rated as having better taste than whole maize *kadal* cooked doughs which decreased with soaking duration. The untreated control doughs whole and decorticated had the poorest taste scores than the *kadal* doughs. Taste appeared not to improve with long fermentation time among the treated. For Colour, the scores ranged from 7.30 to 8.65 and 7.40 to 8.75 for maize and millet *kadal tuwo*, respectively. The colour scores of the whole and decorticated millet *kadal* doughs were equally appreciated by the test panelists; however the

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decorticated millet *kadal* was rated better in colour. Among the maize *kadal* doughs, the decorticated had better colour which improved with increase in soaking time, as also observed in millet *kadal* both whole and decorticated millet *kadals*. Again, the untreated control *tuwo* had the poorest colour indicating the higher the soaking time the better the appearance of the *kadal* flours.

On Flavor, the fermented grains had odour that did not deter the panelists from appreciating the flavor of the *kadal* stiff doughs. Among the decorticated millet *kadal* doughs, flavor scores were higher and not significantly different (p>0.05), but among the whole millet *kadal* doughs flavour scores were equally high and the control as well as the 4th day *kadal* had relatively lower flavour scores. Maize *kadal* dough flavour scores were generally lower than those of millet and the controls (unfermented whole and decorticated cereal flours). For Texture, soft and pliable dough is a desirous attribute, and the texture of whole cereal *kadal* dough appeared to be better than the decorticated especially in the millet *kadals*. Grain decortication impacted excess softness to the *tuwo* with increase in fermentation time and led to excess leaching as well. Overall acceptability showed that treated *kadal* doughs were all accepted and those with higher scores were WMzk2 (8.20), DMzK2 (8.05), DMzK2 (8.15), WMik4 (8.40) and DMik4 (7.55). Overall acceptability of millet *kadals* appeared to improve with soaking time. The bottom line is that decortication improved the sensory attributes of the cooked *kadal* doughs (*tuwo*). Both maize and millet *kadal tuwo* had sensory scores greater than the untreated controls.

Table 4: Sensory Assessment of differently produced *Kadal* Stiff Dough (*Tuwo*)

Sample	Taste	Colour	Flovour	Texture	Overall Acceptability
WMz	$7.70±0.28^{b}$	$7.10±0.14^{c}$	$8.50±0.28^{a}$	$7.70±0.42^{a}$	$8.62±0.07^{a}$
WMzK2	$7.50±0.42^{b}$	$7.30±0.14^{bc}$	$7.60±0.14^{b}$	$7.60±0.85^{a}$	$7.65±0.21^{b}$
WMzK3	$7.25±0.14^{bc}$	$7.30±0.14^{bc}$	$7.15±0.21^{cd}$	$7.30±0.14^{ab}$	$8.20±0.28^{bd}$
WMzK4	$7.50±0.14^{b}$	$7.20±0.14^{bc}$	$7.30±0.28^{c}$	$7.55±0.07^{a}$	$7.30±0.28^{bd}$
DMzF	$8.55±0.07^{a}$	$6.35±0.21^{bc}$	$7.50±0.28^{c}$	$6.20±0.21^{b}$	$7.40±0.21^{d}$
DMzK2	$8.30±0.07^{ab}$	$8.20±0.28^{ab}$	$6.35±0.28^{bc}$	$6.40±0.21^{b}$	$8.65±0.35^{d}$
DMzK3	$8.35±0.21^{a}$	$8.65±0.21^{a}$	$7.60±0.42^{b}$	$7.55±0.50^{a}$	$8.15±0.21^{b}$
DMzK4	$8.60±0.14^{a}$	$7.65±0.21^{b}$	$8.20±0.28^{ab}$	$7.30±0.21^{ab}$	$7.60±0.14^{c}$
WMi	$6.30±0.14^{ab}$	$8.50±0.14^{a}$	$8.25±0.21^{ab}$	$7.45±0.14^{ab}$	$7.55±0.21^{b}$
WMiK2	$8.30±0.28^{ab}$	$8.55±0.07^{a}$	$8.45±0.14^{a}$	$7.35±0.14^{ab}$	$7.40±0.14^{bc}$
WMiK3	$8.70±0.14^{a}$	$7.95±0.64^{d}$	$8.45±0.14^{a}$	$7.15±0.07^{b}$	$7.35±0.07^{bc}$
WMiK4	$8.40±0.14^{ab}$	$7.45±0.14^{dc}$	$8.05±0.64^{b}$	$7.80±0.14^{a}$	$8.40±0.14^{a}$
DMi	$7.35±0.07b^{c}$	$8.25±0.21^{c}$	$8.40±0.14^{a}$	$6.50±0.28^{c}$	$7.35±0.07^{bc}$
DMiK2	$7.70±0.14^{b}$	$8.55±0.07^{a}$	$8.40±0.14^{a}$	$6.45±0.07^{c}$	$7.25±0.07^{bc}$
DMiK3	$7.55±0.01^{b}$	$8.15±0.07^{b}$	$8.40±0.14^{a}$	$6.65±0.35^{c}$	$7.30±0.28^{bc}$
DMiK4	$7.65±0.21^{b}$	$8.75±0.14^{a}$	$8.40±0.14^{a}$	$6.55±0.21^{c}$	$7.55±0.21^{b}$

Results are Mean±SE(n=2). Mean values bearing different superscripts are significantly different at p-value of 5% (p<0.05). WMz: whole maize flour; WMzK: Whole maize kadal; DMz: Decorticated maize flour; DMzK: Decorticated maize kadal; WMi: whole millet flour; WMiK: Whole millet kadal; DMi: decorticated millet flour; DMiK: decorticated millet kadal, and 2,3,4 represents fermentation days.

4. Conclusion

Fermentation of whole and decorticated maize and pearl millet grains to produce *kadal* flour has been an age-long traditional technology for processing cereals. Ferrmentation period has slight impact on the absolute proximate composition of the fermented grain flour or the thick porridge obtainable from them but does positively moderate the functional properties of the *kadal* flours as well the sensory properties of *tuwo*. As a consequence of this observation, it is suggested that 72h fermentation period of undecorticated be applied to limit decline in the nutritive value of *kadal* flours through leaching as a result of prolonged fermentation. However, decreased anti-nutrients and increased bioavailability of remaining nutrients favours the application of extended fermentation period for *kadal* flours production.

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