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Effects of Flour Fractionation and Legume flour Inclusion on Some Phytochemicals and Mineral Profile of the Grains, Blends and Dakere (A Nigerian Agglomerated Steamed Dumpling)

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ABSTRACT

Dakere is a traditional stiff, agglomerated, steamed dumpling, a multipurpose food product, prepared mainly from cereal flour, the cereal grains of choice are millet and sorghum either alone or in combination. In this study millet (M) and sorghum (S) were fractionated separately into fine (f) (<250µm), medium (m) (250-350µm) and coarse (450-500µm) fractions, similar fractions were bended, and fortified with 30% Bambara bean or sesame flour or both(20:10). These fortified blended fractions were used to produce dakere using the traditional method. Combination of unfractionated unfortified blend of millet and sorghum flours (1:1) served as the experimental control.There were 12 formulations code named: MS (control), MfSf, MmSm, McSc, MfSfB, MmSmB, McMcB, MfSfSe, MmSmSe, McScSe, MfSfBSe, MmSmBSe and McScBSe. Mineral contents of the blends were generally enhanced, greater concentration were observed in the fortified dakere, more in the dakere containing either bambara groundnut or sesame flour, greater than in the control. Potassium and Phosphorus were the most dominant elements in the grains (P 246.86-308.28 mg/100g, K 226.86-282.36 mg/100g); the blends (P 203.70-362.54 mg/100g, K 201.31-331.92 mg/100g) and the dakere (P 271.74-295.09 mg/100g, K 218.74-268.24 mg/100g). Anti-nutritional factors were low, tannin concentrations varied from 3.28 to 6.53 g/100g, phytic acid 0.42-0.89 g/100g and total phenolics, 7.20- 12.46 g/100g. McSc and their fortified blends or dakere contained greater amounts of both the investigated minerals and antinutrients. The study had successfully enhanced the mineral profile of dakere and the associated slight increase in the levels of tannin, phytate and polyphenolic compounds, through fortification of similar blended flour fractions from millet and sorghum with legume flours.

Keywords: Flour fractionation, Legume flours, Dakere, Dietary minerals, Phytochemicals.

1.0 Introduction

Dakere also called dambu *gero* or *dawa* is a steamed agglomerated dumpling made from a cereal flour dough. In northeastern Nigeria where it is commonly produced and consumed by different tribes, *dakere* is usually produced by using equal blend of decorticated millet and sorghum flours, the dough is agitated in a container to produce tiny pieces of dough or agglomerates which are steamed to produce fresh *dakere* or sun dried for shelf stability, and in this form it can be stored and later eaten as snack or reconstituted with milk or water and consumed as a breakfast cereal or midday beverage. The importance of *dakere* as food security item during farming season cannot be overstressed. Normads carry this food stuff along with them, school children or students in boarding schools use *dakere* as ready to eat fast food or snack. Millet or sorghum like most cereals contain protein but of low quality because they are deficient in lysine and theorinine, these two amino acids are needed for proper nutrition and health, luckily the same amino acids are available in grain legumes such as bambara groundnut and sesame seeds. Bambara groundnut(*Vigna subterraneae*) has been ranked as the third most important grain legume after ground nut and cowpea in developing countries, but it has not been given proper attention because of the technological or processing qualities which place constraints on large scale industrial or home processing (Xin et al., 2020). Bambara groundnut is usually boiled and eaten as a snack, locally processed and utilized in various forms such as *moimoi* (dumpling), cooked together with cereals or roots as porridge, used to prepare weaning foods and assorted snacks (Doku, 1995). This pulse is nutritionally adequate and contains 18.4% protein, 5.17% lipid, 2.5% ash.4.9% crude fibre, 60.8% carbohydrate and 9.7% moisture (Enwere and Hung, 1996). In the same vein, Nigeria landscape supports the cultivation of sesame seeds (*Sesamum indicum)* and Nigeria ranked third on the list of world sesame producers after leading producers, India and China (NAERLS, 2010). Sesame seed is a familiar ingredient in Asia and middle eastern cuisines, apart from its taste, sesame seeds are known for their high nutritional value.

Sesame seed contains 5.7% moisture, 20% protein, 49% fat, 9.4% crude fibre, 4.2% ash and high amounts of minerals and vitamins (Nzikou et al., 2010). Grain legumes generally are sources of cheap vegetable proteins in developing countries especially among the resource poor families, a rich source of lysine, augumenting lysine-deficient cereal and root-based diets; it is an essential source of iron and zinc, and is 40% richer in amino acid, methionine and lysine than other grains (Krishnan and Meer, 2018). Pearl millet (*Pennisetum glaucum)* is a small-seeded grass grown in semi-arid and arid tropics of Africa and Asia. Pearl millet production in Africa is restricted to countries such as Nigeria, Niger, Burkina Faso, Mali, Senegal and Sudan (FAO, 2011). Sorghum (*Sorghum bicolor* L. Moench), on the other hand plays critical role for food security in some semi arid areas of Africa and Asia and latin America (FAO, 2011). It's production in commercial quantity is affected by biotic and abiotic constraints (FAO, 1995). Sorghum is the world's fourth important food grain being exceeded in utilization for food by wheat, rice and maize (Kumar,1993). Various related tribes domiciled in northeastern Nigeria utilize pearl millet and grain sorghum for preparation of various food items and dakere is one of these food products. Grain milling majorly involves size reduction and classification of flour particles through sieving. Differential sieving produces flour fractions, each fraction has unique proximate composition, mineral and amino acid profile, moreover each fraction yields end products with unique properties including sensory (Ramesh and Prakesh, 2020) because of the presence of flour particles of similar dimension. Therefore, the current study blended similar fractions of millet and sorghum obtained through differential sieving, the same blended fractions were fortified with fours from bambara groundnut or sesame or both, and the blends were used to produce dakere. Thereafter, the mineral and phytochemical profile of both *dakere* and the blends were evaluated.

2.0 Materials and Methods

2.1 Procurement of the grains

Four different grains namely; pearl millet (SOSAT C88) obtained from LakeChad Research Institute); sorghum (Chakalari white), bambara groundnut (cream coloured) and sesame seeds (white) were purchased from Custom Area market of Maiduguri, Borno State, Nigeria.

2.1.1 Raw Materials Preparation

Grain samples were cleaned by winnowing to remove foreign materials like sand, immature seeds and weed seeds.Cleaned grain were conditioned, decorticated, washed, dried and milled into flours. Decorticated bambara groundnut and sesame seeds were toasted, milled into flours then sieved. The flours were stored in plastic containers at room temperature prior to blend formulation and chemical analysis.

2.1.2 Fractionation of the flours and blends formulation

Four standard sieves(0.250mm, 0.350mm, 0.450mm and 0.500mm) were stacked and mounted on a sieve shaker (Endecotts EL080-300), the millet and sorghum flours were separately sieved and the fractions were collected and arbitrarily grouped as fine, f(<0.250mm), medium or intermediate, m(0.250-0.350mm) and coarse, c(0350-0.500mm). Blended fractions were: MfSf, MmSm, & McSc, after fortification with 30% Barbara groundnut (B) or sesame seed(Se) flours or both, coded samples were: MfSfB, MmSmB & McScB; MfSfSe MmSmSe, MfSfSe; MfSfBSe, MmSmBSe & McScBSe. The control(MS) was the traditional blend for dakere, 50:50 blend of millet and sorghum flours.

2.2 Dakere preparation with the blended fractions

One kilogram of each blend was mixed with 750ml of warm salted water in a stainless steel bowl, the mixing continued until a smooth stiff dough was obtained. A small portion of the dough each time was placed in a collander and manually agitated until agglomerates were obtained and steamed for 30min. The fresh dakeres were oven dried at 70°C for 5-6 h and spread on a platform to cool and further hardened. Dried dakere were stored separately in low density polyethylene bags prior to use.

2.3 Chemical analysis of the blends and various dakere

2.3.1 Mineral contents determination

Two grams of each sample (dry weight basis) was dry-ashed and mixed with 20ml 20% HCl in a volumetric flask, heated on a water bath, cooled and filtered, the filterate made up to 100ml in an Erlenmeyer flask. Ca, Mg, Fe, Cu were determined using atomic absorption spectrophotometer (Model l3100, Perkin-Elmer, USA). Concentrations of Na and K in the filterate were assayed using flame photometer (Model PF P7 Jenway, UK) and P was determined colorimetrically using vanado-molybdate method (AOAC, 1990). Concentrations of the minerals (mg/100g) were obtained from respective standard caliberation curves constructed using standard solutions.

2.3.2 Phytochemical Contents Determination

The method of Simpleton and Rossi (1965) as modified by Chandra et al.(2014) was used to determine total phenolic compounds, 0.10-0.50g extract was dissolved in 5 methanol and sonicated 45 min, 40•C, centrifuged 1000 rpm, 10min. The clear supernatant was used for total phenolics determination using Folin -- Ciocalteau reagent method: 0.2ml test sample was mixed with 0.6ml H_2O and 0.2ml of Folin- Ciocalteu phenol regeant (1:1). After 5min, 1ml of saturated solution of Na_2CO_3 (8% W/V) was added to the mixture and the volume brought to 5ml with distilled water, kept in the dark for 30min, then centrifugied, the absorbance of the blue colour was measured at 765nm.The phenolic content was calculated on the basis of standard curve of gallic acid (5-500mg/L), the results were expressed as gallic acid equivalent (GAE) per gram of sample (dry weight basis).

2.3.3 Tannin Content Determination

The method reported by Ejikeme et al.(2014) was just adopted to determine the tannin content of the samples: 1g of sample was placed in conical flask containing 100ml distilled water, boiled on electric plate, cooled and filtered (Whatman No.42) . To 10ml aliquot of the filterate, 50ml Folin Denis reagent and 10ml saturated sodium trioxocarbonate(iv) were added and finally made to volume with distilled water, after 30 min incubation for colour to develope, absorbance was taken at 700nm with the aid of a spectrophotometre (Model 2000, LaMotta). A standard solution of tannic acid was used to obtain the calibration curve and tannin concentration was obtained by extrapolation of the curve

Tannin concentration(g tannic acid/100g sample)= concentration x extract volume/aliquot volume x sample weight

2.3.4 The Phytate Content Determination

The method described by Abou – Arab and Abu- Saleem (2009) was adopted for phytate concentration. Four gram (4g) of sample was dissolved in 100ml of 2% HCl, left to stand for 5h, 25ml of filterate was mixed with 5ml of 0.3% ammonium thiocyanate solution . The resulting mixture was titrated with iron (iii) chloride solution until a brown--yellow end- point persistent for 5min. Phytate concentrations were extrapolated from standard curve made with serial concentrations of phytic acid solution..

2.4 Experimental Design and Statistical Analysis

A factorial design (3x2x2) was used to generate 12 experimental runs.Three (3) flour fractions (fine (f), medium (m) and coarse(c)), from each of the two (2) cereal grains, millet (M) and sorghum (S), similar fractions blended and fortified with either bambara groundnut or sesame seed flour or both. The control representing unfortified, unfractionated 1:1 blend of millet and sorghum flours (MS).

The sample codes of the twelve experimental runs were as stated previously.

Determinations were done in triplicate in most cases; the mean and the standard error of the mean (SEM) of the parameters were calculated and results expressed as mean+-SEM, means were separated using Ducan's Mutiple Range Test and significance was accepted at a p-value of 5% ($p< 0.05$)

3.0 Results and Discussion

3.1 The Mineral contents of the whole grains: pearl millet ,sorghum, bambara groundnut and sesame seeds

Significant variations ($p<0.05$) existed in the minerals contents of whole grains used to prepare the blends for *dakere* production. The order of dominance of the mineral elements observed in the whole grains P>K>Mg>Ca>Fe>Zn>Cu>Na. Bambara groundnut had the highest amounts of these elements followed closely by sesame seeds.The various range of concentrations (mg/100g) obtained for each of the elements assayed were: K 226.86-282.36, P 246.86-306.28, 62.36-91.50, Ca 36.80-77.32, Fe 5.84-16.64, Zn 3.47-12.05, Cu 3.73-6.78 and Na 3.66-7.99. Varietal differences, soil composition, agronomic practices etc are responsible for the variations observed. Definitely, there would be decrease in the process of transforming the grains into refined flour(Awika, 2011) and also in the final product, *dakere.* Hassan et al. (2020) reported comparable values for mineral contents of millets from Southern Africa: K (3864.6 – 4899.3mg/kg) as the most abundant element in pearl millet followed by P ; in that report Fe and Zn were 71, 28-71.96 mg/kg and 17.65 – 52.66 mg/kg respectively while concentrations of Mg, Na were comparatively lower and Ca higher. Tasie and Gebreyes (2020) studied thirty five sorghum varieties of Ethopia and the following values were obtained: P 367.965, Na 6.151, Mg 207.526, K 314.011, Ca 67.159, Fe 14.018, Zn 6.484 all in mg/100g, this result is not far from the mineral content of sorghum in **Table 1.** The order of dominance of mineral elements in Sudanese sesame seeds for K, P, Mg Ca and Na reported by Nzioku et al. (2010)

is not different from the order obtained in this study for sesame seeds used in this study. Bambara groundnut is a good source of essential minerals (Aremu et al.2006; Olalaye et al., 2013).

Table 1. Mineral contents (mg/100g) of raw materials for Dakere productions

Element	Millet	Sorghum	Bambara groundnut	Sesame seed
K	$259.34^{b} \pm 0.5$	$262.0^{ab} \pm 1.15$	$282.36^{a} \pm 1.2$	$226.86^{c} \pm 3.84$
P	$291.77^{ab} \pm 0.5$	$287.57^{b} \pm 1.79$	$306.28^{a} \pm 0.63$	$246.16^{c} \pm 0.54$
Mg	$71.23^{b} \pm 0.60$	$626^{c} \pm 0.60$	$91.50^{a} \pm 0.43$	$81.13^{ab} \pm 0.58$
Na	$4.28^{b} \pm 0.50$	$3.66^{c} \pm 037$	$7.99^{a} \pm 0.44$	$6.73^{ab} \pm 0.23$
Ca	$36.80^{ab} \pm 0.56$	$35.78^{b} \pm 0.26$	$86.85^{ab} \pm 0.37$	$87.32^{a} \pm 0.24$
Cu	$3.95^{c} \pm 0.13$	$3.73^{cd} \pm 0.17$	$6.78^{a} \pm 0.34$	$4.35^{b} \pm 0.18$
Fe	$8.12^{c} \pm 0.32$	$5.84^{d} \pm 0.11$	$16.64^{a} \pm 0.35$	$10.53^{b} \pm 0.3$
Zn	$5.65^{c} \pm 0.04$	$3.47^{d} \pm 0.02$	$12.05^{a} \pm 0.07$	$7.84^{b} \pm 0.18$

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

As **Table 2** reveals, the most significant observation was the concentrations of P and K were higher and Fe and Zn lower in the blends, and blends supplemented with both bambara groundnut and sesame flours had the highest amounts of these minerals investigated, the blended fractions had the least, slightly lower than amounts obtained in the MS, higher concentrations of mineral elements were observed in blends containing bambara groundnut or sesame seed flours or those containing both while the blended fractions had the least, slightly lower than observed in the control.

Most abundant mineral elements were K and P, and Cu, Zn and Fe in decreasing order, were the elements with least concentrations. The concentration (mg/100g) of the elements varied significantly ($p< 0.05$) from 201.31-331.92, 44.39 – 58.23, 203.70-362.54, 61.55 – 85.52, 40.75 -72.43, 1.90 – 7.01, 0.05 – 1.70, 1.81 – 4. 18 for K, Ca, P, Mg, Na, Cu, Zn and Fe respectively.

McSc or its fortified blends had greater concentration of the investigated minerals, however McScBSe for unknown reasons had lower concentration among fortified blends. Similar enhancement of the dietary mineral contents was reported by Khan et al.(2009) for wheat-soybean blends and by Edet et al. (2017) for rice-acha-soybean blends and noodles.

The observed enhancement is beneficial because dietary minerals are indispensable constituents of tissues, enzymes, tissue fluids for electrolyte balance optimum physiological processes of higher organisms.

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Table 2. The mineral contents (mg/100g) of blends for Dakere preparation

	Potassium	Calcium	Phosphorus	Magnesium	Sodium	Copper	Zinc	Iron
M-S (Control)	231.32^{f} ± 0.69	58.073^{a} ± 0.02	260.65^{d} ± 0.33	61.55^{d} ± 0.29	55.63^{d} ± 0.24	1.90^{a} ± 0.05	0.05^{g} ± 0.08	1.81^{g} ± 0.01
Mf-Sf	221.59^{g} ± 0.82	44.39^{i} ± 0.22	203.70^{g} ± 3.35	70.31^{c} ± 0.17	62.19^{c} ± 2.06	2.11^{f} ± 0.06	0.05^{g} ± 0.01	1.81^{g} ± 0.01
Mm-Sm	251.18^{de} ± 0.62	45.44^{g} ± 0.19	301.67^{cd} ± 1.30	70.31^{c} ± 0.15	40.75^{f} ± 013	3.21^{e} ± 0.11	0.95^{f} ± 0.03	1.30^{h} ± 0.07
Mc-Sc	281.42^{c} ± 0.78	46.23^{d} ± 0.12	282.03^{e} ± 1.12	71.39^{bc} ± 0.26	50.61^{e} ± 0.15	4.17^{c} ± 0.09	1.38^{cd} ± 0.08	2.27^{f} ± 0.11
Mf-SfB	201.31^{h} ± 0.66	46.05^{f} ± 0.43	251.47^{fg} ± 0.43	70.84^{c} ± 0.15	61.50^{c} ± 0.14	4.66^{bc} ± 0.08	1.65^{ab} ± 0.05	2.01^{g} ± 0.03
Mm-SmB	303.24^{b} ± 0.62	45.36 ± 0.29	321.20^{b} ± 0.12	72.62^{c} ± 0.24	65.25^{b} ± 0.07	5.11^{b} ± 0.06	1.74^{a} ± 0.08	2.77^{e} ± 0.04
Mc-ScB	331.92^{a} ± 0.54	46.10^{c} ± 0.27	326.17^{bc} ± 0.66	73.71^{c} ± 0.15	70.47^{a} ± 0.14	4.67^{c} ± 0.09	1.42^{c} ± 0.06	3.10^{d} ± 0.20
Mf-Sfse	321.36^{a} ± 0.72	46.78^{c} ± 0.07	291.09^{de} ± 0.54	70.99^{c} ± 0.27	71.34^{a} ± 0.11	4.39^{c} ± 0.14	1.28^{d} ± 0.08	3.28^{c} ± 0.08
Mm-Smse	302.28^{b} ± 0.46	58.23^{a} ± 0.14	305.94^{c} ± 0.46	70.33^{c} ± 0.11	72.43^{a} ± 0.16	3.76^{d}. ± 0.06	1.38^{cd} ± 0.08	3.44^{b} ± 0.11
Mc-Scse	306.11^{b} ± 0.58	57.68^{ab} ± 0.13	351.14^{ab} ± 0.51	75.69^{b} ± 0.23	71.80^{a} ± 0.11	7.01^{a} ± 0.03	1.54^{b} ± 0.14	3.52^{b} ± 0.07
Mf-SfBse	264.37^{d} ± 0.81	44.62^{h} ± 0.12	361.54^{a} ± 0.91	80.66^{ab} ± 0.29	60.67^{cd} ± 0.06	7.01^{a} ± 0.04	1.70^{a} ± 0.17	3.55^{b} ± 0.06
Mm-SmBse	240.84^{e} ± 0.42	46.10^{f} ± 0.05	362.53^{a} ± 0.25	85.52^{a} ± 0.26	66.61^{b} ± 0.17	4.0^{cd} ± 0.02	1.57^{b} ± 0.14	4.18^{a} ± 0.23
Mc-ScBse	242.77^{e} ± 0.41	57.17^{b} ± 0.04	299.70^{d} ± 0.15	79.90^{ab} ± 0.05	65.38^{b} ± 0.07	3.76^{d} ± 0.07	1.15^{e} ± 0.01	4.18^{a} ± 0.21

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

Key: >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 ratio of 70:30. (MfSfB, MmSmB, McScB, MfSfSe, MmSmSe and McScSe). >The same fractions fortified with 20% bambara groundnut and 10% sesame flours in the ratio of 70:20:10 (MfSfBSe, MmSmBSe and McScSe).

Mineral Composition of the Modified dakere

The order of dominance of elements in increasing concentration was P > K > Ca > Mg > Na > Fe > Zn > Cu and the variations (mg/100g) of P, K, Ca, Mg, Na, Fe, Zn, and Cu were 271.74-295.10, 218.74-268.24, 80.30-95.21, 73.19-79.06, 47.73-58.68, 8.46-9.13, 6.33-9.84, and 4.82-6.20 accordingly. McScBse (70:20:10) had higher amount of P (295.09mg/100g), K (268.24mg/100g), Ca (90.85mg/100g), Mg (78.42mg/100g) and Na (58.68mg/ 100g), for MmSmBSe (70:20:10) the values were: P (293.78mg/100g), K (266.37mg/100g), Ca (80.31mg100g), Mg (73.84mg/100g) and Na (58.38mg/100g), for M_fS_fBse (70:20:10): K (261.86mg/100g), P (292.927mg/100g),

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Ca (84.21mg/100g), Mg (74.49mg/100g) and Na (54.80mg/100g). Comparatively, da*kere* containing bambara groundnut such as M_fS_fB, MmSmB and McScB had lower values of macro and micro elements than those blends with both bambara groundnut and sesame, in addition to millet and sorghum flours. This could be attributed to combined effect of higher mineral contents in 70:20:10 blends. *Dakere* produced from blended fractions without fortification (MfSf, MmSm and McSc) contained lower amounts of both macro and micro minerals, lower than the control. The range of macro and micro elements obtained in this study is higher than reported by Mensar et al.(2003): K (212 to 244.50mg/100g), P (198 to 320.20mg/100g), Mg (50 to 61mg/100g) and Cu (2.5 to 3.5mg/100g). Zn (0.92 to 1.5mg/100g) Fe (1.2 to 2.0 mg/100g) for formulation and evaluation of cereal/legume based weaning supplements. Edet et al.(2017) reported higher mineral contents in the rice-acha-soybean noodles than in the untreated control. Here, McSc blended fraction had greater amounts of mineral than MfSf and MmSm. Potassium contents in M_fS_fSe, MmSmBSe and McScBSe all containing sesame were not higher in the fortified *dakere*. Magnesium levels (73.19-79.32mg/100g) and in McScB and McScBSe respectively 78.317 and 78.417mg/100g were higher than in others. Minerals are higher in the dakere than in the blends despite their moisture contents were equivalent. Apart from K and P, the level of other minerals could be said to be low. This may be associated with the effect of decortications and sieving in the process of flour extraction from the grains. This is due to the fact that majority of the mineral elements are contained in the bran or precarp and germ parts, thus decortication which removes the outercoats reduces the level of minerals and sieving that followed, further removes the residual bran and germ particles present in the unsieved flour, which further reduced the mineral content of *dakere*. Similarly, Sankararao et al. (1980); Pedersen and Eggum (1983) observed decline in the mineral contents with decortications and milling for flour of higher extraction.

Table 3. Mineral Composition (mg/100g)of Modified Dakere

Sample Codes	K	P	Mg	Na	Ca	Cu	Zn	Fe
M:S (1;1)	$256.48^{ab} \pm 1.60$	$282.57^{b} \pm 23$	$76.40^{c} \pm 2.06$	$50.16^{b} \pm 3.23$	$80.85^{c} \pm 7.08$	$5.55^{b} \pm 0.43$	$6.33^{e} \pm 0.23$	$8.46^{bc} \pm 0.28$
Mf-Sf(1:1)	$248.23^{b} \pm 7.55$	280.43 ± 5.52	$74.64^{d} \pm 5.55$	$59.87^{a} \pm 627$	$84.51^{bc} \pm 3.50$	$5.49^{bc} \pm 0.28$	$6.44^{e} \pm 0.021$	$8.96^{ab} \pm 0.09$
Mm-Mc(1:1)	$241.29^{b} \pm 5.19$	$279.92^{b} \pm 4.79$	$74.11^{d} \pm 0.45$	$46.75^{c} \pm 6.27$	85.13b$^{c} \pm 3.34$	$6.15^{a} \pm 0.02$	$6.75^{d} \pm 0.35$	8.58 ± 0.30
Mc-Sc(70:30)	$255.^{77c} \pm 2.41$	$271.74^{cd} \pm 0.78$	$77.54^{ab} \pm 0.49$	$48.73^{c} \pm 0.71$	88..43$^{b} \pm 0.24$	$5.70^{b} \pm 0.19$	7.43 ± 0.05	$8.50^{bc} \pm 0.30$
Mf-SfB(70-30)	$249.26^{ab} \pm 4.70$	$272.41^{d} \pm 1.50$	$77.45^{ab} \pm 0.72$	$48.73^{c} \pm 0.10$	$78.38^{cd} \pm 5.83$	$5.84^{ab} \pm 0.11$	$7.66^{b} \pm 0.03$	$8.56^{b} \pm 0.31$
Mm-SmB(70:30)	$252.93^{b} \pm 2.68$	$274.68^{cd} \pm 1.58$	$76.06^{c} \pm 1.27$	$58.10a \pm 9.97$	$87.03^{b} \pm 1.89$	$6.13^{a} \pm 0.58$	$7.75^{ab} \pm 0.11$	$9.10^{a} \pm 0.02$
Mc-ScB(70:30)	$234.13^{ab} \pm 3.48$	$279.41^{c} \pm 1.36$	$79.32^{a} \pm 0.27$	$48.44^{c} \pm 0.26$	$95.21^{a} \pm 0.55$	$6.18^{a} \pm 0.07$	$7.89^{ab} \pm 0.02$	$9.20^{a} \pm 0.09$
MfSfSe(70:30)	$218.74^{c} \pm 4.77$	$284.90^{b} \pm 1.08$	$73.52^{e} \pm 0.63$	$47.73^{b} \pm 0.22$	$94.86^{a} \pm 2.97$	$5.54^{b} \pm 0.29$	$7.59^{b} \pm 0.07$	$8.60^{b} \pm 0.22$
Mm-SmSe (70:30)	$245.77^{d} \pm 4.77$	$279.30^{c} \pm 3.76$	$73.19^{e} \pm 0.63$	$51.18^{b} \pm 3.43$	$87.14^{b} \pm 1.75$	$4.82^{bc} \pm 0.14$	$7.09^{cd} \pm 0.01$	$8.90^{ab} \pm 0.09$
Mc-ScSe(70:30)	$245.77^{b} \pm 1.85$	$290.29^{ab} \pm 0.56$	$74.10^{d} \pm 0.55$	$57.87^{ab} \pm 0.26$	$85.14^{bc} \pm 1.19$	$5.48^{bc} \pm 0.32$	$7.30^{c} \pm 0.07$	$9.13^{a} \pm 0.04$
Mf-SfBSe (70:20:10)	$261.86^{a} \pm 1.77$	$294.93^{a} \pm 0.44$	$74.49^{d} \pm 0.60$	$54.80a \pm 3.32$	84.21b$^{c} \pm 2.84$	$5.31^{c} \pm 0.02$	$7.12^{c} \pm 0.05$	$8.33^{bc} \pm 0.1$
Mm-SmBSe (70:20:10)	$266.37^{a} \pm 3.03$	$293.78^{a} \pm 0.87$	$74.84^{d} \pm 0.39$	$58.38^{a} \pm 0.10$	$80.30^{c} \pm 4.61$	$5.12^{d} \pm 0.20$	$7.19^{c} \pm 0.06$	$8.87^{ab} \pm 0.13$
Mc-ScBSe (70:20:10)	$268.24^{a} \pm 1.12$	$295.09^{a} \pm 0.64$	$78.42^{a} \pm 0.77$	$58.68^{a} \pm 0.27$	$90.85^{ab} \pm 2.77$	$6.20^{a} \pm 0.06$	$9.84^{a} \pm 0.05$	$9.14^{a} \pm 0.02$

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

Key: >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 ratio of 70:30. (MfSfB, MmSmB, McScB, MfSfSe, MmSmSe and McScSe). >The same fractions fortified with 20% bambara groundnut and 10% sesame flours in the ratio of 70:20:10 (MfSfBSe, MmSmBSe and McScSe).

Phytochemical Contents of the Modified *Dakere* and Control

Significant variations ($p \leq 0.05$) were observed in the tannin (3.276-6.53g/100g), phytate (0.41-0.887g/100g) and total phenolics (7.20-12.463g/100g) contents of the modified *dakere* and Control (MS). Higher concentrations were recorded in the *dakere* containing both bambara groundnut and sesame meal, more in McScBse. The control (MS) had the least level of the phytochemicals investigated indicating fortification with grain legumes at the same time increased the phytochemical contents of the modified *dakere*. The fine fractions (MfSf) and the control had the least content of phytochemicals. Fortification of the blended flour fractions increased the level of the antinutrients, highest levels were obtained in *dakere* contained both bambara groundnut and sesame seed meal; phytic acid content of cereals according to Coulibaly *et al*. (2011) is between 0.5g and 2g/100g. Tannins are not found in major cereals such as rice, maize, wheat but present in coarse cereals especially in sorghum with pigmented testa, tannins are known to reduce protein digestibility (Yuye Wu et al., 2012); for sorghum tannins content of 0.788-2.197 g/100g has been reported (Dyke and Rooney, 2007) and is the most abundant antinutrient in sorghum with multiple hydroxyl groups that form complexes with protein, metal ions and other macromolecules and thereby reduce their bioavailability. Reported total phenolics in cereals and legumes are 3.2-50.7mg/g and 17.0-21.9mg/g dried extract (Hung, 2016). Ramesh and Prakash (2020) reported lower amount of tannin and higher amount of phytic acid in fine amaranth flour fractions. Flour refining practices like dehulling, sieving helped to reduce the anti nutritional factors in the dakere, therefore values obtained in this study are less than reported values in the literatures. Some of the phytochemicals like tannin and phytate although interfere with digestion and absorption of minerals, protein and therefore called anti nutrients, but they are recently recognized as useful antioxidants (Brewer, 2015). The presence of antinutritient such as tannin imparts an astringent taste which affects palatability and thereto reduce food intake and consequently body growth (Elgailani and Ishak, 2014).

Table 4. Phytochemical Composition of Dakere

Sample Code	Tannin(g Tannic acid/100g)	Phytic acid (g/100g)	Total phenolics (g GAE/100g)
M:S (1;1)	$3.276^{g} \pm 0.06$	$0.46^{e} \pm 0.01$	$7.20^{f} \pm 0.02$
Mf-Sf(1:1)	$3.763^{f} \pm 0.06$	$0.50^{de} \pm 0.01$	$8.187^{e} \pm 0.02$
Mm-Sm(1:1)	$4.003^{de} \pm 0.09$	$0.42^{c} \pm 0.06$	$8.403^{cd} \pm 0.03$
Mc-Sc(70:30)	$4.217^{a} \pm 0.05$	$0.41^{c} \pm 0.06$	$8.843^{c} \pm 0.03$
Mf-SfB(70-30)	$5.257^{bc} \pm 0.07$ c	$0.513^{bc} \pm 0.01$	$8.57^{cd} \pm 0.06$
Mm-SmB(70:30)	$4.12^{d} \pm 0.06$	$0.54^{bc} \pm 0.01$	$8.553^{cd} \pm 0.02$

Mc-ScB(70:30)	4.42c ± 0.05	0.583[c] ± 0.08	8.767[c] ± 0.03
MfSfSe(70:30)	4.087[d] ± 0.05	0.62[c] ± 0.01	8.877[c] ± 0.01
Mm-SmSe (70:30)	4.203[c] ± 0.03	0.68[bc] ± 0.01	9.113[b] ± 057
Mc-ScSe(70:30)	5.78[b] ± 0.07	0.733[b] ± 0.02	9.227[b] ± 0.018
Mf-SfBSe (70:20:10)	6.21[ab] ± 0.32	0.887[a] ± 0.02	11.567[ab] ± 0.06
Mm-SmBSe (70:20:10)	6.117[ab] ± 0.05	0.84[a] ± 0.02	11.883[ab] ± 0.06
Mc-ScBSe (70:20:10)	6.53[a] ± 0.04	0.85[a] ± 0.01	12.463[a] ± 012

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

Key: GAE= gallic acid equivalent. >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 ratio of 70:30. (MfSfB, MmSmB, McScB, MfSfSe, MmSmSe and McScSe). >The same fractions fortified with 20% bambara groundnut and 10% sesame flours in the ratio of 70:20:10 (MfSfBSe, MmSmBSe and McScSe).

4. Conclusion

Phosphorous (P) and potassium (K) were the dominant elements in the grains, blends and the various modified dakere. The concentrations of sodium, calcium, magnesium, Iron, copper, zinc were lower in the blended unfortified fractions, indicating the mineral profile of modified dakere were enhanced, more in dakere containing grain legume flours. Observed values of antinutrients (phytate, tannin and total phenolics) were low, lower in the control and blended fine fraction (MfSf) indicating the beneficial effects of decortication, milling and flour fractionation, observed values of the antinutrients were low, less than reported values in the literature. Blended coarse fractions or their fortified equivalents showed greater mineral and antinutrient enhancement than other fractions. The study therefore, had successfully enhanced the levels of micro and macroelements in dakere through the use of blended similar fractions of millet and sorghum flours fortified with bambaragrounut and sesame flours.

Declarations

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Competing Interests Statement

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Consent for publication

Authors declare that they consented for the publication of this research work.

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