



Physico-functional properties of flour blends and dakere (A Nigerian steamed agglomerated dumpling) as affected by flour fractionation and grain legume fortification

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Abstract

Dakere is an agglomerated dumpling produced from a blend of millet and sorghum flours and eaten either fresh or dried for future use. Three fractions (< 250mm fine (f), 250-350mm medium (m) and coarse (c) 350-500mm) were made from debraned millet and sorghum flours. The blended fractions (1:1) were fortified with either 30% Bambara (B) groundnut or sesame (Se) flour or both (BSe). A 3x2x3 factorial was used to generate the experimental runs twelve in all: MfSf, MmSm, McSc, MfSfB, MmSmB, McScB, MfSfSe, MmSmSe, McScSe, MfSfBSe, MmSmBSe and McScBSe. The Control was 1:1 of unfractionated and unfortified millet and sorghum flour. The particle size distribution and functional properties of the blends and *dakere* were studied. Particle size of the fortified blended fractions or *dakere* were higher as shown by higher retentions on the sieves with bigger mesh size which in turn impacted on functional properties and chemical compositions of the blends and *dakere*. Fortification of the blended fractions with legume flours modified the solubility, bulk density, water absorption capacity (WAC) and swelling capacity of the blends and the various *dakere*: 19.53-25.205, 0.68-1.90g/ml, 69.45-81.41%, 16.46-21.55% respectively for the blends, 18.03-25.20%, 0.58-0.97g/ml, 70.42-82.65%, and 18.36-23.15% for the various *dakere* respectively. Solubility and WAC were higher in the unfortified blends or *dakere* while swelling power and bulk density were higher in the fortified blends and *dakere*. It was concluded that blended similar fractions of millet and sorghum flours responded differently to legume flour fortification in terms of functional properties and particle/ granular size distribution of either the blends or *dakere*. The study revealed the effects of flour fractions on physical properties of foods as well as the beneficial effects of fortification of flour fractions with legume flour.

Keywords: flour fractionation, dakere, food fortification, Bambara groundnut, sesame seed, flour particle size

Introduction

Dakere is a steamed cereal –based agglomerated dumpling usually produced from millet or sorghum flour and their combination. *Dakere* is differently called “dambu gero or dawa or dambu nono”, it is considered a snack, a meal, or a beverage depending on the mode of preparation and consumption. Traditionally, *dakere* is made from an equal blend of dehulled millet and sorghum flour, the flour is mixed with water to form stiff dough. The dough is placed into a container and agitated to form agglomerates which are steamed to produce *dakere*. It is either consumed fresh or dried to safe moisture content for future use. *Dakere* is produced and consumed by most tribes in northeastern Nigeria, a semi-arid region populated by many related tribes with weather conditions that permit the cultivation and utilization of coarse cereals mainly different varieties of pearl millet and sorghum. Dried *dakere* is storage stable and can be reconstituted with either water or milk and sweetened to become a refreshing beverage. In dried form, *dakere* is a food security item, easily distributed, a handy snack for school children and farmers alike. Millet is a general term referring to a number of small-seeded grasses that are widely grown around the world as a cereal crop (Donough *et al*, 2000) [7]. It is an important crop in the arid and semi-arid of tropics of Asia and Africa, especially in India, Mali, Nigeria and Nigeria, 97% of millet produced and consumed in developing countries (Debbouz and Donnelly 1994) [6]. In Asia and Africa continents millets are the basis of assorted

traditional food and beverages mainly thin or thick porridges and various snacks especially among the poor segment of the population (Chandrasekara and Shahidi, 2011) [5]. Pearl millet is a good source of essential amino acids except lysine and threonine but it contains relatively higher methionine than other cereals (Aboubakar, 1999) [1]. Pearl millet is also a rich source of micronutrients (Mal *et al*, 2010) [13]. Sorghum on the hand is the world's third important food grain being exceeded in utilization for food by wheat, rice and maize (Kumar *et al*, 1993) [4]. In Nigeria, sorghum is one of two most important cereal crops (the other is millet) which constitutes the largest volume of cereals produced and consumed in northern Nigeria (Hulse *et al*, 1994) [11]. Sorghum is found significantly rich in minerals, soluble and insoluble fibre and antioxidants (Ragae *et al*, 2006) [14]. Carbohydrate is the most predominant nutrient which amount to 62.9%, other constituents are protein 15%, lipid 7.5%, fibre 2.2%, and ash 3.2% (FAO, 2015). Bambara groundnut (*Vigna Subterranea* L.) is the third most important pulse after cowpea and groundnut in Nigeria and many West African countries where it originated. Bambara bean is regarded as complete food because it contains 49-63.5% carbohydrate, 15-25% protein, 4.5-7.4% fat, 5.2-6.4% fibre, 3.2- 4.4% ash (FAO (2011). It is reported to be a crop of high potential owing to its nutritional composition, functional properties, antioxidant potential (Heuz *et al*, 2016). Bambara groundnut is an important pulse and cheap source of protein in an

amount that can combat malnutrition (Donough *et al*, 2000) [7]. Sesame seed (*Sesamum indicum* L.) like Bambara groundnut is largely grown in Nigeria in a commercial quantity. It is a good source of protein, minerals, fibre, fats and vitamins. According to Nigerian Export Promotion Council (NEPC, 2014) sesame seed contains 15-20% protein, 3.8-8.4% crude fibre, 40.0 -49.7 % fat and a good source of vitamins and minerals. The practice of sieving flour with sieves of different sizes to produce flour fractions of different particle size distribution, with each fraction or end product having different proximate composition, mineral content, functional and sensory properties is well recognized (Sakhare *et al* 2014, Belorio *et al*, 2019). Sakhare *et al* (2016) reported that finer fraction produces better Indian parota bread with better sensory and textural attributes than those made with coarse fractions. Ramesh and Prakash (2010) reported higher nutrient density in fine fraction in amaranth grain flour, Bolade *et al* (2009) made similar observation with non-fermented maize-based food gel produced from different maize flour fractions. Fortifying different fractions with grain legume such as Bambara groundnut or sesame flour gives rise to an enriched flour blend or food product (Hulse 1994) [11]. Therefore, the objective of this study was to produce *dakere* from blended fractions (1:1) of millet and sorghum flours (>250um, 250-350um and 350-500um) supplemented the same with Bambara groundnut or sesame flour or both and thereafter evaluate the particle size distribution and functional properties of the blends and as well as the modified *dakere* with reference to the Control.

Materials and Methods

Collection of Raw Materials

Four different raw materials namely; millet, sorghum (Chakalari white), Bambara groundnut (creame colour) and sesame seeds (white) were procured from Custom area market, Maiduguri, Borno State, Nigeria.

Raw Materials Preparation

Grain samples were cleaned by winnowing to remove foreign materials like sand, immature seeds and weed seeds. The dehulled grains were separated from the bran using the local trays, later washed and sun dried. The dried cereal grains were milled using attrition mill. Clean Bambara groundnut and sesame seeds were mildly toasted, milled, sieved, (350um) the resulting flour was stored in transparent plastic containers tight fitting lid prior to use for formulation of blends, *dakere* preparations, functional properties and chemical composition analysis. The sorghum or millet flour obtained were fractionated into three fractions using sieve of different mesh sizes, namely fine, medium and coarse sieves to yield fine flour (f) (250um), medium or intermediate flour(m) (250-350um), and coarse flour (c) (350-500um)..

Experimental Design

A factorial design of (3x2x2) was used to generate the 12 experimental runs. Three flour fractions (fine (f), medium (m) and coarse(c)), from each of two (2) cereal grains millet (M) and sorghum (S) similar fractions blended, then supplemented with either Bambara groundnut flour, sesame seed flour or both. The control representing un-

supplemented unfractionated 1:1 blend of millet and sorghum flours (MS).

Formulations/experimental runs with coded names were; MfSf, MmSm, McSc, MfSfB, MmSmB, McScB, MfSeSe, MmSmSe, McScSe, MfSfBSe, MmSmBSe and McScBSe and MS

Particle size distribution and functional properties Analysis

- Particle size distribution of the samples were determined according to AACC Standard 55 – 10 (AACC, 2000)

Particles sizes of the various blends and modified *dakere* were determined using standard sieves, 100g each of blends or *dakere* samples was placed on the top sieve of a nest of standard sieves of different mesh sizes. This was covered with a lid with receiver pan at the bottom and the sieves were clamped together by wing nuts and interchangeable studs to the machine, sieve shaker (model EL 80-03, Endecotts, UK) was run for 10 min. Weight of flour retained on each sieve was carefully noted and the percentage retention was calculated with an estimate 0.3% loss, as described by Allman and Lawrence, 1972.

Pearl millet and sorghum flour fractionation

Flour fractions obtained by differential sieving using a slight modification of the method of Ramesh and Prakash (2020). Four sieves (250um, 350um, 450um and 500um) were stacked in descending order with 500um sieve at the top. The stacked sieves was mounted on the sieve shaker and with the flour on the top sieve, machine was operated to obtain the different fractions which were arbitrarily called fine (250um), medium (<250-350um) and coarse (> 350-500um) fractions.

Formulations and sample codes

Fine (f) millet and sorghum fractions (<250mm), medium (m) grained millet and sorghum fractions (250 -350mm) and coarse (c) grained millet and sorghum fractions (350 - 500um) were blended (1:1) a total of three samples was obtained namely, MfSf, MmSm and McSc. MfSf, MmSm and McSc were each fortified with 30% Bambara groundnut(B) flour which resulted to extra three samples coded as; MfSfB, MmSmB and McScB (70:30), MfSf, MmSm and McSc were again fortified with 30% sesame flour (Se), which gave rise to; MfSfSe, MmSmSe and McScSe (70:30); again a combination of Bambara groundnut and sesame flours (20:10) was used to fortify MfSf, MmSm and McSc which yielded another three samples coded thus: MfSfBSe, MmSmBSe and McScBSe (70:20:10). The total number of samples was 12 and unfractionated blends of millet and sorghum flours (1:1) served as the control. The samples were thoroughly mixed and separately placed in different plastic buckets each bearing the sample code and they were stored at room temperature prior to production of *dakere* and determination of functional properties and Particle size distribution of the blends.

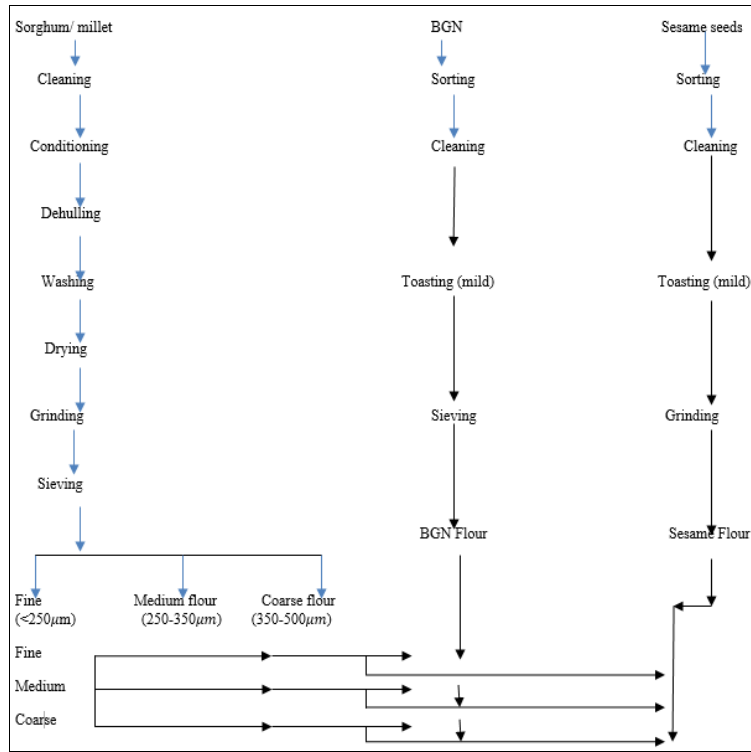


Fig 1: Differential sieving and blend formulation for dakere production

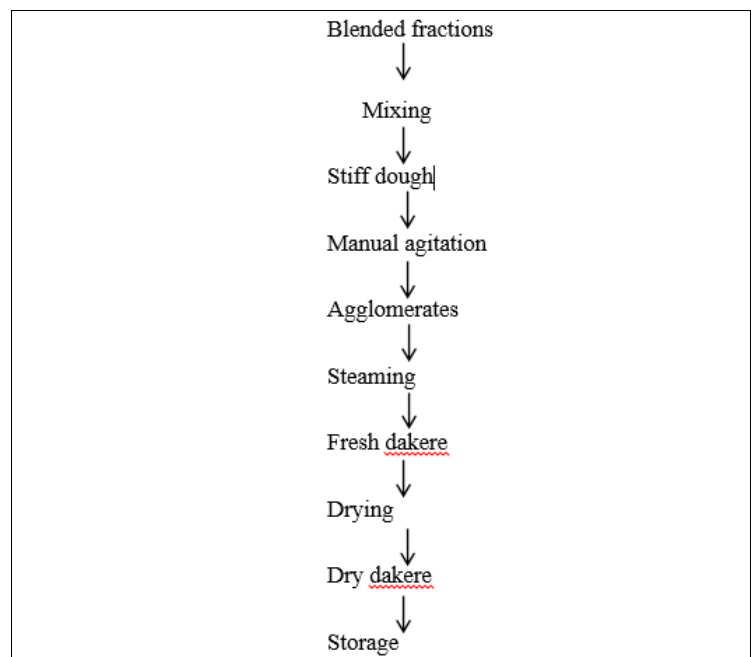


Fig 2: Flow chart for the production of modified *dakere*.

Functional properties of the blends and modified dakere
Bulk Density

Packed densities of the samples were obtained as described by Onwuka (2015). A specified quantity (W) of the flour or *dakere* sample was transferred into a measuring cylinder and gently tapped to eliminate spaces between flour particles. The level was taken to be the volume of the sample. Packed density was calculated (weight of sample divided by volume of sample).

Water absorption Capacity

One gram of each sample was weighted into a conical graduated centrifuge tube and 10 millilitre of distilled water was added and mixed thoroughly for 30 seconds. The

mixture was allowed to stand for 30 mins at a room temperature and then centrifuged at 5,000 x g for 30 mins. And the volume of free water (supernatant) was read directly from the tube and the water absorption capacity was expressed (1ml=1g) as gram water retained per 100g of sample (Onwuka, 2005).

Swelling Power and Solubility Index Determination

Swelling power and solubility of the flour blends and modified dakere were determined using the method of Leach *et al* (1959) with modifications for smaller samples, one gram (g) sample was placed in 50ml centrifuge, mixed with 10ml of distilled water. The mixture was placed on water bath at 80C for 30mins. Stirred occasionally, and then

cooled to room temperature, centrifuged at 2500rpm for 15mins. The supernatant was poured into dried pre weighed crucibles and evaporated in the oven at 100°C. The weight of solid residue left behind was expressed as percentage of sample weight, to obtain solubility indices of the samples. The weight of paste in the tube was expressed as percentage of the sample weight which was taken as swelling power.

Statistical Analysis

Determinations were in triplicate, the mean and the standard error of the mean(SEM) were calculated and the results expressed as mean + SEM, means were separated using Duncan’s Multiple Range Test and significance was accepted at p-value of 5% (p< 0.05)

Results and Discussion

Particle size distribution of the blends used for dakere Production

As shown in Table1, the range of retentions for blended fine

grained fractions (M_fS_f) on sieves varied from 0.37% (1mm) sieve to 38.30% (0.30mm), highest retention of 38.3% recorded for M_fS_f (1:1 blend of fine millet and sorghum flours) was on 0.30mm sieve, followed by 24.15% on 0.425mm and 19.20% on 0.150mm; negligible retentions were recorded on sieves with aperture greater than 0.50mm. For medium- grained blended fractions (M_mS_m, 1:1), retentions ranged from 0.89% (1mm) to 31.18% (0.425mm sieve), on sieves 0.30mm and 0.50mm retentions were 19.54% and 24.16% respectively and for blended coarse fraction (M_cS_c, 1:1) the highest retention was 39.19% on 0.50mm sieve followed by 24.14% on 0.425mm and 12.50% on 0.71mm.

This shows that blending flours from different grains slightly modify the Particle size distributions of the original individual flours which in turn affect the chemical composition, functional and as well as the sensory properties of the end products made from the blended similar cereal flour fractions.

Table 1: Particle size distribution of blends made from similar flour fractions of millet and sorghum Retention on Sieve (%)

Sieve(mm)	M _f S _f (1:1)	M _m S _m (1:1)	M _c S _c (1:1)
1.00	0.37 ^f ± 0.08	0.89 ^f ± 0.03	4.22 ^e ± 0.03
0.85	0.66 ^f ± 0.03	0.96 ^f ± 0.14	2.31 ^f ± 0.01
0.71	2.25 ^e ± 0.12	9.08 ^d ± 0.63	12.50 ^e ± 0.30
0.50	5.30 ^c ± 0.02	24.16 ^b ± 0.04	39.19 ^a ± 0.07
0.425	24.15 ^b ± 0.08	31.18 ^a ± 0.21	29.14 ^b ± 0.11
0.30	38.30 ^a ± 0.09	19.54 ^c ± 0.08	10.29 ^d ± 0.03
0.150	19.20 ^e ± 0.04	9.64 ^f ± 0.03	2.19 ^e ± 0.02
0.063	10.29 ^d ± 0.05	4.39 ^e ± 0.07	0.49 ^g ± 0.01

Mean ± SEM (n=3) means not followed by the same super scripts in a column are significantly different (p< 0.05) —

- Fine (f), Medium (m), and coarse (c) flour fractions of millet (M) and Sorghum (S) equally blended similar (1:1) fractions (M_fS_f, M_mS_m, M_cS_c)

As shown on Table 2, supplementation of equally blended similar fractions of millet and sorghum with Bambara groundnut (B) flour redistributed the flour particle sizes further towards bigger particles. For Bambara bean supplemented M_fS_f, negligible retentions were located on

sieves less than 0.50mm, therefore most retentions were located on 0.5-0.71mm sieves for all the blended similar flour fractions fortified with Bambara bean flour: 46.42-32.23%,44.51-28.63%, and 40.21-20.18% for M_fS_fB, M_mS_mB and M_cS_cB respectively. It indicated that fortification of blended flour fraction with legume flour increases the sizes of the flour particles, a redistribution towards the bigger particles which will definitely affect the properties of the blends and the end –products.

Table 2: Particle size distribution of equally blended similar flour fractions of millet and sorghum flour fractions Retention on Sieve (%)

Sieve (mm)	M _f S _f B (70:30)	M _m S _m B (70:30)	M _c S _c B (70:30)
1.00	0.51 ^f ± 0.06	1.97 ^f ± 0.03	19.19 ^c ± 0.03
0.85	0.56 ^f ± 0.05	12.15 ^c ± 0.14	16.49 ^d ± 0.01
0.71	32.23 ^b ± 0.12	28.63 ^b ± 0.63	20.18 ^b ± 0.30
0.50	46.42 ^a ± 0.09	44.51 ^a ± 0.04	40.21 ^a ± 0.13
0.425	6.18 ^c ± 0.09	6.12 ^d ± 0.21	1.33 ^e ± 0.11
0.30	4.98 ^d ± 0.06	4.13 ^e ± 0.08	0.16 ^e ± 0.03
0.150	4.60 ^d ± 0.03	1.84 ^f ± 0.03	1.60 ^e ± 0.21
0.063	1.88 ^e ± 0.02	0.25 ^g ± 0.07	1.20 ^e ± 0.01

Mean ± SEM (n=3) means not followed by the same super scripts in a column are significantly different (p< 0.05) —

- Fine (f), Medium (m), Coarse (c) flours of millet (M) and Sorghum (S) equally blended similar flour fractions fortified with Bambara bean flour (M_fS_f, M_mS_m, M_cS_c)

As revealed in Table 3, addition of 30% sesame seed (se) meal to each of the blended similar fractions (M_fS_f, M_mS_m and M_cS_c), further increased the coarseness of the fortified blends, although highest retentions were still on 0.50mm

sieve except M_cS_cSe, 46.24%, M_fS_fSe 48.22%, and M_mS_mSe 30.98% on 0.71mm sieve. The same trend was repeated in Table 1c when 30% sesame seed meal fortification increased the coarseness of the similar blended fractions, the flour particles were located mainly on 0.50-0.71mm sieves, 46.24-30.57%, 48.22-28.69% and 20.98-30.98% for M_fS_fSe, M_mS_mSe, and M_cS_cSe respectively; M_cS_cSe was the most coarse among them, the oily nature of sesame seeds do not permit the production of fine meal.

Table 3: Particle size distribution equally blended similar flour fractions of millet and sorghum fortified with 30% sesame seed meal Retention on Sieve (%)

Sieves (mm)	M _f S _f Se (70:30)	MmSmSe (70:30)	McScSe (70:30)
1.00	3.26 ^c ± 0.13	4.89 ^d ± 0.13	20.66 ^c ± 0.41
0.85	11.11 ^c ± 0.05	12.51 ^c ± 0.09	24.75 ^b ± 0.24
0.71	30.57 ^b ± 0.14	28.69 ^b ± 0.21	30.98 ^a ± 0.34
0.50	46.24 ^a ± 0.14	48.22 ^a ± 0.31	20.98 ^c ± 0.17
0.425	4.40 ^d ± 0.07	4.9 ^e ± 0.15	2.07 ^d ± 0.08
0.30	2.20 ^f ± 0.02	0.67 ^f ± 0.01	0.52 ^e ± 0.17
0.150	1.70 ^g ± 0.14	0.66 ^f ± 0.68	0.09 ^f ± 0.04
0.063	0.37 ^h ± 0.10	0.13 ^g ± 0.04	0.07 ^f ± 0.03

Mean ± SEM (n=3) means not followed by the same super scripts in a column are significantly difference (p< 0.05)

- Fine (f), Medium (m), Coarse (c) flours of millet (M) and Sorghum (S) equally blended (1:1) (M_fS_f, MmSm, McSc)
- Fortification of equally blended flour fractions with sesame seed (Se) meal in the ratio of 70:30. (M_fS_fSe, MmSmSe and McScSe)

fractions with both B and Se (2:1) flours resulted to the highest level of coarseness for the fortified blended fractions especially McScBSe with the highest retentions located on 0.85 and 1.00mm sieves.

Therefore, unfortified blended fractions had the finest particle size and very likely to have the highest surface area, therefore better hydration and sensory properties.

As shown in Table 4, supplementation of the three blended

Table 4: Particle size distribution equally blended similar fractions of millet and sorghum fortified with combination of Bambara groundnut (20%) and sesame (10%) flours Retention on Sieve (%)

Sieve mm	M _f S _f BSe (70:20:10)	MmSmBSe (70:20:10)	McScBSe (70:20:10)
1.00	4.17 ^d ± 0.12	6.98 ^d ± 0.18	22.48 ^c ± 0.14
0.85	12.02 ^c ± 0.67	20.38 ^c ± 0.07	30.54 ^b ± 0.20
0.71	44.07 ^a ± 0.03	40.18 ^a ± 0.17	44.19 ^a ± 0.30
0.50	32.64 ^b ± 0.03	31.27 ^b ± 0.03	2.15 ^d ± 0.21
0.425	1.59 ^e ± 0.04	0.50 ^e ± 0.30	0.32 ^e ± 0.02
0.30	0.35 ^f ± 0.06	0.35 ^e ± 0.20	0.27 ^e ± 0.02
0.150	0.10 ^g ± 0.03	0.18 ^e ± 0.02	0.05 ^f ± 0.03
0.063	0.06 ^e ± 0.00	0.11 ^e ± 0.00	NA

Mean ± SEM (n=3) means not followed by the same super scripts in a column are significantly difference (p< 0.05) NA: not available.

- Fine (f),Medium (m), Coarse (c) flours of millet (M) and Sorghum (S) equally blended (1:1) (M_fS_f, MmSm, McSc)
- Same fractions fortified with 30% (Bambara groundnut (B) or 30% sesame seed (Se) flours in the ratio of 70:30. (M_fS_fB, MmSmB, McScB, M_fS_fSe, MmSmSe and McScSe)
- Same fractions fortified with both 20% Bambara groundnut and 10% sesame flours (M_fS_fBSe, MmSmBSe and McScSe).

with Bambara groundnut or sesame seed flours produced dakere with higher granular size. The Control (MS) as well as M_fS_f, MmSm and McSc which was not fortified with legume flours had granular sizes about 0.85mm. On 0.71mm sieve, mainly unfortified dakere as well as M_fS_fB, McScB, M_fS_fSe, M_fS_fBSe had higher retentions indicating they contained granules about the size of 0.71mm. Retentions on 0.5mm sieve were negligible for the various *dakere* indicating that the control and various modified dakere had granular size in the range of 0.71mm to 1.00mm. Manual or traditional method of obtaining and handing agglomerates definitely produced dakere with diverse granular sizes unlike commercially produced couscous made from wheat semolina; lack of uniform granular size will affect dakere reconstitution into 'tuwo'(stiff dough) or breakfast gruel, it will also affect the packing and handling of modified *dakere*. Agbara *et al* (2020) reported retentions of 24.22 – 71.20 on 1.00mm sieve for couscous produced from blends of semolina and legume flours implying granular of about 1.00mm.

Presented in Table 5 is the particle size/granule size distribution of modified dakere and the Control. MmSmB, MmSmSe and McScBSe had the highest retentions on 1.0mm sieve which indicated the presence of bigger sized-modified *dakere* granules produced through agglomeration of stiff-dough and that fortification of the similar blended flour fractions resulted to bigger granules with implications in packaging, distribution and storage as well as reconstitution in water or milk. Therefore, Supplementation

Table 5: Particle size distribution of modified dakere and control

Sieve Sample	1.00mm	0.85mm	0.71mm	≤0.50mm
MS	22.01 ^c ±1.50	42.01 ^a ±0.45	23.85 ^b ±0.36	10.34 ^b ±0.13
M _f S _f	4.44 ^d ±0.24	41.40 ^a ±0.12	31.85 ^f ±0.08	4.13 ^c ±0.19
MmSm	27.37 ^b ±0.39	40.77 ^a ±0.24	30.39 ^f ±0.14	1.45 ^b ±0.37
McSc	28.51 ^b ±0.17	40.15 ^{ab} ±0.15	27.76 ^g ±0.34	3.46 ^f ±0.38
M _f S _f B	20.91 ^d ±0.06	20.70 ^f ±0.52	51.25 ^b ±0.34	7.16 ^c ±0.42
MmSfB	40.43 ^{ab} ±0.80	28.50 ^d ±0.07	27.09 ^g ±0.01	4.00 ^e ±0.80

McScB	20.91 ^d ±0.19	28.74 ^d ±0.17	45.68 ^c ±0.29	4.67 ^d ±0.07
MfSfSe	20.91 ^d ±0.19	40.76 ^a ±0.07	45.68 ^c ±0.29	4.67 ^d ±0.17
MmSmSe	43.89 ^a ±0.12	30.33 ^c ±0.15	36.56 ^e ±0.01	1.47 ^h ±0.10
McScSe	20.06 ^d ±0.11	23.08 ^c ±0.21	24.01 ^h ±0.16	1.38 ^h ±0.28
MfSfBSe	20.48 ^d ±0.06	23.06 ^c ±0.07	54.66 ^a ±0.05	2.20 ^g ±0.25
MmSmBSe	20.33 ^d ±0.24	40.21 ^{ab} ±0.01	38.19 ^{ab} ±0.21	0.55 ⁱ ±0.22
McScBSe	40.61 ^{ab} ±0.50	38.18 ^b ±0.02	18.58 ⁱ ±0.22	21.70 ^a ±0.28

Mean ± SEM (n=3) means not followed by the same super scripts in a column are significantly difference (p< 0.05)

- Fine (f), medium (m), coarse (c) flours of millet (M) and sorghum (S) equally blended (1:1) (MfSf), MmSm, McSc)
- Same fractions fortified with 30% (Bambara groundnut (B) or 30% sesame (Se) flours in the ratio of 70:30 (MfSfB, MmSmB, McScB, MfSfSe, MmSmSe and McScSe)
- Same fractions fortified with both 20% Bambara groundnut and 10% sesame flours (MfSfBSe, MmSmBSe and McScBSe).

Functional Properties of the Blends

Presented in Table 5 is the functional properties of the blends. Solubility varied from 19.03 to 25.20%, unfortified blended fractions had the highest solubility which decreased with addition of legume flours. This could be attributed to finer particle size of the un-supplemented blend. The lowest solubility was observed in multi-grain blends either due to high oil content of the sesame seed meal or bigger flour particle of both sesame seed and bambara groundnut flours. Solubility influences other functional properties such as water absorption capacity, emulsion capacity or foam formation (Hatcher and Kruger, 1997). The bulk density of food materials is affected by the particle size and density of the flour (Adebowale *et al.* 2005). Bulk density is an important factor in food packaging. The bulk density of the blends increased with increased level of supplementation with legume flours. The difference in bulk densities of the blends might be related to different Particle size distribution of the blended fractions. Table 5 indicates the bulk densities of blends varied from 0.68g/ml to 1.90g/ml. This shows there is a greater ease of dispersibility and greater package and storage space requirements as a result of legume supplementation. Comparatively, this is in line with what Abubakar and Hamaker (1999) [1] reported on physicochemical properties of flours that relates to sorghum couscous quality, who reported a range of 0.67g/ml - 1.35g/ml. Table 2b indicates functional properties of the various dakere. The bulk densities of various dakere ranged between 0.58g/ml and 0.97g/ml (MfSfBSe and McScBSe), MmSmBSe (0.96g/ml), McScB (0.84g/ml), Control and untreated blended fractions within it had lower values. The

low bulk density of the dakere compared with that of blended fractions is attributed may to the porous nature of the product: voluminous and couscous-like product. Water absorption capacity of the blends ranged from 69.45 to 81.41%, Table 5 and dakere 70.42 to 82.65% lower than 75 to 112.69% reported for wheat-fermented soy flour composite mixes (Hameeda *et al.*, 2012). It was discovered that WAC of the Control (MS) and unsupplemented blended fractions (MfSf, MmSm and McSc) were higher perhaps due to larger surface area of the flours. Water absorption capacity is a measure of the hydrophilic functional groups of proteins and carbohydrates to associates with water in a water stressed environment (Sigh, 2001). Water absorption capacity (WAC) is very important in the development of ready to eat foods, and high water absorption may ensure product cohesiveness (Adebowale *et al* 2015). Consistency and stability of viscous foods such as soups, gravies, dough and baked products entirely depends on enough water hydration of the constituents starch and protein polymers (Adeyeye and Ayeye 1998). Higher swelling power of the blends (>20%) containing both Bambara groundnut and sesame could be due to higher protein or other hydrophilic constituents, the swelling power of sesame flour treated blends (MfSfSe, MmSmSe, and McScSe) were the lowest due to higher oil content of seed meal. The unfortified blended fractions and the Control had also low swelling power. (Table 5 and 2b)Swelling power decreased gradually with addition of Bambara groundnut flour in MfSfB(18.55%) McScSe (16.46%) and suddenly increased in MfSfBSe (20.60%), MmSmBSe (20.71%) and McScBSe (21.55%) The higher the swelling power, the higher the associative forces within the starch granules. Swelling properties of flour determines the crystalline arrangement and degree of hydrogen bonding in starch granules (Bilcaders 1982). High swelling power is desirable for bakery products. Sakhare *et al.*(2014) observed that higher protein and damaged starch in fine wheat flour was responsible for higher solubility and water absorption, the same factors might be responsible for higher solubility and water absorption of un-supplemented blended fractions (MfSf, MmSm andMcSc).

Table 6: Functional Properties of the blends for Dakere Preparation

Sample code	Solubility (%)	Bulk density (g/ml)	Water absorption Capacity (%)	Swelling Index (%)
MS (1:1)	23.40 ^b ± 0.08	0.68 ^c ± 0.016	81.41 ^a ± 0.103	17.80 ^e ± 0.36
MfSf(1:1)	24.80 ^a ± 0.04	0.78 ^d ± 0.01	79.58 ^b ± 0.03	18.14 ^{de} ± 0.03
MmSm(1:1)	25.20 ^a ± 0.40	0.79 ^c ± 0.04	79.31 ^b ± 0.03	19.40 ^c ± 0.04
McSc(1:1)	24.02 ^a ± 0.04	0.80 ^c ± 0.02	78.01 ^{bc} ± 0.06	19.46 ^c ± 0.04
MfSfB(70-30)	23.02 ^{bc} ± 0.04	0.80 ^c ± 0.01	80.42 ^{ab} ± 0.04	18.55 ^d ± 0.04
MmSmB(70:30)	23.20 ^{bc} ± 0.03	1.00 ^{bc} ± 0.01	79.50 ^b ± 0.04	17.85 ^e ± 0.07
McScB(70:30)	23.55 ^b ± 0.04	1.30 ^b ± 0.01	79.20 ^b ± 0.46	18.80 ^d ± 0.66

MfSfSe(70:30)	19.75 ^d ± 0.03	0.77 ^d ± 0.04	74.08 ^c ± 0.05	17.06 ^{ef} ± 0.05
MmSmSe (70:30)	20.09 ^{cd} ± 0.04	0.79 ^{cd} ± 0.01	73.81 ^c ± 0.04	16.75 ^f ± 0.04
McScSe(70:30)	20.27 ^c ± 0.06	0.87 ^c ± 0.01	73.82 ^c ± 0.01	16.46 ^f ± 0.41
MfSfBSe (70:20:10)	19.03 ^{de} ± 0.04	1.81 ^a ± 0.01	71.90 ^d ± 0.03	20.60 ^b ± 0.05
MmSmBSe (70:20:10)	19.53 ^d ± 0.03	1.90 ^a ± 0.05	71.08 ^{de} ± 0.06	20.71 ^b ± 0.05
McScBSe (70:20:10)	21.02 ^{bc} ± 0.04	1.80 ^a ± 0.00	69.45 ^e ± 0.06	21.55 ^a ± 0.04

Mean ± SEM (n=3) means not followed by the same super scripts in a column are significantly different (p< 0.05) —

- Fine (f), medium (m), coarse (c) flours of millet (M) and sorghum (S) equally blended (1:1) (MfSfB), MmSm, McSc)
- Same fractions fortified with 30% (Bambara groundnut (B) or 30% sesame (Se) flours in the ratio of 70:30 (MfSfB, MmSmB, McScB, MfSfSe, MmSmSe and McScSe)
- Same fractions fortified with both 20% Bambara groundnut and 10% sesame flours (MfSfBSe, MmSmBSe and McScSe).

Functional Properties of Modified Dakere

As presented in Table 7, the control and fractionated blends had higher percentage solubilities greater than the supplemented blends and this could be attributed to finer particle size in the untreated fractionated blends the values are ranged from 18.03% (MfSf BSe) to 22.85% (MmSm). Solubility values are influenced by many factors such as temperature, PH and Ionic activity (Singh *et al.*, 2012). High

oil content of sesame flour inhibited solubility, water absorption and swelling capacity. The bulk densities of modified dakere were higher than those obtained from untreated fractionated dakere and control. MS dakere had the least bulk density 0.58g/ml followed by those obtained from untreated fractionated blends. The highest values were observed in modified dakere which in turn requires modification of packaging, handling and storage spaces Adeyeye and Aye, (1998), reported that water absorption, increases quality of flour mixture which also en sure the retention of moisture for dough steamed products.

Water absorption capacity in the modified dakere production from the untreated fractionated blend MfSf, MmSm and McSc and control (M-S) had significant higher water absorption capacity (p ≤ 0.05), higher than the grain legume flour, also in this case, high oil content of sesame seed flour inhibited solubility and swelling index, however swelling indices of dakere with both Bambara groundnut and sesame flour were higher than others.

Table 7: Functional Properties of the *Dakere*

Sample Code	Solubility%	Bulk Density (g/ml ^l)	Water absorption capacity (%)	Swelling Index
M:S (1:1)	20.40±0.08 ^b	0.58±0.02 ^e	82.65±0.01 ^a	19.75±0.03 ^e
MfSf (1:1)	21.80±0.03 ^a	0.65±0.02 ^d	80.54±0.03 ^b	20.24±0.03 ^d
MmSm(1:1)	22.85±0.04 ^a	0.66±0.04 ^c	80.23±0.03 ^b	21.52±0.03 ^c
McSc (1:1)	21.93±0.04 ^a	0.75±0.02	79.00±0.06 ^{bc}	21.85±0.04 ^c
MfSfB (70-30)	20.02±0.04 ^{bc}	0.78±0.01	81.52±0.04 ^{ab}	20.53±0.04 ^d
MmSmB (70:30)	20.20±0.12 ^{bc}	0.80±0.02 ^{bc}	80.44±0.03 ^b	19.84±0.07 ^c
McScB (70:30)	20.54±0.04 ^b	0.84±0.01 ^b	80.23±0.04 ^b	20.86±0.06 ^d
MfSfSe (70:30)	18.85±0.03 ^d	0.67±0.01 ^d	76.08±0.05 ^c	19.08±0.05 ^f
MmSmSe (70:30)	19.02±0.04 ^{sd}	0.70±0.01	74.89±0.06 ^c	18.74±0.04 ^f
McScSe (70:30)	19.28±0.05 ^c	0.74±0.01	75.94±0.04 ^c	18.36±0.04 ^f
MfSfBSe (70:20:10)	18.03±0.03 ^{de}	0.97±0.01	72.63±0.04 ^d	22.56±0.04 ^b
MmSmBSe (70:20:10)	18.52±0.03 ^d	0.96±0.01 ^a	72.07±0.06 ^d	22.79±0.03 ^b
McScBSe (70:20:10)	20.02±0.04 ^{bc}	0.97±0.01 ^a	70.42±0.06 ^e	23.15±0.02 ^a

Mean ± SEM (n=3) means not followed by the same super scripts in a column are significantly difference (p< 0.05)

- Fine (f), Medium (M), Coarse (C) flours of millet (M) and Sorghum (S) equally blended (50:50) (MfSf, MmSm, McSc)
- The same fractions fortified with 30% (Bambara groundnut (B) or 30% sesame seed (Se) flours in the proportion of 70:30. (MfSfB, MmSmB, McScB, MfSfSe, MmSmSe and McScSe)
- The same fractions fortified with 20% Bambara groundnut and 10% sesame flours in the proportion of 70:20:10 (MfSfBSe, MmSmBSe and McScSe).

Conclusion

Dakere is an agglomerated dumpling usually produced from 1:1 blend of millet and sorghum flours. Fractionation of flours provides fractions with different Particle size distribution therefore, different functional and chemical properties which further alter on fortification with legume

flours; the bulk densities, swelling power were higher in the fortified blends or dakere while the solubilities and water absorption capacities were higher the in Control and the blended unfortified fractions. The particle sizes of the blended fractions or the granular size of the dakere increased with legume flour fortification indicating the need for the adjustment of packing and packaging requirements for fortified blends and dakere.

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