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Review Article

Production and Assessment of Bio Functional Cookies from Millet and Defatted Soya bean Flour Blends, Spiced with Cinnamon powder

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Abstract

The use of millet flour defatted soya bean flour blends spiced with cinnamon flour in the production of functional cookies was studied. Functional cookies were produced using processed millet flour and defatted soybean flour blends with cinnamon flour in the labelled ratios: UMMF-1: 75% MF:20%DSF:5%CF, UMMF-2: 65% MF:30%DSF:5%CF and UMMF-3: 55% MF:40%DSF:5%CF respectively. The whole MF served as control. The functional characteristics and proximate composition of the composite flours before cookies production and after production of functional cookies were determined. The study evaluated the nutritional, antioxidant, and anti-diabetic properties of blends from Millet, Defatted Soya beans and Cinnamon flours. The crude protein content of the experimental samples ranged between 10.27 % and 13.54 %. The crude fiber of the samples ranged from 2.54-4.0 %. The ash content for the experimental composite flour ranged from 2.10- 2.39 % while the ash content of millet, defatted soybeans and cinnamon flours are 2.78 %, 3.86 % and 2.29 % respectively. The fat content ranged from 3.18 %- 6.10 %. However, the functional properties of the flour blends increased as the inclusion of soybeans flour increased after evaluating the bulk density, swelling capacity, oil and water absorption capacity of the blends used for the functional cookies. There was also increase in the nutritional properties of the functional cookies as the inclusion of soya beans flour increased. The protein content of the functional cookie's samples ranged from (13.03-17.17) %. fiber content increased from (2.39-3.18) %, fat content ranged between (8.33-12.55) % and ash content ranged between (3.21 to 5.03) %. The cookies antioxidant DPPH, FRAP and metal chelation ranged from (51.64 -48.39) %, (0.66-0.92) % and (30.45-31.96) % respectively. Anti-diabetes inhibition of the functional cookie's samples increased with increase in supplementation with soya beans flour and inclusion of cinnamon flour which has diabetic inhibition properties. Addition of defatted soya beans flour and cinnamon to unmalted millet flour produced a noticeable effect on color, taste, flavor, texture, crispiness, and overall acceptability on the cookies produced.

Key Words: millet flour; defatted soybean flour; cinnamon flour; functional; cookies; anti-oxidant; anti-diabetes nutrition; sensory properties

Introduction

Functional food goes by many closely related definitions around the world [7]. One point of view is that functional food has a significant physiological effect on human health as it can be a source of essential nutrients [14]. If a food has the claim of improving health and associated with therapies, it is known as functional food. The latest trend in food industry is the incorporation of other flours form other plant sources in producing a functional food and this is due plant source for bioactive diets is on the high demand. There is increasing use of legume and cereals in production of functional cookies due to their health benefits and ability to reduce risk from several Nutritional and non-nutritional diseases (Ayo et al., 2018). Millet grains are gluten-free, non-acid-forming, easy to digest with low glycemic index foods which is known to be good for people with celiac and diabetes patients, this is because the consumption of this grain assist in the regulation of blood glucose level. The millet grains are substantially rich in dietary fiber, carbohydrates, iron, and calcium. The grain is also rich in phytochemicals, including phytic acid, which is believed to lower cholesterol, associated with reduced cancer risk. Cinnamon is a spice from bark of Cinnamomum. Though, it is a condiment but investigation into its health benefit and phytochemical presence proved to be a functional spice. The research on functional ingredients in food is not only limited to phytochemicals, but also the revelation of new effects of traditional nutritional ingredients such as cinnamon flour [16]. Hence, the need for the inclusion of cinnamon in this work. Cinnamon is known to have strong antioxidant activity which correlates well with the phenolic compounds and essential oil. Cinnamon has been reported to have anti-inflammatory, antimicrobial, antibacterial, antitumor, cardiovascular, cholesterol-lowering, immunomodulatory, larvicidal, and antioxidant properties [13]. Soybean is a valuable crop worldwide mainly because of soybean meal's nutritional efficacy as a food and feed ingredient. It has high protein content, balanced essential amino acid profile, and the presence of other beneficial nutrients all contribute to its economic and nutritional value. The key advantages of soya are its high protein content, vitamins, minerals, and insoluble fiber. Soybeans are helpful in preventing diarrhea, constipation, and diabetes in the health sector of the economy [15]. The general objective of the study is to obtain a low glycemic index flour blend from millet, soybeans and cinnamon and utilize it to produce functional cookies with a view to make functional cookies readily available for diabetic patients, celiac patient, and a view to reducing dependence on wheat.

Materials and Methods

Materials

Millet flour, defatted soya beans flour, cinnamon, date (natural sweetener) butter, milk powder, salt, water, butter essence, baking powder, calcium propionate were materials ingredients used in the production of the functional cookies.

Preparation of Samples

Preparation of Whole Millet Flour

Whole millet flour was obtained by cleaning to remove dirt, stones, and other extraneous materials. It was dry milled, sieved and packaged as shown in **figure 1.**

Figure 1: Flow diagram for the production of Millet Flour

Preparation of Defatted Soya beans flour

The soya beans were 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 is dry milled and sieved into fine flour, by passing them through a 2 mm mesh sieve as shown in **Figure 2.**

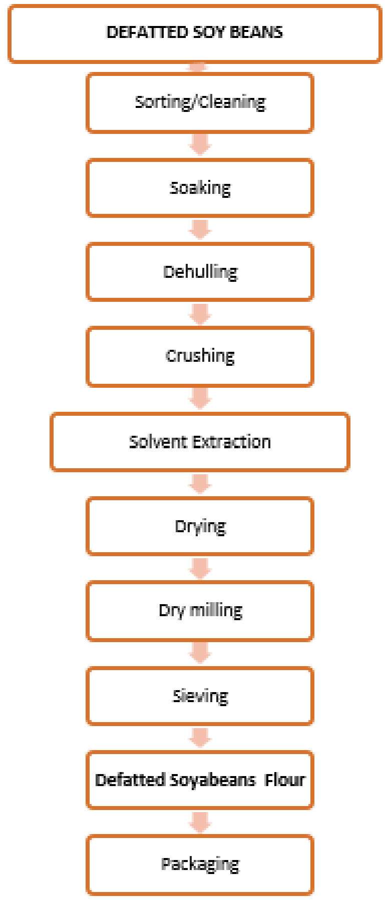


Figure 2: Flow diagram for the production of Soyabeans flour

Preparation of Cinnamon powder

The Cinnamon barks will be cleaned from dirt by sorting out contaminants such as sands and any other evident impurities, then washed and oven dried. The barks will be dried and milled using attrition mill and sieved into fine flour, by passing them through a 0.35 mm mesh sieve as shown in **figure 3.**

MF- Millet flour; DSF- Defatted Soybeans flour; CF- Cinnamon flour

Figure 3: Flow diagram for the production of Cinnamon flour

Preparation of Functional cookies

The development of functional cookies was adopted as given by [32] with slight modifications.

Ingredient (g/100g flour)	Blend 1	Blend 2	Blend 3
MF	75	60	55
CF	5	5	5
DSF Corn starch	20 20	30 20	40 20
Milk	13	13	13
Date (Natural sweetener)	27	27	27
Whole egg	10	10	10
Butter	7	7	7
Water	20	20	20
Baking Powder	3.0	3.0	3.0

Table 1. The Formulation of Cookies Blend

Ingredient (g/100g flour)	Blend 1	Blend 2	Blend 3
MF	75	60	55
CF	5	5	5
DSF **Corn starch**	20 20	30 20	40 20
Milk	13	13	13
Date (Natural sweetener)	27	27	27
Whole egg	10	10	10
Butter	7	7	7
Water	20	20	20
Baking Powder	3.0	3.0	3.0

(Weight of ingredients shown as percentage of flour weight)

MF- Millet flour; DSF- Defatted Soybeans flour; CF- Cinnamon flour

Table 2 Formulation of Cookies using Millet, Defatted Soyabeans and Cinnamon Flour Blends.

Functional Properties of cookies

Water absorption capacity (WAC)

The WAC will be determined at room temperature following the [30] method.

Oil absorption capacity (OAC)

The OAC will be determined at room temperature following the [30] method.

Swelling capacity index

The method of [31] with slight modification was used to determine the swelling power of all samples

Packed Bulk Density

The packed bulk density of the flour samples was determined according to the method of [4]

Proximate Analysis

The proximate composition of the cookies will be determined. Their moisture, crude protein (N × 6.25), fat, ash and fiber contents will be determined by standard procedures [8] and the total carbohydrate will be calculated by difference. All analyses will be carried out in triplicates.

Antioxidant Properties Determination

2, 2-diphenyl-2-picrylhydrazyl hydrate; ferric reducing antioxidant power and metal chelating assay were determined in sequence.

2, 2- diphenyl-2-picrylhydrazyl hydrate (DPPH) assay

The radical scavenging ability of the samples was determined using the stable radical DPPH (2, 2-diphenyl-2-picrylhydrazyl hydrate) as described by [23].

Determination of Ferric reducing antioxidant power (FRAP)

The principle of FRAP method will be based on the reduction of a colorless ferric tripyridyltriazine complex to its blue ferrous colored form due to the donation of electron by antioxidant compounds. The ferric reducing antioxidant power (FRAP) assay was carried out according to the method of [27].

Metal chelating ability assay

The metal-chelating assay of the samples will be carried out according to the method of [29]

Anti-diabetic properties

Inhibition of α-glucosidase activity

This assay was carried out using the method described by [9] with slight modification.

Inhibition of α-amylase activity

The α-amylase inhibition assay was carried out according to the method of [33]

Result and Discussion

Proximate Composition of Millet, Defatted Soya and Cinnamon and their Blends

The proximate composition of millet, defatted soya beans and cinnamon flours are represented on **Table 3.** The value of the moisture content for the flours used for producing the composite flour for this study are reported as 8.45 % for unmalted millet flour 8.27 % for soya flour and 6.15 % for cinnamon flour. The moisture content of combined mixture of unmalted millet, defatted soya and cinnamon flour is between the range of (8.83% – 9.11%) with the highest value in sample UMMF-3 (9.11%) and the lowest value in sample UMMF-1 (8.83%). Moisture contents obtained from this study is higher than range of moisture (3.34-4.06%) reported by [18] but lower than those obtained by [21] that ranged from 7.24 – 9.80% for wheat and full fat soybeans cookies. This observation implies that the spoilage period of the flour would be longer, since the moisture content of the flour samples were very low for the activity of microorganisms; and this finding agreed with other reports for flour samples [11][6]

The crude protein content of the flours that make up the composite flour are 9.69 % for millet flour, 9.13 % for defatted soya flour and 2.61 % for cinnamon flour. The crude protein content of the experimental samples ranged between 10.27 % and 13.54 % for samples having unmalted millet flour as its main flour (UMMF1-3). UMMF-3 had the highest protein value of 13.54 %. This observation could be attributed to the inclusion of defatted soya flour, which is good source of protein [11]. It is evident that composites flour from grain and legumes usually increased the protein quality of the overall desired products.

The crude fiber for the flours that make up the composite are 3.79 % for millet flour 6.57% for soya beans flour and 28.42 % for cinnamon flour. The crude fiber of the samples ranged from 2.54-4.0 % in MF samples. Nutritionally, consumption of these experimental dough meals from malted millet flour would be of benefits to the consumers, since evidence have shown that dietary fibers promote good health by prevent degenerative diseases like diabetes and hypertension [22]. It is expected that the high content of crude fiber in cinnamon and soyabeans should have great influence on the experimental flour samples. However, the values obtained could be because of the 5% level of cinnamon flour added and varied quantities of the defatted soya beans flour.

SAMPLE	MOISTURE	FIBRE	ASH	PROTEIN	FAT	Carbohydrate
MF	8.45±0.32^{d}	3.79±0.06^{d}	2.78±0.13^{b}	9.69±0.06^{e}	1.38±0.04^{e}	73.91^{a}
DSF	8.27±0.04^{d}	6.57±0.06^{b}	3.86±0.03^{a}	9.13±0.07^{a}	2.20±1.39^{d}	69.97^{c}
CIN	6.15±0.07^{e}	23.42±0.11^{a}	2.29±0.04^{c}	2.61±0.02^{f}	3.70±0.20^{c}	61.83^{e}
UMMF-1	8.83±0.08^{bc}	2.54±0.03^{e}	2.10±0.04^{d}	10.27±0.03^{d}	3.18±0.06^{c}	73.08^{a}
UMMF-2	8.95±0.04^{a}	2.88±0.04^{d}	2.28±0.04^{c}	11.07±0.02^{c}	4.67±0.03^{b}	70.15^{b}
UMMF-3	9.11±0.03^{ab}	4.0±0.03^{c}	2.39±0.03^{c}	13.54±0.05^{b}	6.10±0.03^{a}	64.86^{d}

MF- Millet flour; DSF- Defatted Soybeans flour; CF- Cinnamon flour, UMMF-1: 75% MF+20%DSF+5%CF; UMMF-2: 65% MF+30%DSF+5%CF; UMMF-3: 55% MF+40%DSF+5%CF

Table 3: Proximate Composition of Millet, Defatted Soya beans, Cinnamon flours and their Functional Blends

The ash content for the experimental composite flour ranged from 2.10- 2.39 % while the ash content of millet, defatted soyabeans and cinnamon flours are 2.78 %, 3.86 % and 2.29 % respectively. An increase was observed in the value of the ash content. The ash content gives a measure of the total amount of inorganic compounds like minerals present in a sample. An increase in the ash contents with an increase in defatted soyabeans flour is an indication of nutrient enhancement by defatted soyabeans and cinnamon. This agrees with the findings of [19]

The fat content values increased with increase in quantities of defatted soyabeans and cinnamon flours incorporated. This in concordance with the findings on plantain, groundnut, and cinnamon flour blends by [3] (1.96 % - 8.57 %). A high value of 3.7 % for cinnamon flour and 2.2 % flour was observed. For UMMF samples, the fat content ranged from 3.18 %- 6.10 %. However, Crude fat determines the free fatty lipids of a product. Higher crude fat content indicates that the composite flour may be good sources of fat-soluble vitamins.

Correspondingly, another study by [17] found in Cinnamon, the content of moisture, protein, fat, carbohydrates, fibre and ash ranged as 5.1%, 3.5%, 4.0%, 52%, 33.0, 2.4% and respectively.

Functional Properties of Millet, Defatted Soyabeans and Cinnamon Functional Blends

The results of the functional properties of millet, defatted soya-cinnamon composite blends are presented in Table 4. The defatted soyabeans flour had its bulk density as 0.66 g/ml and millet flour as 0.59 g/ml. The bulk density (BD) improved significantly for the composite flour with increasing the level of soybean and cinnamon flour. The results indicated that supplementation of millet with soybean and cinnamon flour improved significantly ($P \leq 0.05$) the bulk density of millet. The bulk density for UMMF samples ranged from 0.59-0.70 g/ml. The values obtained could be slightly compared to the value of bulk density for plantain-soyabeans-cinnamon flour (0.52 to 0.68 g/ml) by [2]. However, values obtained from this study were comparable with the

values reported by [26] for cowpea (0.60 g/ml) and also for pearl millet as reported by [29]. The differences in the values of bulk density between this study and previous ones are likely due to be product and varietal differences [12].

The water absorption capacity (WAC) of UMMF samples ranged from 165-174 %. An increase trend was observed for the oil absorption capacity. With increase in the formulation there happens a more starch damage than 100% millet flour by blending process. With high proportion of starch damage, water absorption rises, and it realizes high starch gelatinization and finally the crumb becomes softer. The WAC and OAC values of the MMF samples increased as the inclusion of CIN and DSF increased which agrees with the findings of [2,3].

The oil absorption capacity (OAC) of UMMF samples ranged from 147- 117 %. The OAC values of the MMF samples increased as the inclusion of CIN and DSF increased. Though, the oil-absorption capacity of all flour blends suggests that it is not useful for baking alone but would also be useful in formulation of foods where oil absorption property is an important consideration. [10] reported OAC ranging from 1.75 to 2.21 g/g for rice, cassava and 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 swelling capacity of flours depends on size of particles, types of variety and types of processing methods or unit operations. The temperatures for determining the swelling capacity of the experimental flour samples varied with the three different temperatures used. The temperatures used were 70, 80, 90^{o}C. The values of swelling capacity obtained in this study ranged from 198.67 to 226.33 % for UMMF samples at 70 °C, 229-239 % for MF samples at 80 °C and 237 – 334.7 % for MF samples at 90 °C. The swelling capacity of defatted soya flour also ranged from 233-286 % as temperature increased. It was also noted that as temperature increased, the swelling capacity of the flour increased. The result obtained might be due to the different proportion of the protein molecules present in each of the samples [11].

SAMPLE	B.D (g/ml)	WAC (%)	OAC (%)	S.C 70 (%)	S.C 80 (%)	S.C 90 (%)
MF	0.59±0.01^{d}	184±1.00^{bc}	189.7±1.53^{cd}	206.3±1.53^{d}	236±0.26^{g}	253.7±1.53^{de}
DSF	0.66±0.06^{cd}	195±2.08^{a}	122.3±1.73^{a}	233.3±2.31^{b}	275±0.06^{g}	286±2.00^{de}
UMMF1	0.59±0.02^{d}	165±2.52^{e}	147.3±1.15^{b}	198.7±1.53^{d}	229±1.15^{h}	237±1.00^{f}
UMMF2	0.67±0.02^{cde}	174±3.56^{d}	120.7±1.53^{de}	222±2.00^{d}	232±2.00^{h}	311±1.15^{cd}
UMMF3	0.70±0.02^{bc}	186.7±3.21^{c}	117±4.35^{e}	226±2.89^{c}	239±2.08^{f}	334.7±2.08^{bc}

MF- Millet flour; DSF- Defatted Soybeans flour; CF- Cinnamon flour, UMM-F1: 75% MF+20%DSF+5%CF; UMMF-2: 65% MF+30%DSF+5%CF; UMMF-3: 55% MF+40%DSF+5%CF

Table 4: Functional Properties of Millet, Soya Beans Cinnamon flours and Functional blends.

Proximate Composition of Functional Cookies produced from Millet, Defatted Soyabeans and Cinnamon Flour Blends

The study was carried out to understand the influence of blend ratio (millet: defatted soya: cinnamon flour), upon the nutritional and Overall acceptability of cookies. The prime objective of defatted soy flour and cinnamon flour incorporation in preparation of composite flour for the functional cookies was to enhance its nutritional value, its anti-diabetic properties, antioxidant properties. Hence, during present investigation, cookies prepared with different concentration of defatted soy flour and cinnamon at 5 % for all samples were analyzed for its proximate composition and the obtained results are given in Table 5. It could be seen from the Table 3 that increase in concentration of DSF in cookies has significant effect on its proximate composition.

The moisture content of cookies decreased linearly with increase in concentration of DSF, this may be attributed to high water binding capacity of DSF which is retaining higher moisture content in ultimate product. There was no significant difference ($p < 0.05$) in the moisture content of the samples. The moisture content for the MF cookies samples decreased from 5.43-5.08%. Low moisture content is important in cookies production as it limits the water available for microbial activity and thereby resulting into a stable product with longer shelf life. The values obtained are close to those obtained by [20] for sorghum-soybean-finger millet biscuits who observed there was decrease from 3.78% to 3.27% while substitution of soybean flour from 10% to 50%.

The protein content of the cookies increased with increasing in the percentage substitution of soybean flour in the cookie's dough blends. The increase in the protein content of the cookies could be due to the significant quantity of protein in soybean seeds. Soybeans have been reported to be a good source of cheap protein. The protein content of the UMMF cookies samples ranged from 13.03-17.17 %. These values are higher than the protein content (7.06% to 11.84%) of sorghum-wheat composite flour biscuits reported by Adebowale et al., (2012).

SAMPLE (Cookies)	MOISTURE (%)	FIBRE (%)	ASH (%)	PROTEIN (%)	FAT (%)	CARBOHYDRATE (%)
MF	8.45±0.32d	3.79±0.06d	2.78±0.13b	9.69±0.06e	1.38±0.04e	73.91a
UMMF1	5.43±0.25^{b}	2.39±0.00^{c}	3.21±0.68^{a}	13.03±0.29^{a}	8.53±0.24^{c}	70.04±0.48^{d}
UMMF2	5.38±0.88^{ab}	2.58±0.00^{b}	3.83±0.71^{b}	13.47±0.58^{c}	10.43±0.10^{b}	73.75±0.35^{bc}
UMMF3	5.08±0.35^{ab}	3.18±0.00^{a}	5.03±0.05^{c}	17.17±0.57^{a}	12.53±0.01^{a}	73.08±0.61^{c}

UMMF1: 75% UMMF+20%DSF+5%CF; UMMF2: 65% UMMF+30%DSF+5%CF; UMMF3: 55% UMMF+40%DSF+5%CF

Table 5: Proximate Composition of the Functional cookies

The fiber content of the UMMF cookies samples increased from 2.39-3.18 % as the defatted soyabeans inclusion increased from 20% to 40%. Nutritionally, consumption of these experimental dough meals from malted millet flour would be of benefits to the consumers, because evidence have shown that dietary fibers promote good health by prevent degenerative diseases like diabetes and hypertension [22]. Cinnamon has high fiber content. Therefore, the inclusion of cinnamon in composite flour for cookies

enhanced its nutritional constituents and hold the potential to deliver safe foods for obese, hypertensive, diabetic patients, and patients with colon disease.

The fat content values increased with increase in quantities of soyabeans flour incorporated. The fat content for UMMF cookies samples ranged between 8.33-12.55 %. Though a defatted soya beans flour was used in the study but it still contains essential fatty acid. Legumes are said to contain oil. The other ingredients used to produce cookies such as margarine could contribute to the fat content. The values obtained in this study for fat are lower than the values (17.61-20.54 %) reported by [2, 3] to produce cookies from plantain, groundnut, and cinnamon blends.

The ash content ranged from 3.21 to 5.03 for UMMF cookies. Ash is indicative of the amount of minerals contained in any food sample. Hence, UMMF cookies sample may have high mineral contents when analyzed for it. Carbohydrate contents are generally high. This will have good energy effects.

Antioxidant Properties of the functional Cookies

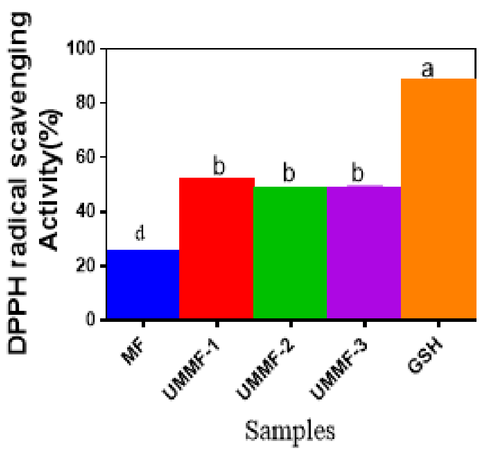
The results of antioxidants activities of the cookies are presented in Table 4. a, b and c. The cookies were evaluated for DPPH, metal chelating ability and ferric reducing antioxidant power (FRAP). The free radical scavenging activities of the cookie's extracts were concentration dependent for the antioxidant properties evaluated.

DPPH scavenging activity as shown in Fig 4 a, ranged from 51.64% to 48.39% of functional cookies samples. UMMF-1 (51.64%), UMMF-2

(48.86%) and UMMF-3 (48.39%) also exhibited significantly high radical scavenging activities. The formulated cookies (were observed to scavenge the DPPH better. The results obtained in the present study are higher than those reported by [1] for wheat–Bambara cookies.

Unmalted cookies sample showed progressive increase in FRAP as the soyabeans and cinnamon flour inclusion increased. This shows the potency of the cereal not malted with antioxidant ability to scavenge free radicals. The ability to reduce Fe3+ to Fe2+ by the cookies increased with increase in supplementation with soyabeans and cinnamon flour which may be attributed to the ability of incorporated cinnamon and soyabeans flour to form reductants that could react with the free radicals thereby stabilizing and terminating the radical chain [24]

A



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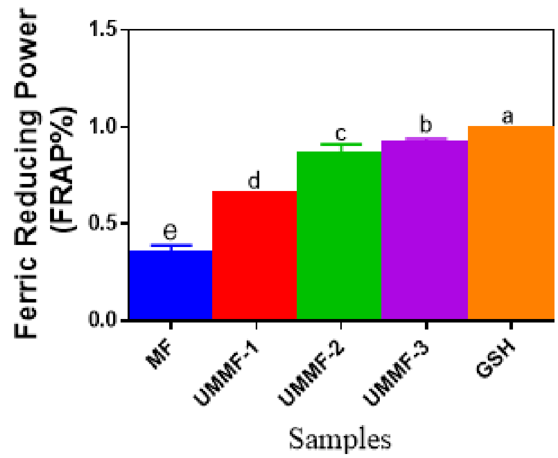

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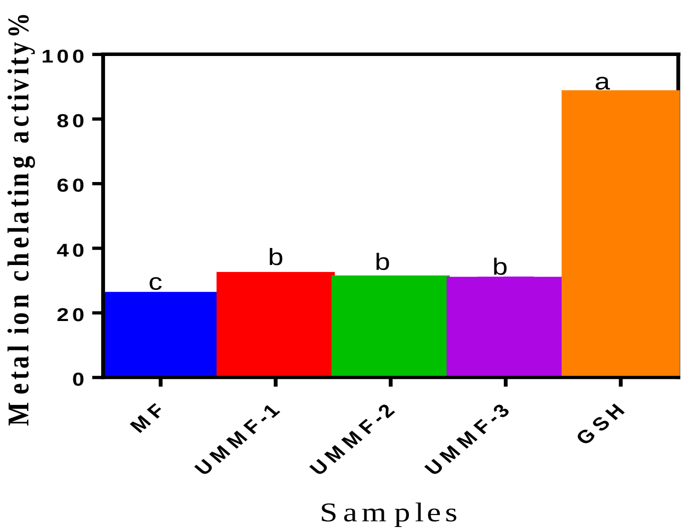


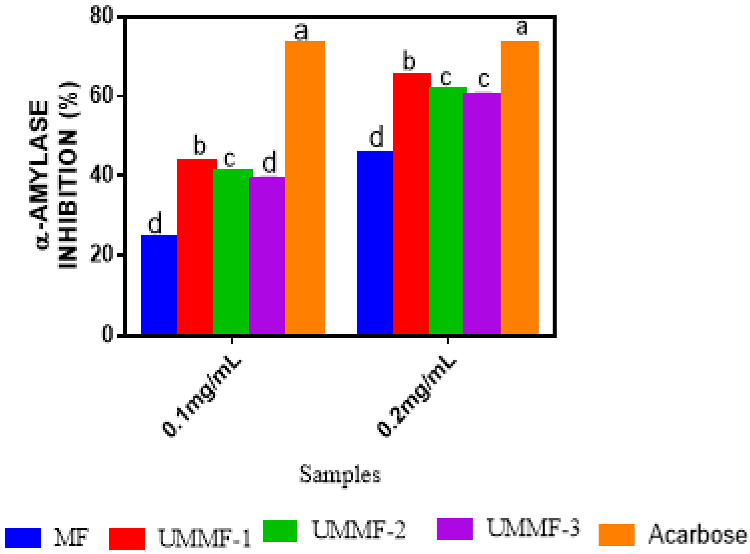
UMMF-1: 75% UMMF+20%DSF+5%CF;
UMMF-2: 65% UMMF+30%DSF+5%CF;
UMMF-3: 55% UMMF+40%DSF+5%CF

Inhibition of α-amylase and α-glucosidase activities α-amylase inhibition

The percentage α-amylase inhibition of millet-soyabeans-cinnamon is presented in Fig 5. The result depicts that percentage inhibition was concentration dependent. It was observed that MF had higher values indicating the millet also has high potency to inhibit amylase with UMMF-1 showing inhibitory activity of 44.09 % at 0.1 mg/mL concentration and 68.86% at 0.2 mg/concentration. This discovery in this study agrees with previous reports which ascertained that plant phytochemicals and certain amino acids could inhibited α-amylase activities [5][25]. The results obtained for alpha amylase inhibition in this study is similar to (23.59 - 54.22%) values obtained by Olagunju et al., 2018 [34] from the development of value-added nutritious crackers with high antidiabetic properties from blends of Acha (Digitaria exilis) and blanched Pigeon pea (Cajanus cajan)

The percentage α-glucosidase inhibition of millet-soyabeans-cinnamon cookies is presented in Fig 6. The results depict that percentage inhibition was concentration dependent as activities increased with increase in concentration of cookies extract, and higher concentration (10 mg/ml) was required to achieve significant inhibitory activity. Enzyme inhibition for functional cookies samples increased with increase in supplementation with soyabeans flour. The functional cookies samples ranged between (38.36-44.09%) decreased as the proportion of the millet flour reduced because millet flour had significant alpha glucosidase inhibitory ability.

Consequently, UMMF-3 showed the highest α-glucosidase inhibition potential. [5] reported a high α-glucosidase inhibition activity in some legumes studied. Their study also speculated that plant-based α-amylase and α-glucosidase may help lower postprandial hyperglycemia by partially inhibiting the enzymatic hydrolysis of complex carbohydrate which may delay the rapid absorption of glucose. The supplementation of the cookies with defatted soyabean flour and cinnamon flour may be responsible for the good digestive enzyme inhibitory activity of the functional cookies. The enzyme inhibitory activity is concentration dependent and when compared to the efficacy of the α –amylase and α –glucosidase of the functional cookies from blends of millet, defatted soyabeans and cinnamon with acarbose, it showed that the samples at 0.2 mg/mL concentration dose are better when compared to the value for acarbose 73.31% as control standard. Hence, the functional cookies have anti-diabetic properties and can be consumed by diabetic patients.



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