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Research Article

Effect of malted millet blends with defatted soybean and cinnamon flours on physiochemical and bioactive properties

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Abstract The study was on physiochemical and bioactive properties of malted millet blends with defatted soybean and cinnamon flour envisaged for porridge use. The proximate composition of the blend decreased with malting addition from millet but increased with soybean flour addition except in ash content. Moisture content ranged between 8.74-9.00%, crude protein 10.08-12.18% crude fiber 1.56-2.25%, ash 3.56-2.02% and crude fat content was 3.00-5.75%, respectively. The functional properties of the flour blends decreased as the inclusion of malted millet increased, but bulk density, swelling capacity, oil and water absorption capacities of the blends used as functional porridge increase with soybeans flour ration inclusion. The antioxidant and anti-diabetes properties of FRAP 0.85-0.47% and α-amylase 32.20-27.47 g/mL increased with millet malt addition but DPPH 44.68-53.66% and metal chelation 23.73-34.40% and α-glycosidase 21.49-34.37 g/mL was high as defatted soybean flour addition increased. Addition of defatted soybean flour on malted millet and cinnamon flour produced a noticeable effect on the sensory color, taste, flavor, texture, crispiness and overall acceptability on the porridge produced. Malted millet addition has less significant effect compared to defatted soybean flour in making functional and bioactive composite flour porridge production from millet malting, defatted soybean and cinnamon spice flour blends.

Keywords bioactives, malted millet, defatted soybean flour, cinnamon powder, functional property

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1. Introduction

Cereal grains such as oat, millet, barley, flaxseed, brown rice, acha, soy and their products are notified as the most common cereal based functional foods and nutraceuticals (Ahmed et al., 2014). These cereals could improve human health, prevent and reduce the risk factor for several nutritional diseases. The consumption of whole cereal grains is an excellent source of dietary fiber and nutraceuticals that are of benefit in the management of obesity and diabetes (Jideani and Jideani, 2011). There is need to utilize composite flour from cereal and legume sources geared for this research work to remedy nutritional deficiencies.

Millet grains are gluten-free, non-acid-forming and easy to digest with low glycemic index foods (Akinjayeju et al., 2019). Its low glycemic index property is reported to be better choice for people with celiac disease and diabetes, because consumption of the millet grain assist in the regulation of blood glucose and level. Millets are unique among the cereals because they are rich in dietary fibers, polyphones and proteins. They have been reported to effect free radical quenching potentials (Devi et al., 2014). Cinnamon is a spice obtained from the inner bark of tree species, genus cinnamon. Cinnamon is used mainly as an aromatic condiment and flavoring additive in a wide variety of cuisines, sweet and savory dishes, as breakfast cereals, snack foods, teas, and traditional foods. The research on functional ingredients in food is not only limited to phytochemicals, but also the revelation of new effects of traditional nutritional ingredients or spices such as cinnamon flour; which has become a traditional functional spice (Dong, 2019). Hence, the need for inclusion of cinnamon in this work, because of the flour high protein content, balanced essential amino acid profile, and the presence of other beneficial bio-nutrients, that has brought to light cinnamon, as economic and nutritional value ingredients. Soybeans are high in protein content, vitamins, minerals and insoluble fiber. This oil seed is viewed as equivalent to creature nourishment in protein quality, yet it is believed that plant proteins are prepared diversely to creature proteins. It has been reported that soybeans are helpful in preventing diarrhea, constipation and diabetes as reported from the health sector of the economy (Cristina et a., 2011; Kang et al., 2017). The study and use of this composite flour will lead to a surge in its use in the baking and confectionery cottage industries as well as in making stiff and moist porridges at home and in vulnerable, displaced homes and places.

2. Materials and methods

2.1. Materials and petreatments

Millet, cinnamon and soybean were purchased from Ondo central market and identified at the Herbarium Unit, Department of Botany, Obafemi Awolowo University, Ile-Ife, Nigeria. Malted millet was processed following the method described by Ogunjemilusi et al. (2022) and Sighn et al. (2012). Malted millet flour was obtained by cleaning whole millet flour to remove extraneous materials. It was soaked and spread in a soaked bag for sprouting before kilning and eventually dry milled, sieved and packaged as shown in the preparation of malted millet flour as reported by Alka et al. (2012) and Ogungemilusi et al. (2022). The process of kilning at 40℃ was to arrest the enzymes in action during sprouting and prevent further actions.

2.2. Preparation of defatted soybeans flour

Defatted soybeans flour was processed following the method described in flow diagram on def-fated soybean flour as described by Kang et al. (2017) and Ogunjemilusi et al. (2020). The soybeans was cleaned from dirt by sorting out contaminants such as sands and any other evident impurities, crack, dehulled, milled and extracted with solvent through FDS (flash desolventising system) technology, then the cake was dry milled and sieved into fine flour, by passing them through 2 mm mesh sieve as shown flow diagram on def-fated soybean flour. The heating and milling process was to orient the molecular protein to enhance functional properties. Table 1 shows blend proportion used for the formulation from defatted soybean flour.

2.3. Preparation of cinnamon flour

The Cinnamon barks was cleaned from dirt by sorting out contaminants such as sands and any other evident impurities then washed and oven dried. The barks were dried and milled using attrition mill (SK-30-SS, Munson Mach Co, Utica, NY, USA) and sieved into fine flour, by passing them through a 0.35 mm mesh sieve as shown in the preparation of cinnamon flour before packaging. Table 1 shows blending proportions used for the formulation from cinnamon flour.

2.4. Determination of functional properties malted millet blends with defatted soybean and cinnamon flours

The water absorption, oil absorption, and swelling capacity of the flour blends [MDSCB1, millet flour (75%) + defatted soybeans flour (20%) + cinamon flours (5%); MDSCB2, millet flour (65%) + defatted soybeans flour (30%) + cinamon flours (5%); MDSCB3, millet flour (55%) + defatted soybeans flour (40%) + cinamon flours (5%)] as shown in Table 1 were determined at room temperature following the AACC (2005) method. The method described by Okezi and Bello (1988) were used to determine the packed and loosed bulk

Table 1. Blend ratios and formulation of malted millet with defatted soybean and cinnamon flours

Samples	Malted millet (%)	Defatted soybean (%)	Cinnamon flour (%)
MDSCB1	Malted millet flour (75)	Defatted soybeans flour (20)	Cinnamon flour (5)
MDSCB2	Malted millet flour (65)	Defatted soybeans flour (30)	Cinnamon flour (5)
MDSCB3	Malted millet flour (55)	Defatted soybeans flour (40)	Cinnamon flour (5)

densities of the flour.

2.5. Determination of proximate composition of malted millet blends with defatted soybean and cinnamon flours

Following the procedure described by AOAC (2005), the proximate composition of the flour blends as shown in Table 1 was determined.

2.6. Determination of antioxidant properties of malted millet blends with defatted soybean and cinnamon flours

DPPH radical scavanging ability was determined according to the method described by Pownall et al. (2010). The method described by Benzie and strain (1999) was applied to calculate the FRAP of flour blends in Table 1. The approach outlined by Singh and Kumar (2022) was employed for the metal chelating ability assay.

2.7. Assay of anti-diabetic properties of malted millet blends with defatted soybean and cinnamon flours

The α-glucosidase inhibition was accomplished by the use of a slightly modified version of the approach outlined by McCue et al. (2005). A technique described by Giancarlo et al. (2006) was used to determine the α-amylase inhibition of the flour blends in Table 1.

2.8. Sensory analysis

A nine-point hedonic scale was used as described by Iwe and Onuh (2009) with an approved Reference code wesy-023 on the 2nd of September, 2022 by the Sensory Department Wesley University Ondo. The panelists for the sensory test were students and lecturers at the Department of Fod Science and Technology, Wesley University Ondo. Nigeria. Trained panelists were asked to rate each sensory characteristic of the coded porridge of defatted soybean and malted millet mixture with added cinnamon powder on a scale from extremely liking (9) to extremely disliking (1).

2.9. Statistical analysis

All values are mean±SD (n=3) from three readings. Data were analyzed statistically using analysis of variance (SPSS version 2.0) technique. Values with level of significance within mean was separated using the Duncan's multiple range test (Steel and Torrie, 1980).

3. Results and discussion

3.1. Proximate composition of malted millet blends with defatted soybean and cinnamon flours

Table 2 shows the proximate composition of the blends. The values of moisture content for the flours used for producing the composite flour in this study are 7.86% in malted millet flour, 8.27% in soy flour, and 6.15% in cinnamon flour. The moisture contents of combined mixture of malted millet, defatted soy, and cinnamon flour were 8.74-9.00% with the highest value in sample 55% (malted millet flour + 40% defatted soybean flour + 5% cinnamon flour) MDSCB3 (9.00%). Moisture content obtained from this study was higher than the range of moisture (3.34-4.06%) reported by Ikuomola et al. (2017) but lower than those obtained by (Ndife et al., 2014), which ranged from 7.24-9.80% for wheat and full fat soybeans cookies. The crude protein content of

Table 2. Proximate composition of malted millet blends with defatted soybean and cinnamon flours

Proximate composition (%)	Malted millet blends[1)]		
	MDSCB1	MDSCB2	MDSCB3
Moisture content	8.74±0.06[2)b]	8.82±0.03[b]	9.00±0.03[a]
Crude protein content	10.08±0.03[c]	11.00±0.04[b]	12.18±0.03[a]
Crude fat content	3.00±0.04[c]	3.58±0.05[b]	5.75±0.03[a]
Ash content	3.56±0.03[a]	2.81±0.03[b]	2.02±0.04[b]
Crude fibre content	1.56±0.04[c]	1.85±0.03[b]	2.25±0.06[a]

[1)]MDSCB1, millet flour (75%) + defatted soybeans flour (20%) + cinamon flours (5%); MDSCB2, millet flour (65%) + defatted soybeans flour (30%) + cinamon flours (5%); MDSCB3, millet flour (55%) + defatted soybeans flour (40%) + cinamon flours (5%).
[2)]Values are mean±SD (n=3). Means with different superscript letters ([a-c]) in the same row are significantly different ($p<0.05$) by Duncan multiple range test.

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the flours that make up the composite flour are 9.45% for malted mullet flour, 9.13% for defatted soy flour and 2.61% for cinnamon flour. The crude protein values in Table 2 showed a significant ($p<0.05$) decrease with millet malting maybe due to heat effect on protein natures. Protein content also ranged between 10.08-12.18% for samples having malted millet flour as its main flour MDSCB1, 3 with MDSCB3 having the highest values. The crude fiber ranged was 1.56-2.25% in 75% malted Millet flour+20% defatted soybean flour+5% cinnamon flour MDSCB1 samples. The inclusion of rootlets and shoots during milling of germinated grains also appears to increase the fiber content of the malted millet flour (Muyanja et al., 2003). The increase agrees with the research work done by Ogbonna et al. (2012) which showed increase in crude fiber in sorghum grist after malting. Low quantities of ash obtained in MDSCB1 samples is an indication of its low mineral contents as the ash content decreased from 3.56-2.02% which was caused by uptake during malting. An increase in the ash contents with an increase in defatted soybeans flour is an indication of nutrient enhancement by defatted soybeans and cinnamon flours. This agreed with the findings of Jakhetia et al. (2010). Also, the fat content value for the MDSCB1 samples ranged between 3.00-5.75%. MDSCB3 had the highest value due to increased inclusion of defatted soybeans flour.

3.2. Functional properties of malted millet blends with defatted soybean and cinnamon flours

The defatted soybean flour had its bulk density as 0.66 g/mL and malted millet flour as 0.71 g/mL. The bulk density for MDSCB1 samples ranged from 0.64-0.73 g/mL. The bulk density (BD) improved significantly for pearl millet with increase in the level of soybean and cinnamon flour. The Table 3 results indicated that supplementation of pearl millet with soybean and cinnamon flour improved significantly ($p\leq 0.05$) the bulk density of millet composite flour. The values obtained could be slightly compared to the value (0.52-0.68 g/mL) of bulk density for plantain-soybeans-cinnamon blended flour (Adegunwa et al., 2019).

The swelling capacities (SC) of the blends increased with increase in swelling temperature. The water absorption capacity (WAC) of the flour ranged from 167.67-187.67 g/g in MDSCB1 samples while the oil absorption capacity (OAC) of MMF samples ranged from 120-125 g/g. The OAC and WAC values of the MDSCB1 samples increased as the inclusion of cinnamon and defatted soybeans flour increased. The result obtained is close to that obtained by Awolu et al. (2015) for rice, cassava and kersting’s groundnut composite flour, that falls in the range of 1.53-2.23 g/mL obtained by Awolu et al. (2017) for millet flour fortified with soybeans and tiger nut flour. Meanwhile, there was significant difference ($p<0.05$) between the flour formulations. Awolu et al. (2015) reported OAC ranging from 1.75-2.21 g/mL for rice, cassava and kersting’s groundnut composite flour. Variation in oil absorption capacity might be due to the different proportion of the protein molecules present in each of the samples. The temperatures for swelling capacity are 70, 80, and 90°C. The values of SC obtained in this study were ranged from

Table 3. Functional properties of malted millet blends with defatted soybean and cinnamon flours

Properties[1)]	Malted millet blends[2)]		
	MDSCB1	MDSCB2	MDSCB3
Bulk density (g/mL)	$0.64\pm0.03^{3)c}$	0.69 ± 0.02^{b}	0.73 ± 0.01^{a}
WAC (g/mL)	167.7 ± 1.15^{c}	182.7 ± 2.31^{b}	187.7 ± 1.8^{a}
OAC (g/mL)	120.3 ± 1.55^{c}	122.3 ± 2.5^{b}	125.7 ± 0.06^{a}
SC (%) at 70°C	297 ± 1.00^{a}	299.7 ± 2.08^{a}	300 ± 1.00^{a}
SC (%) at 80°C	397 ± 1.15^{c}	406.7 ± 2.08^{b}	410 ± 1.50^{a}
SC (%) at 90°C	365 ± 0.57^{b}	437 ± 1.00^{a}	441 ± 2.31^{a}

[1)]Bulk density g/mL; WAC, water absorption capacity; OAC, oil absorption capacity; SC 70°C, swelling capacity at 70°C water; SC 80°C, swelling capacity at 80°C; SC 90°C, swelling capacity at 90°C.
[2)]MDSCB1, millet flour (75%) + defatted soybeans flour (20%) + cinamon flours (5%); MDSCB2, millet flour (65%) + defatted soybeans flour (30%) + cinamon flours (5%); MDSCB3, millet flour (55%) + defatted soybeans flour (40%) + cinamon flours (5%).
[3)]Values are mean±SD (n=3). Means with different superscript letters ($^{a-c}$) in the same row are significantly different ($p<0.05$) by Duncan’s multiple range test.

297-300% in MDSCB1, 3 samples at 70℃; 397-410% in MDSCB1, 3 samples at 80℃, and 365-441% in MDSCB1, 3 samples at 90℃.

3.3. Antioxidant properties of malted millet blends with defatted soybean and cinnamon flours

DPPH scavenging activity ranged from 44.68-53.06% for MDSCB1 samples. It was observed that sample MDSCB3 had the highest value 53.05% of DPPH. Hence, exhibit the highest ability to scavenge free radicals. The results obtained in the present study on Table 4 are higher than those reported by Adefegha and Oboh (2013) for wheat–bambara flour blends and cookies made from un malted millet flour, defatted soybean and cinnamon flours blend. The ability to reduce Fe^{3+} to Fe^{2+} by the blended flours decreases with decrease in supplementation with malted millet flour and increase with defatted soybeans flour which may be attributed to the ability of incorporated soy defatted soybean flour to form reductant that could react with the free radicals thereby stabilizing and terminating the radical chain (Moktan et al., 2011). The metal chelating ability of the blends revealed that MDSCB3 exhibit the highest metal chelating ability. This implies that combination of malted millet, defatted soybeans flour at 40% level and cinnamon flour at 5% level is the best in terms of sequestering or chelating metals in the blends. The result suggests that the blends possess an average potency to chelate metal. Following this observation, Sample MDSCB3 reported the highest value, which could be due to the possible high contents of hydrophobic amino acids.

3.4. α-Amylase and α-gucosidase inhibition activities of malted millet blends with defatted soybean and cinnamon flours

On Table 4, the results depict that percentage inhibition was concentration dependent. MDSCB3 and MDSCB2 at 0.1 concentration had the least inhibitory activity 27.47% and 24.64%, respectively. Percentage α-amylase inhibition increased with increase in supplementation with soybeans and decrease in malt from millet flour. However, MDSCB1 exhibited the highest α- amylase inhibitory activity (32.20%). There were significance differences between the percentage α-amylase and α-glucosidase inhibitory activity of samples. This discovery in this study agreed with previous reports which ascertained that plant phytochemicals and underutilized legumes inhibited salivary and pancreatic α-amylase activities (Ademiluyi and Oboh, 2012; Nickavar and Yousefian, 2009). Sample MDSCB3 had the highest value of α-glycosidase amongst all, hence could inhibit disaccharide breakdown and absorption within the mucosal wall linings.

3.5. Sensory characteristics of malted millet blends with with defatted soybean and cinnamon flours

Addition of defatted soybeans flour and cinnamon to malted millet flour produced a noticeable effect on color, taste, flavor, texture, crispiness and overall acceptability on the blends produced on Table 5. Gruel produced from 55:40:5 had higher sensory characteristics in the malted millet samples except for aroma. Among the porridge produced, sensory scores increased with an increase in the addition of

Table 4. Antioxidant and anti-diabetic properties of malted millet blends with defatted soybean and cinnamon flours

Properties[1)]	Malted millet blends[2)]		
	MDSCB1	MDSCB2	MDSCB3
DPPH scavenging activity (%)	44.68±0.41[3)]^{b}	44.91±0.21^{b}	53.06±0.83^{a}
FRAP (%)	0.85±0.01^{a}	0.73±0.01^{b}	0.47±0.05^{c}
Metal chelation (%)	23.73±0.65^{c}	31.86±0.58^{b}	34.40±0.32^{a}
α-Amylase inhibition (%)	32.20±0.19^{a}	31.46±0.06^{b}	27.47±0.05^{c}
α-Gucosidase inhibition (%)	21.49±0.07^{c}	24.65±0.08^{b}	34.37±0.05^{a}

[1)]DPPH, 2,2-diphenyl-1-picryl hydrazyl; FRAP, ferric reducing antioxidant property; metal chelation; α-amylase inhibition; α–glucosidase inhibition.
[2)]MDSCB1, millet flour (75%) + defatted soybeans flour (20%) + cinamon flours (5%); MDSCB2, millet flour (65%) + defatted soybeans flour (30%) + cinamon flours (5%); MDSCB3, millet flour (55%) + defatted soybeans flour (40%) + cinamon flours (5%).
[3)]Values are mean±SD (n=3). Means with different superscript letters ($^{a-c}$) in the same row are significantly different ($p<0.05$) by Duncan's multiple range test.

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Table 5. Sensory properties (scores) of porridge from malted millet blends with defatted soybean and cinnamon flours

Samples[1)]	Appearance	Aroma	Taste	Flavor	Color	Acceptability
MDSCB1	6.00±1.31[2)b]	8.13±0.92[a]	5.20±1.16[c]	5.26±0.82[c]	7.18±0.74[c]	7.60±0.74[b]
MDSCB2	7.60±1.55[a]	8.07±1.03[a]	7.07±0.88[ab]	6.93±1.53[b]	7.23±0.88[b]	7.8±0.56[a]
MDSCB3	7.63±0.9[a]	7.93±1.03[ab]	7.80±1.01[a]	7.53±1.19[a]	7.4±0.74[a]	7.93±0.70[a]

[1)]MDSCB1, millet flour (75%) + defatted soybeans flour (20%) + cinamon flours (5%); MDSCB2, millet flour (65%) + defatted soybeans flour (30%) + cinamon flours (5%); MDSCB3, millet flour (55%) + defatted soybeans flour (40%) + cinamon flours (5%).
[2)]Values are mean±SD (n=3). Means with different superscript letters ([a-c]) in each column are significantly different ($p<0.05$) by Duncan's multiple range test.

defatted soybeans flour with MDSCB1 having the least acceptability (See Table 5). However, there was a decrease in the values for aroma scores in MDSCB3 samples. This could be the effect of malting on millet flour used. The sensory scores for taste ranged from 5.20-7.80 for MDSCB1-3 samples, respectively. The increase in the values for each group could be due to the increase in the inclusion of defatted soybeans flour, which added to appearance and the Taste. Flavor scores for the cookies ranged from 5.26-7.53 in MDSCB1-3 samples. The brown color resulting from Maillard reaction and inclusion of defatted soybeans and cinnamon flour were responsible for the chocolate cookies obtained though Maillard reaction is always associated with baked food products. The MDSCB3 blend with 40% replacement with defatted soybean flour had the highest overall acceptability. The result confirmed that taste, color, flavor and crispiness as an important effect on overall acceptability.

4. Conclusions

Malting brought about an appreciable increase in fiber, and some functional properties in the malted millet inclusive blended samples. Malted millet high blended flours at 75% inclusion were found to posses certain excellent radical and alpha amylase inhibition potentials which may have free radical abstraction and prevention of glucose generation to guts. Therefore, inclusion of malted millet flour at 75% and defatted soybean flour at 40% inclusion independently are needed to potentiate the blend ration as functional ingredient in making food with certain and acceptable flow consistencies. The sample MDSCB3 had the best physiochemical and bioactive properties that could be advocated for adults and children. Further research is required for evaluating the effects of this malted millet blends on baking and confectionary products.

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Conflict of interests

The authors declare no potential conflicts of interest.

Author contributions

Conceptualization: Ogunjemilusi MA. Methodology: Ogunjemilusi MA. Formal analysis: Friday OA. Validation: Ogunjemilusi MA, Friday OA. Writing - original draft: Ogunjemilusi MA. Writing - review & editing: Friday OA.

Ethics approval

An approved reference code WESY-023 on the 2nd of September, 2022 by the sensory Department Wesley University Ondo, Nigeria.

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