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Research Article

Partial replacement of cocoa nibs with sorghum malt in chocolate: An evaluation of the blends' chemical compositions and sensory profiles

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Abstract: Sorghum is widely grown in Nigeria, but scientific data is sparse about the replacement of cocoa nibs with sorghum malt in chocolate production. The nutritional colour, Fourier Transform Infrared Spectroscopy (FTIR) spectrum bands and sensory characteristics of plain chocolate and chocolate barsamples partially replaced with malted sorghum grits were evaluated. The level of replacement with malted sorghum in the chocolate-sorghum malt blends varied from 10-50%.The protein content of the samples reduced with increased replacement of cocoa nibs with malted sorghum, varied from 7.29% (10% inclusion) to 6.27% (50% inclusion) while the control sample had 8.05%. The crude fat, fibre, ash, moisture and carbohydrate content of the samples varied from 34.46-38.10, 2.51-1.17, 2.68-2.43, 5.76-1.41 and 47.2-48.84 respectively. The control sample had crude fat and carbohydrates values higher than the values obtained in the malted sorghum chocolate samples. The L* colour characteristics ranges from 29.23-36.27 (10-50% inclusion), and the control sample had 34.11. The colour characteristics of the malted sorghum chocolate revealed a reduction in the darkness of the samples with increased inclusion of the sorghum malt. The *a and*b colour characteristics varied significantly from 12.86 - 27.22. There was no profound difference between the atomic spectrum plain chocolate sample and malted sorghum chocolate samples. The sensory results showed that there are significant differences in the taste (6.4- 8.1) and overall acceptability (6.8 - 8.5) of the samples. The acceptance of the malted sorghum chocolate samples beyond 20% was almost in-achievable.

Keywords: Sorghum Malt, Cocoa, Chocolate, Spectroscopy, Quality Attributes

1. INTRODUCTION

The utilization of malt and its extracts in the production of different foods and beverages ranges from breakfast cereals, cookies, bakery products, milk and confectioneries etc (Tricase *et. al.,* 2018). Malt is most importantly used as a source of yeast-fermentable sugars for the production of alcoholic beverages, most importantly in the manufacture of beer. For lager production, kilned malts are used. Although in the production of beer, brewers use barley, in recent times, other sources (sorghum and some other cereal crops like guinea corn and millets) have been explored for malts production. The expensive nature of barley and the competitive nature of its supply which perhaps add to the cost of production and consequent increase in prices resulted in the utilization of other sources of malts from other cereals. However, the utilization of sorghum malts in beverages had been established by Beta *et al.* (1995).

Lipid oxidation is responsible for the changes in the quality attributes of foods such as aroma, taste, color, texture, and nutritional value. Antioxidants are compounds having the ability to prevent or delay oxidation reactions that lead to off-flavor development during processing and storage. Chocolate possesses antioxidant properties which are linked to the prevention of cancer, cardiovascular disease and anti-obesity effects (Doss, 2005). Chocolate contains antioxidants

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having health promoting properties (Aroyeun & Jayeola, 2016). Naturally occurring components of cocoa with antioxidant activity are mainly polyphenols (catechin, and phenolic acids), epicatechin and epicatechin gallate (Ogbonna *et. al,* 2012). Other naturally occurring antioxidants of cocoa include thiols, carotenoids and vitamins such as ascorbic acid (Ogbonna *et. al,* 2012). The amount of these compounds in cocoa bean depend on the variety, location, period of production, fermentation methods, climatic factors, among others (Ogbonna *et. al,* 2012). Carotenoids and ascorbic acid are effective antioxidants but they change as a result of processing (Ogbonna *et. al,* 2012). Malt contains antioxidants which are beneficial to consumers` health, thereby preventing and neutralizing oxidizing reactions that are associated with various diseases (Landete, 2013). Majority of works on chocolate centered on thermo resistance chocolate, which is suitable for the tropics. This is because chocolate consumption is common in Europe and other temperate countries which favour the melting of chocolate at room temperature. Different spices had been used to enhance the nutritional and the antioxidant properties of chocolate (Asif, 2015). Other researchers had also used peanuts, hazelnuts, walnuts and other fruit pulses in chocolate products. However, due to dearth of knowledge in the utilization of sorghum malt in chocolate production, this study becomes necessary to fill the gap in knowledge. This work was carried out to establish the influence of partial replacement of cocoa nibs with malted sorghum grits in chocolate production.

2. MATERIALS AND METHODS

2.1 Chemicals and reagents

Analytical grade chemicalswere used. Ferulic acid (4-hydroxy-3-methoxycinnamic acid), 2,2′-azinobis(3-ethylbenzothiazoline-6-sulfonic acid) diammo- nium salt (ABTS), potassium persulfate, glacial acetic acid, sodium acetate trihydrate, sodium dihydrogen orthophosphate dehydrate, di- potassium hydrogen orthophosphate, ethyl acetate, hydrochloric acid, potassium chloride, and sodium sulfate were obtained from Sigma (Poole, U.K.). Methanol was obtained from Merck (Darmstadt, Germany). Disodium fluorescein and sodium tetraborate decahydrate were obtained from Fluka (Gillingham, U.K.). 2, 2′-Azobis (2-amidinopropane) dihydrochloride (AAPH) was obtained from Aldrich (Gillingham, U.K.). Water of high-purity was produced in-house throughout the production of chocolate bars.

2.2 Preparation of sorghum malt

Sorghum grains were purchased from Oja Oba markets in Ibadan, Nigeria.Sorghum malt was prepared following the process reported by Aroyeun *et al.* (2019). The grains were soaked in water and the bad ones were removed which floatedon the water surface. After soaking for 24 hrs at room temperature, the grains were drained and left in baskets for 10 to 12 h in order to allow shoots initiation (pre-germination). The grains were then spread out in thin layer (3-5 cm thickness), covered and germinated during 72 hrs. The grains were watered at 6 hours interval for 72 hours, and germinated grains were dried inside the forced-air oven at 50°C for 24 h for drying. Winnowing was done in order to clean the dried malt by removing the roots and shoots. The flow chart for the modified malt production process is described below:

Sorghum Grains
↓
Soaking (24 h) and removal of floating grains
↓
Draining
↓
Pre-germination in basket (10 – 12 h)
↓
Germination
↓
Drying (500C for 24 h)
↓
Winnowing
↓
Sorghum malt

Figure 1: Modified Sorghum Malt Production Process
Source: Aroyeun *et al.* (2019)

2.3 Malted Chocolate Processing

Roasting of the fermented and dried beans was done in a circular roaster (JafInox, Sao Paulo, Brazil) at 120° C for 1 hour. Afterwards, the roasted beans were crushed and the shell and germ (cocoa nibs) were removed. The nibs were ground in a knife mill and refined sugar was added for sweetening. The cocoa mass was refined in a five-roll mill to yield optimal particle size for the cocoa liquor. The refined mass and other ingredients of chocolate were mixed during conching operation and the weight was taken. The incorporation of sorghum malt was based on different combination such as 10:90, 20:80, 30:70, 40:60, 50:50 (w/w) of the sorghum malt powder and the liquor. Conching operation was carried out in accordance with the method of Aroyeun and Jayeola (2018). The chocolate was tempered in a shaking platform brand, until it reach a temperature of 29-30°C (30minutes) to form stable crystals of cocoa butter. The chocolate was molded in a 5g bars polyethylene former. The chocolates were then cooled, packaged in wrap-able laminates (polyethylene-aluminum foil) and stored at - 4°C to - 6°C prior to further analyses. The flow chart of chocolate processing is shown in Figure 2:

Cocoa Pods
↓
Breaking
↓
Fermentation-5-7 days
↓
Roasting 1 Hours at 120°C
↓
Deshelling
↓
Grinding of malted sorghum
↓
Mixing with ingredients (Sugar, milk, lecithin) (at 68-70°C for30minutes)
↓
Refining (1Hour)
↓
Conching- 64-65°C (4hours)
↓
Tempering 29-30°C (30minutes)
↓
Molding
↓
Freezing (- 4°C to -6°C)   Wrapping/labeling

Figure 2: Flow Chart for Melted Chocolate Production
Source: Aroyeun & Jayeola (2018)

2.4 Proximate Analysis

Proximate analyses were carried out on the malted sorghum chocolate samples using standard AOAC (2005) methods. After drying at 105oC to constant weight in an air oven (Thermo Scientific-UT 6200, Germany), the moisture content was calculated. Lipids were estimated by continuous extraction of known weight of samples with petroleum ether, using rapid Soxhlet extraction apparatus (Gerhardt Soxtherm SE-416, Germany). Protein determination of the malted sorghum chocolate samples was by Kjeldahl method. The nitrogen values' efficiency was corrected with acetanilide values and multiplied by the factor of 6.25 to obtain the protein value. Ash content was determined gravimetrically after incinerating the samples in a muffle furnace (Carbolite AAF-11/18, UK) for 24 h at 550oC. Crude fibre was obtained by difference after the incineration of the insoluble materials contained in the ash-less filter paper by the hydrolysis and washing of moisture free defatted sample (0.5 g). The carbohydrate content was calculated by weight difference.Energy (Kcal/g) was calculated using the Atwater factor of 4.0 Kcal/g for protein and carbohydrate and 9 Kcal/g for fat.

2.5 Colour Analysis

Colour determination for each sample was done with the portable Minolta Chroma meter CR (Minolta, Osaka, Japan). The Lab values followed the Hunter Lab color scale.

2.6 Fourier Transform Infrared Spectroscopy (FTIR)

For the FTIR analysis, 2 g of the samples were frozen for 24 hours at− 20 °C. The frozen samples were lyophilized for 30 h.afterwards the FTIR spectra of chocolate and cocoa beans were recorded on a Digilab Excalibur, series FTS 3000 (United States), coupled with an attenuated total reflectance (ATR) accessory, equipped with a ZnSe reflection crystal. The spectra were acquired at room temperature with 32 scans/sample in the range of 4400 to 600 cm−1 at a resolution of 4cm−1, using Origin 8.0 software

2.7 Sensory Properties

The sensory properties were carried out to determine the colour, taste, texture, aroma and the overall acceptability of the chocolate bars using 9 points hedonic scale.

3. RESULTS AND DISCUSSION

From the statistical analyses, all the chemical properties measured varied significantly ($p < 0.05$) among the chocolate samples produced with different supplementation of sorghum malt in the recipe. In table 1, the proximate chemical composition of the chocolates such as the crude protein, crude fibre, total ash, moisture content, and crude fat differed significantly ($p < 0.05$) with an increase in the levels of the sorghum malt added. The average protein of the control chocolate (plain) was 8.05%, whereas that of chocolate supplemented with malted sorghum varied as follows: The protein values varied from 7.29 for 10%, 6.97% for 20%, 6.58% for 30%, 6.37% for 40% and 6.27% for 50% sorghum malt supplementation respectively. This indicates a decrease in the protein content with an increase in the level of supplementation. The implication of this was that an increase in sorghum malt leads to protein reduction in the partially supplemented malt sorghum chocolate samples. The decrease in protein content observed might be due to the increase in moisture content exhibited by the samples, while malted sorghum inclusion increased.A possible explanation for this is that an increase in moisturehas an implication on protein content;hence, leading to protein degradation. This was also reported byAjobieweet al. (2019), who worked on the effect of malting on sorghum and maize for weaning food production. Contrarily, Hounhouiganet al. (2011) reported an increase in the protein content of sprouted sorghum. The % crude fibre for the control chocolate sample was 1.17% and for other supplemented levels, it varied from 2.51for 10% sorghum malt addition, 2.55 - 2.64 for others (Table 1).This result shows that the crude fibre of the control sample was lower than the crude fibre value of the sorghum malted samples.This might be attributed to increased bran matter and the building of dry matter during the growth and development (germination) of the plant (Chima et.al, 2012). Also, there was an increase in the crude fibre with an increase in supplementation. This is a desirable result as fibre control of food has several health benefits, especially for gastrointestinal problem. The total ash of the control was 2.43% and it increased significantly from 2.68 at 10% level of inclusion to 2.91 at the 50% sorghum malt supplementation. As for the % crude fat, the control chocolate sample had the highest crude fat content while the samples in which sorghum malt has been supplemented increased steadily and significantly with the increased amount of sorghum malt powder. The chocolate sample containing the least inclusion seemed to have the lowest amount of crude fat. Although, at these levels, the effect on the crude fat of the chocolate was not significant, while the significance was observed only at 50% sorghum malt inclusion. This might be due to the fat content in sorghum malt, which reflected in the crude fat of the chocolate.

Table 1: Proximate Chemical Composition of Chocolate Supplemented with Sorghum Malt

Sample	Crude Protein (%)	Crude Fat (%)	Crude Fibre (%)	Ash (%)	Moisture (%)	%Dry Matter	Carbohydrate (%)
A	7.29±0.05[d]	34.46±1.00[a]	2.51±0.02[b]	2.68±0.05[a]	5.76±0.02[b]	94.24±0.02[a]	47.20±0.06[a]
B	6.97±0.09[c]	34.53±0.09[ab]	2.55±0.01[b]	2.73±0.02[a]	5.81±0.01[b]	94.19±0.03	47.51±0.09[ab]
C	6.58±0.07[b]	34.61±1.02[a]	2.57±0.11[b]	2.77±0.01[a]	5.93±0.03[b]	94.27±0.02 [a]	47.64±0.08[abc]
D	6.37±0.05[a]	35.28±1.15[ab]	2.62±0.01[b]	2.84±0.02[a]	5.72±0.02[b]	94.28±0.01[a]	48.51±0.05[bc]
E	6.27±0.04[a]	35.79±0.07[b]	2.64±0.04[b]	2.91±0.03[a]	5.97±0.01[b]	94.03±0.01[a]	49.06±0.10[bc]
F	8.05±0.08[e]	38.10±0.03[c]	1.17±0.03[a]	2.43±0.01[a]	1.41±0.02[a]	98.59±0.04[a]	48.84±0.12[c]

% carbohydrate = 100 – (% protein+% fat+% crude fibre + % ash + % moisture); % dry matter = 100 -% moisture. A(10% sorghum malt: 90% cocoa nibs), B (20% sorghum malt: 80% cocoa nibs), C (30% sorghum malt: 70% cocoa nibs), D ((40% sorghum malt: 60% cocoa nibs)), E (50% sorghum malt: 50% cocoa nibs) and F (control samples)

3.1 Colour Characteristics

This colour characteristics of chocolate supplemented with sorghum malt is presented in Table 2. Changes in colour parameters L* of chocolate with sorghum malt is a function of aesthetic value. The L* value increased significantly from 10% to the 50% sorghum malt inclusion in the order: control> 10% < 20% < 30% < 40% < 50%, representing 34.11 %, 29.23%, 32.15%, 35.06%, 35.69% and 36.27% in values respectively. A different trend was observed in a* values with the values reducing from the control by 10% inclusion up to 50%. The values for the b* increased from the control up to 50% inclusion. Lower L* value indicated reduced darkness and lower b* value suggested increasing yellowness. This result was not in agreement with the findings of Aroyeun and Jayeola (2016), who reported that the addition of green tea extract to chocolate increased the darkness of the chocolate and reduced its yellowness.Butthis is in line with the observation of Wang (2000), who reported an increase in L* values of commercially packaged dark chocolate. Worthy to note is the formation of large white spots on the surface of the chocolate known as fat bloom as observed by Wang (2000) in his findings which was absent in the present study. The freshness of the chocolate and the implication of a fat bloom formation were well recognized. A well-tempered chocolate, placed under good storage will tend towards reduced yellowness value as reported by Aroyeun and Jayeola (2018).

Table 2: Colour Characteristics of Chocolate Supplemented with Sorghum Malt

Sample	L*	a*	b*
A	29.23±0.10[a]	24.02±0.13[d]	19.06±0.14[a]
B	32.15±0.16[b]	21.12±0.10[c]	19.81±0.15[ab]
C	35.06±0.17[c]	14.73±0.11[b]	21.37±0.19[bc]
D	35.69±0.13[c]	13.26±0.15[ab]	21.79±0.24[c]
E	36.27±0.11[c]	12.86±0.21[a]	21.98±0.20[c]
F	34.11±0.12[bc]	27.22±0.17[e]	19.03±0.18[a]

A (10% sorghum malt: 90% cocoa nibs), B (20% Sorghum malt: 80% Cocoa nibs), C (30% sorghum malt: 70% cocoa nibs), D ((40% sorghum malt: 60% cocoa nibs)), E (50% sorghum malt: 50% cocoa nibs) and F (control samples)

3.2 The FTIR Spectroscopy of Malted Sorghum Chocolate Samples

The FTIR of the samples are shown in figures 3 -8. The FTIR of the malted sorghum chocolate was necessary to obtain the functional groups contained in the samples. The wavelengths (broad) of the samples ranged between 3558-683 cm-1. The water absorption bands of all the samples were between 3558-3327 cm-1 (O-H groups) and 1655 cm-1 (H-OH stretching), and these are in accordance with the literature, which reported a waveband in the regions between 3650-3000 and 1680-1600 cm-1 (Hop *et al.*, 1993; Inon *et al.,* 2003). Also, Golubstova (2017) reported that the frequency range between 3800-2600 cm-1, mostly contained valence fluctuation frequencies of OH groups (including inter and intra molecular hydrogen bonds) and also CH2 and CH3 groups. The frequencies between 1800- 1200cm-1 indicated the characteristic frequencies of the valence vibrations of C=O and –C=O deformation vibrations of methylene and methyl groups as well as –OH groups. The maximum peak frequencies for all the samples appeared between the frequency range 2500 – 2000 cm-1. with sample A (2125 cm-1.), having the highest peak frequency within the range 2500 – 2000 cm-1. This was followed by B, D and F, having the same frequencies (2121 cm-1) and C showed the least value within this range. This frequency shows the vibration of terminal alkyne group (CΞC group). The bands observed in the regions 2921-2851 cm−1 was related to the aromatic ring (attributed to the stretch of the CH of aromatic ring).

The frequency vibrations of the samples at 3558cm-1, implied an internally bonded OH stretching; while the frequencies observed at 3327 cm-1 indicated a normal polymeric OH stretch.

The result obtained shows fluctuations associated with C-O-H groups at frequencies 1279, 1346,1369, 1439, 992, 683 and 724 cm-1 (which fall between the range 1450- 1250, 992–680 cm−1 (attributed to angular deformation of CH of aromatic ring)). Frequencies between 1007-1346 fell within the range reported by Golubstova (2017)(1000-1075, 1260-1350cm-1) for primary alcohols. Frequencies 1030-1125 are for secondary alcohols, chocolate samples with this range were in frequencies range between 1052-1119 cm-1. Phenols were in the 3562-3322 (O-H stretch), 1244-1064 (C-H stretch) 2925 -2854 (C-H aromatic ring), 992-680 (C-H aromatic ring of angular deformation) 1645-1544(C-C stretch aromatic ring) cm-1(Barbosa, 2007; Silverstein *et al.,* 2006). Malted chocolate samples bands were within these phenol ranges as follows 3558,3383 and 3331-3324 (O-H stretch), 1212-1071 (C-H stretch) 2921 (C-H aromatic ring), 992-683 (C-H aromatic ring of angular deformation) cm-1 Frequency 1238 cm-1 were assigned to Amide group of the protein molecules (C-N stretching and N-H bending).

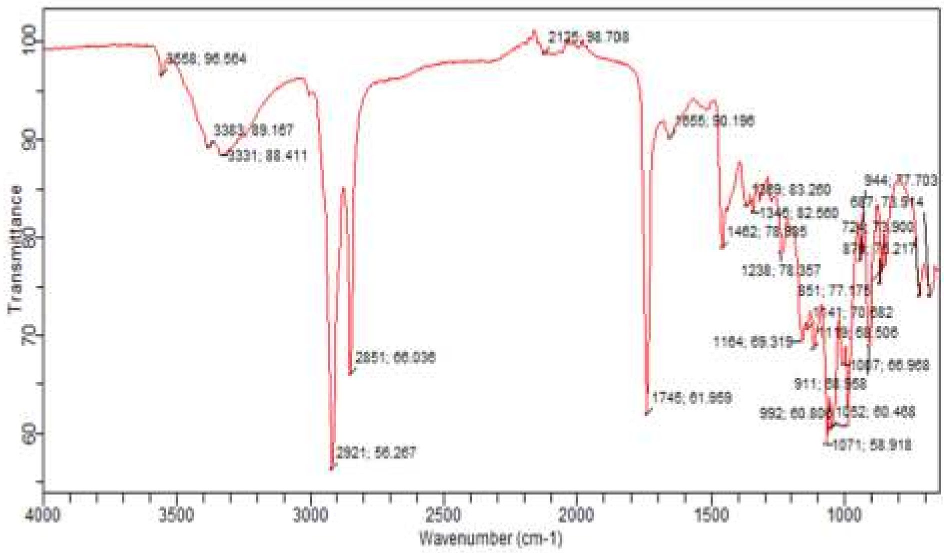

Figure 3:FTIR Spectra of A (10%)Sorghum Malt: 90% Cocoa Nibs)

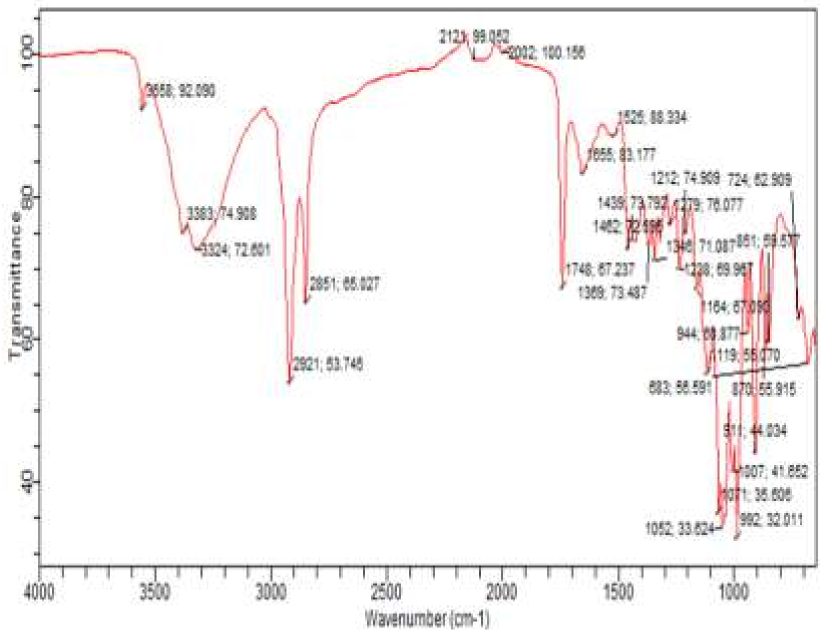

Figure 4: FTIR Spectra of B (20%) Sorghum Malt: 80% Cocoa Nibs)

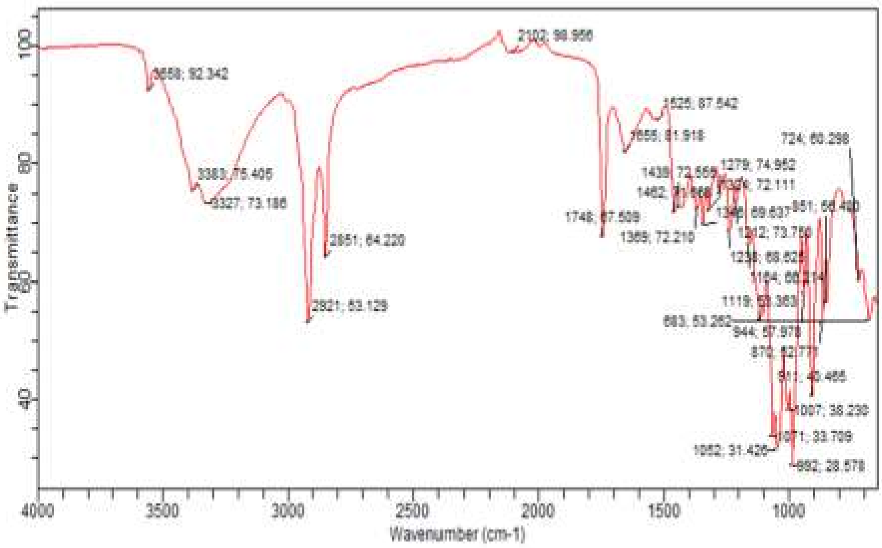

Figure 5: FTIR Spectra of C (30% Sorghum Malt: 70% Cocoa Nibs)

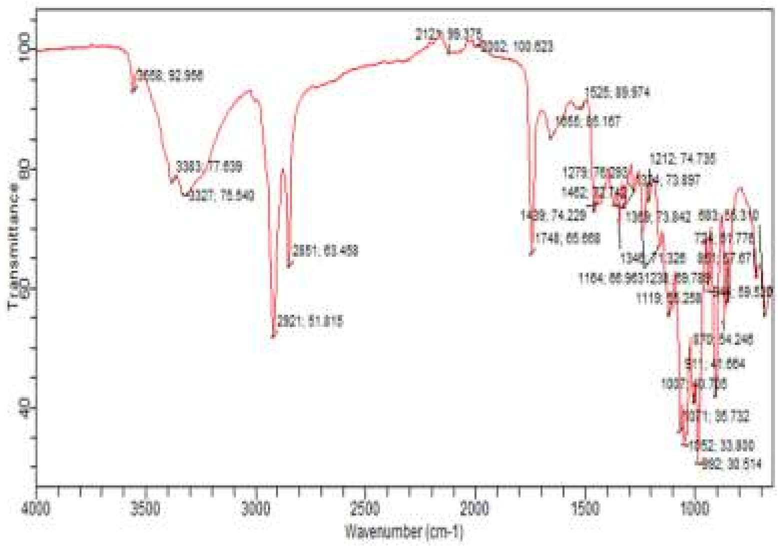

Figure 6: FTIR Spectra of D (40% sorghum malt: 60% cocoa nibs)

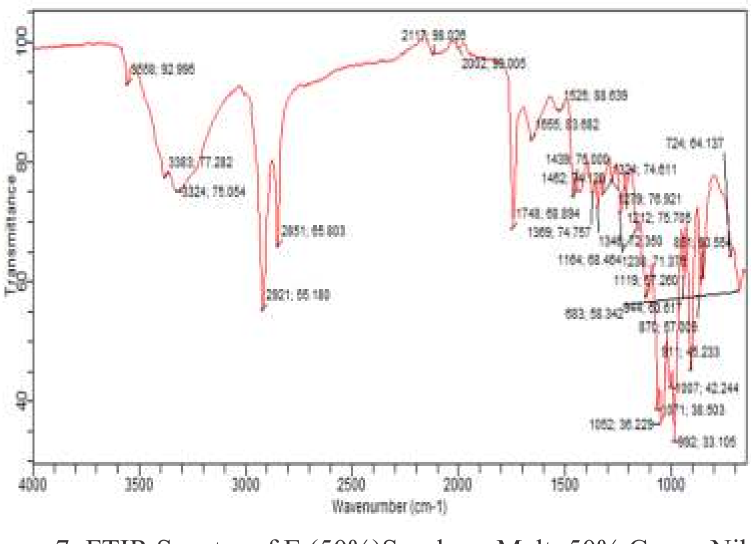

Figure 7: FTIR Spectra of E (50%)Sorghum Malt: 50% Cocoa Nibs)

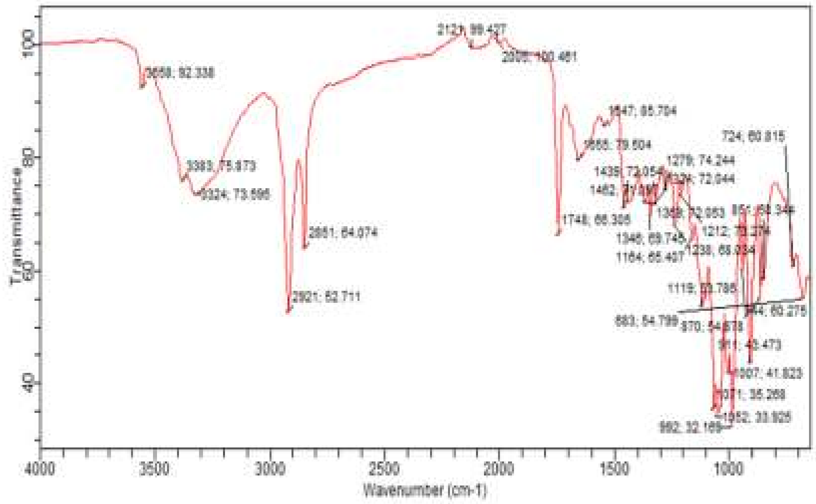

Figure 8: FTIR Spectra of F (Control Samples)

3.3 The Sensory Properties of Malted Sorghum Chocolate Samples

The organoleptic properties of the chocolate samples (cocoa nibs partially replaced with sorghum malt) is presented in Table 3. There were no significant differences in the colour of the malted chocolate blends as well as the control. Samples A and B were the most preferred in terms of colour. The sensory scores for the flavour of the malted chocolate showed that there were no significant differences in all the samples. However, the panelists preferred chocolate samples, which their levels of malted sorghum inclusion did not exceed 20%. Similarly, there were no significant differences in the texture of the samples. The panelists rated the texture of samples A and B, whose levels of malted sorghum inclusion did not go beyond 20% as the highest. Significant differences were observed in the taste and overall acceptability of the malted chocolate samples. The taste of sample B was the most preferred followed by A, while the control sample was the least preferred. The taste of the malted chocolate increased up 20% inclusion, before decreasing with increased replacement of mated sorghum. This indicates that increasing the mated sorghum beyond 20% impaired the taste of the malted chocolate. Also, the overall acceptability of the malted chocolate samples with 20% of sorghum malt was rated best, followed by 10%. This indicates that the acceptance of the malted chocolate samples beyond 20% was less achievable. Sample B (with 20% inclusion) was the most preferred, whereas the least preferred was sample E. The result obtained was similar to the report given by Aroyeun and Jayeola (2016), on the effect of green tea extract on chocolate.

Table 3: Sensory Evaluation of Malted Sorghum Chocolate Samples

Sample	Colour	Flavour	Taste	Texture	Overall acceptability
A	8.10±0.01^{a}	7.20±0.03^{a}	7.80±0.03^{b}	8.10±0.01^{a}	7.80±0.05^{ba}
B	8.30±0.02^{a}	7.40±0.01^{a}	8.10±0.02^{b}	8.30±0.02^{a}	8.50±0.03^{b}
C	7.60±0.01^{a}	7.10±0.02^{a}	7.30±0.01^{ba}	7.60±0.01^{a}	7.70±0.02^{ba}
D	7.70±0.03^{a}	7.20±0.04^{a}	7.30±0.02^{ba}	7.70±0.02^{a}	7.30±0.01^{a}
E	8.00±0.01^{a}	6.40±0.02^{a}	6.40±0.04^{a}	8.00±0.00^{a}	6.80±0.04^{a}
F	7.60±0.04^{a}	7.10±0.01^{a}	7.50±0.03^{ba}	7.60±0.01^{a}	7.30±0.02^{a}

A (10% sorghum malt: 90% cocoa nibs), B (20% sorghum malt: 80% cocoa nibs), C (30% sorghum malt : 70% cocoa nibs), D (40% sorghum malt : 60% cocoa nibs)), E (50% sorghum malt : 50% cocoa nibs) and F (control samples)

4. CONCLUSION

The inclusion of sorghum malt grits in chocolate bars production significantly influenced their quality. The use of malted sorghum as a partial replacement for cocoa nibs in chocolate production is acceptable but with only up to 20% inclusion.

5. APPRECIATION

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6. DECLARATION

There was no conflict of interest.

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