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Proximate composition microbial and sensory analyses of butter made from cashew kernel pieces

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Abstract

Cashew pieces are less valued compared to whole kernels. This study aimed to formulate cashew butter from splits (S), large white pieces (LWP) and small white pieces (SWP). Roasted and unroasted butter were made from S, SWP and LWP. The moisture, total ash, crude fat and crude protein contents for both raw and roasted butter products were evaluated by standard methods as per (AOAC, 2000). Also microbiological quality (total plate count, total coliform, *S. aureus*, *Salmonella*, *E. coli*, yeast and moulds) of the raw pieces and butter were assessed using standard methods. Sensory acceptability and willingness to purchase cashew butter were also evaluated. Results showed a significant difference ($p < 0.05$) in the crude fat (45.12 - 46.79g/100g) and moisture content of raw pieces (2.7 - 2.9g/100g) while there was no significant difference in the crude protein and total ash content ($p > 0.05$). There was no significant difference ($p > 0.05$) in the crude protein content while the moisture (0.3 - 1.74g/100g), total ash (2.34 - 2.48g/100g) and crude fat (43.78 - 52.6g/100g) contents showed a significant difference between the types of butter. *Salmonella* was below the detection level in all the samples while total coliform and *E. coli* were below 3 MPN/g. With regard to sensory acceptability of the cashew butter, all scores were within the acceptance range (5 - 9). However roasted cashew butters were highly accepted compared to unroasted cashew butter. The results also showed a significant difference ($p < 0.05$) in terms of spread ability, colour, taste, flavour, mouth feel and overall acceptability between the roasted and unroasted cashew butter. This study concluded that all the types of cashew butter produced are of good microbial and nutritional quality and they are fit for human consumption.

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Introduction

The cashew (*Anacardium occidentale* L.) is a medium-sized tropical tree that is mainly cultivated for its true fruit (cashew nut) and pseudo fruit (cashew apple). Cashew is one of the cash crops in Tanzania considered as a primary source of income for over 300,000 households in Southeastern Tanzania (FAOSTAT, 2020). Approximately 980,363 ha is planted with cashew trees in the country, which produce about 225,106 tons of raw cashew nuts (FAOSTAT, 2020). Cashew nut is of great economic importance than cashew apples in Tanzania (Msoka *et al.,* 2017). Therefore, the nut is the most commercialized part of the cashew plant (Berry & Sargent, 2011). The edible part of the nut is the kernel, which is situated inside the tough shells and surrounded by the testa (Joker, 2003).

Cashew nut kernels are a rich source of macronutrients, including protein, carbohydrates, and fats (Brufau *et al.*, 2006). For instance, cashew kernels can contain up to 21.3g/100g of proteins and 48.3g/100g of fats, of which 79.7% is unsaturated fats, mostly oleic and linoleic acid (Rico *et al.*, 2016). In addition to that, unsaturated fats are considered healthy and therefore essential to be included in a healthy diet. These fats help lower high blood cholesterol levels and reduce the risk of cardiovascular diseases (Lunn & Theobald, 2006). Moreover, cashew kernels contain a wide variety of micronutrients, including vitamins (vitamin E is the most abundant) and minerals such as iron, zinc, calcium, and phosphorus (Rico *et al.*, 2016). Furthermore, cashew kernel pieces have high nutritional values similar to the whole kernels.

The grading and pricing of cashew nut kernels is based on the size, color and whether the kernels are whole or broken. Cashew kernel pieces have a lower commercial value compared to whole kernels (Banerjee & Shrivastava, 2014). In Tanzania, the price for one kilogram of cashew kernel pieces ranges from 5, 000 - 10,000 TZS (2-5 USD) while the price for one kilogram of whole kernel ranges from 18,000 - 26,000 TZS (7.8 - 11.3 USD) depending on the grade. Whole kernels are mainly categorized into four different grades depending on the size: WW 180, WW 210, WW 240 and WW 320. Whereby WW refers to white whole kernels and the number is the quantity of kernels in 454 g (Azam-Ali & Judge, 2001). Cashew nut kernel pieces can be processed into other products such as butter as a way of adding value in order to capture higher market value (Lima *et al.*, 2012).

Industrial cashew processing involves several steps such as steaming, shelling, drying, peeling and packaging. Breakage of the cashew nuts can occur at any step of the process and yield up to 20g/100g of cashew nut pieces (Fitzpatrick, 2011). The pieces can be classified into different grades based on size. There are five standard grades of cashew nut kernel pieces: butts (B), splits (S), Large White Pieces (LWP), Small White Pieces (SWP) and Baby Bitts (BB).

In Tanzania, cashew kernel pieces are generated as by-products of cashew nut processing. Because the pieces fetches low market prices, there is a need for value addition through producing other valuable products such as cashew butter. Therefore, the present study aimed to formulate cashew nut butter from three low grades of cashew nut kernel pieces, namely splits, LWP and SWP. Moreover, the effect of roasting on the proximate, sensory and microbiological quality of the formulated cashew nut butter was also investigated.

Materials and methods

Collection and preparation of cashew kernel pieces

Three types of cashew kernel pieces 12kg each selected from white kernels with moisture content below 5% and free from infestation were collected from the cashew processing factory at Tanzania Agricultural Research Institute (TARI) Naliendele in Mtwara, Tanzania. The kernel pieces collected were: Splits (S), Large White Pieces (LWP) and Small White Pieces (SWP). The kernels were then packed in plastic zip bags to prevent them from losing and absorbing moisture. Two kilograms of each of the grades collected was kept for laboratory analysis of raw cashew kernel pieces, and 10kg of each grade was used to make cashew butter. From the 10kg, half of it was used to make roasted cashew butter, and the remaining 5kg was used to make unroasted cashew butter. Sunflower oil, salt and sugar were purchased from Naliendele market in Mtwara.

Cashew butter preparation

Unroasted and Roasted cashew butter

The unroasted cashew nut butter (UrCB) and roasted cashew nut butter (RCB) were formulated from S, SWP, and LWP kernels. 10kg of each of the kernel type was used to make two types of cashew nut but, 5kg UrCB and 5kg RCB. For the RCB the kernels were first roasted by deep frying in sunflower oil at 190°C for 5 min were by the kernels turned color from white to brown. The RCB and UrCB were formulated from ground cashew kernels using a C15 food processor (Cottage Industries, Ghana) for 15 min. 30g of sugar and 8.5g of salt were then added as ingredients. The cashew butter products were then packed in food-grade plastic containers (Safe Pak, Kenya) with a net weight of 200g and 350g. The packaged cashew butter samples were stored at room temperature prior laboratory and sensory analyses.

Proximate composition

Crude protein

Crude protein of the Cashew kernel pieces samples, roasted and unroasted cashew butter were determined using the Kjeldahl method as described in the AOAC (2000). About 0.5g of sample was placed in a digestion flask, followed by the addition of 5g Kjeldahl catalyst and 200mL of concentrated sulfuric acid (H_2SO_4) (Lab Deal Co, Tanzania). A blank was prepared in a tube in the same manner as for a sample, however the sample was not added. The flask was placed in an inclined position and then heated gently until frothing ceased. Boiling was done until all the solution cleared. The solution was then cooled, and 60mL of distilled water was added. The flask was immediately connected to the digestion bulb on the condenser and with a tip of the condenser immersed in standard acid and indicator in the receiver. The flask was then rotated to mix the contents thoroughly then heated until all ammonia gas (NH_3) is distilled. The receiver was then removed, and the tip of the condenser was washed, and then the excess standard acid was then titrated with NaOH solution. The percentage crude protein was calculated as per the formula below;

Crude Protein (%)=$\frac{(A-B)\times N\times 14.007\times 6.25}{W}$

Where: A = volume (mL) of 0.2 N hydrochloric acid (HCL) used sample titration; B = volume (mL) of 0.2 N HCL used in blank titration; N = normality of HCL; W = weight (g) of sample; 14.007 = atomic weight of Nitrogen; 6.25 = the protein-nitrogen conversation factor.

Crude fat

Crude fat content in the raw and cashew nut butter products were determined by the Soxhlet method as described in AOAC (2000). The samples were ground in a motor and pestle in order to increase the surface area for the extraction. About 5g of each of the samples was added into an extraction thimble. 250mL of petroleum ether was added and heated for 5 hours. The heating mantle was then switched on, and the samples were heated for 14 hours. The solvent was then evaporated by using the vacuum condenser. The bottles were incubated at 80 - 90 °C until the solvent completely evaporated and the bottles were dried. After drying, bottles were transferred to the desiccators with the lids partially opened, and the dried content was reweighed. The percentage crude fat was calculated as per the formula below;

Crude fat percentage (%) = $\frac{weight\ of\ fat}{weight\ of\ sample}\times 100$

Moisture content

The moisture content of foods determines how fast the food can spoil and therefore it is important to know the amount of moisture in foods. The moisture contents of the raw and cashew nut butter products was determined in triplicates following the AOAC (2000) method No. 925.10. The dishes and the lids were first dried in the oven at 105 °C for 3 h, and then transferred to the desiccator to cool. The dishes and the crucibles were weighed. About 3 g of all the samples were then spread uniformly on the dishes and placed in the oven to dry at 105 °C. After drying, the dishes were transferred to the desiccator to cool.

The dishes and the dried samples were then reweighed (AOAC, 2000). The percentage moisture content was calculated as per the formula below;

Moisture percentage (%) = $\frac{W1-W2}{W1} \times 100\%$

Where: W1 = initial weight (g) of the raw sample; W2 = weight (g) of the dried sample.

Ash content

The total ash content of the raw and cashew butter products were determined according to AOAC method No. 942.05 (AOAC, 2000). The crucible and the lid were preheated in the Muffle furnace at 550°C overnight to ensure that impurities on the surface of the crucible are burned off. The crucible were then cooled in a desiccator for 30 min. The crucible and the lid were then weighed. Five gram of each of the samples were heated over low Bunsen flame with lid half covered until fumes were no longer produced and the placed in Muffle furnace (Advanced Technocracy INC, India)at 550°C overnight. After complete heating the lid was placed on in order to prevent the loss of fluffy ash. The ash content was presented as the percentage of the sample weight.

$$\frac{W2}{w1}\, x\ 100 = \%Ash$$

Where: W1 = weight (g) of the sample before drying; W2 = weight (g) of the ash

Microbiological analysis

Raw and cashew nut butter products (UrCB and RCB) were analyzed for the total coliform, fecal coliforms, *Salmonella*, *E. coli*, *Staphylococcus aureus* (CFU), yeast and molds (CFU/g) according to ISO guidelines (Jeršek, 2017).

Total Coliforms

The total coliforms were determined according to ISO 4831 (2006) standard. The serial dilutions from the samples were prepared and incubated at 35°C or 37°C for 24 hours. The gas in Durham tube indicated the presence of coliforms. If the result was negative, the incubation of the tubes with Lauryl Sulphate Tryptose Broth (LSTB) (Lab Deal Co, Tanzania) was prolonged for another 24 h. The confirmation of coliform bacteria was done after getting a positive result in LSBT with re-inoculation of one loop of suspension in Brilliant Green Lactose Bile Broth (BGLBB) (Lab Deal Co, Tanzania), then incubated at a temperature of 30 °C for 24 - 48 h, and a positive result was detected by gas production in Durham tubes and yellow medium. The most probable number (MPN) of coliforms was calculated using MPN tables.

Fecal coliforms

According to ISO 4831 (2006), fecal coliform was determined except that the LSBT was inoculated at 44°C (Jeršek, 2017).

Escherichia coli

The detection and enumeration of *E. coli* were done according to ISO 7251 (1991). Decimal dilutions of raw and cashew butter products were prepared. Firstly, 3x10mL of-undiluted sample was added to 10mL Lauryl Tryptose Broth (LSB) (Lab Deal Co, Tanzania) medium with a double concentration. Secondly, 3x1mL of the undiluted sample was added to 10mL of LSB medium with normal concentration, and lastly, 3 x 10mL of diluted food sample 10^{-1} in 10mL LSB with normal concentration.

The 9 test tubes were then inoculated at 37 °C for 24 h. Positive results were shown by the formation of gas in the Durham tubes. If there are no positive results, incubation was prolonged for another 24 h. Confirmation of *E. coli* was done after getting a positive result in LSB or after turbidity of LSB with re-inoculation of one loop of suspension into E.C. broth, which was then incubated at 44°C for 24 - 48 h. The formation of gas in the Durham tube indicates a positive result. Each tube with a positive result was then re-inoculated with a loop into the tube with peptone water containing tryptophan, then incubated for 48 h at 44 °C. After incubation, Kovacsev reagent (Lab Deal Co, Tanzania) was added, the formation of Indole, which is a characteristic of *E. coli*.

The positive results in LSB for each food sample was then counted (Jeršek, 2017).

Staphylococcus aureus

Ten grams (10 g) of each of the samples were aseptically transferred into a container having 90mL of sterile buffer peptone water to make the initial suspension. The resulting mixture was shaken thoroughly, 0.1mL of the initial suspension (10^{-1} dilution) was then spread on two agar plates, and the procedure was repeated until 10^{-4} dilution. The inoculum was then quickly spread over the surface of agar plates without touching the sides of the dish. The plates were then allowed to dry with their lids on for about 15 min at ambient temperature. The plates were then inverted and incubated at 37°C for 24 h. After incubation, the bottom was marked at the positions of any typical colonies present. The plates were then re-inoculated at 37°C for 24 h. The marking of any new typical colonies was also done. Enumeration was done only on the plates with a maximum of 300 colonies at two consecutive dilutions. A coagulase test was then conducted for confirmation of *S. aureus* according to ISO 6888-1 (2002).

Salmonella

The detection of *Salmonella* was done according to ISO 6579 (2002) standard. Twenty-five grams of each sample was transferred under aseptic conditions using a sterile spatula to a container having 225mL of sterile buffer peptone. The mixture was then shaken and incubated at 37°C for 18 h, thereafter homogenized. An aliquot of 0.1mL of suspension was transferred to the SSR selective enrichment medium (10mL) and then incubated at 41.5°C for 24 h. Isolation was done by a loop to the selective agar plates (XLD) (Labdeal, Tanzania). *Salmonella* has the ability to decarboxylate lysine, which will result in an alkaline reaction, and the phenol red becomes red. Colonies will become dark red, and in the case that they will form H_2S they will have a black center. Confirmation was done according to ISO 6579 (2002) (Jeršek, 2017).

Yeasts and molds

The number of yeasts and molds was enumerated according to ISO 7954 (1987). One milliliter of the sample was pipetted on a petri dish, and then a 10-fold dilution was prepared. From each dilution, 1.0mL was pipetted into a sterile petri dish. Fifteen milliliters of Yeast Extract Dextrose Chloramphenicol Agar (YEDC) (Lab deal, Tanzania) was added, and heated, and then cooled to 45°C and the inoculum was carefully mixed. After solidification, petri dishes were inverted and then incubated at 25°C for 5 days. Colonies formed were counted on the 3rd, 4th, and 5th day of incubation. Plates containing 15 - 150 colonies were used to calculate the number of yeast and mold.

Sensory evaluation

The sensory evaluation for the developed cashew nut butter samples was conducted using a 9-point hedonic scale, like extremely scoring as the highest and disliked extremely scoring as the lowest (Srilakshmi, 2015). The experiment involved 50 untrained panelists comprising of students and staff of the Nelson Mandela African Institution of Science and Technology (NM-AIST) Tengeru Campus in Arusha, Tanzania. The panelists were non-smokers and frequent cashew nuts and peanut butter consumers. About 20g of all the six samples and a reference sample (peanut butter) were placed in transparent plastic containers, which were coded with three-digit numbers. Panelists were served with the seven samples including the reference samples at one time. In addition to that, they were provided with a slice of bread and plastic spoons for spreading the butter and drinking water for rinsing purposes.

The panelists were then instructed to taste each of the seven samples after spreading on a piece of bread. In addition that, they were instructed to rinse their mouth with drinking water in between samples tasting in order to eliminate the residual flavors. The panelists were not allowed to discuss their opinions on the sensory attributes of the products during the tasting to ensure truthful information with no influence from each other's generated. The panelists were then required to fill in a sensory analysis questionnaire after tasting each sample.

Consumer's willingness to buy

Parallel to the sensory evaluation, the panelists were requested to fill a questionnaire, which was intended to find out on the willingness to buy and also study on whether panelists are regular consumers of nut butter. In this section questions on whether the panelists would be willing to buy the product should they find it in stores, the price they will be willing to pay for the product and how often do they consume nut butters were asked.

Statistical analysis

The nutritional and sensory analysis data were analyzed by one-way analysis of variance (ANOVA) with SPSS statistical package version 23. The means and standard deviations were calculated and when the F values were significant ($p \leq 0.05$). Tuckey test was performed at 0.05 significance level for comparison of means (Landau, 2004).

Results and discussion

Proximate composition of cashew kernels and formulated cashew butter

Proximate composition of the cashew kernel pieces (S, SWP & LWP) and their corresponding cashew butter products are shown in Table 1. Results on the moisture content showed a significant difference between the cashew nut kernels. The SWP (2.92g/100g) had significantly highest moisture content than the S (2.75g/100g) and LWP (2.69g/100g). The LWP was observed to have the lowest moisture range from 2.69 - 2.92g/100g, which is in agreement with the cashew kernel standard. According to the Global Cashew Council (2012) and TBS (2010) the moisture content of cashew kernels both whole and broken should be below 5g/100g.

Table 1. Proximate composition of cashew kernel pieces.

Type of kernel	Moisture (g/100g)	Ash (g/100g)	Protein (g/100g)	Fat (g/100g)
Split	$2.75^b \pm 0.503$	$2.41^a \pm 0.0115$	$19.9^a \pm 0.361$	$45.12^c \pm 0.1041$
SWP	$2.92^a \pm 0.153$	$2.42^a \pm 0.2000$	$20.83^a \pm 1.607$	$46.79^a \pm 0.0764$
LWP	$2.69^c \pm 0.100$	$2.43^a \pm 0.0057$	$21.57^a \pm 0.929$	$46.04^b \pm 0.0361$

Values are means ± standard deviation of triplicates. Means with same super script within the same column are not significantly different at (P>0.05) Cashew kernel pieces: SWP= Small white pieces; LWP = Large white.

On the other hand, the moisture content of the cashew butters was observed to range from (0.63 - 1.74g/100g) which was significantly different (P = 0.00) from their corresponding cashew nut pieces. Similar findings of moisture content of cashew nut butter products in the range between 0.3 and 1.4 g/100 g have been reported (Lima *et al.*, 2012). The butters made from unroasted cashew nuts had higher moisture content (1.39 - 1.74 g/100 g) compared to those from roasted nuts (0.63 - 0.73g/100g). The difference could be attributed by loss of moisture during frying in exchange of oil.

The moisture content of foods is a crucial quality parameter as it affects the texture and shelf life of foods, including cashew nuts and butter. In order to avoid rapid microbial growth in foods, the moisture content should be kept below 10g/100g (Vera Zambrano *et al.*, 2019). Results for total ash content showed no significant variation (P>0.05) between the cashew kernel pieces. The total ash content of the cashew nut kernels ranged from 2.41 - 2.43g/100g (Table 1). The splits had the lowest ash content (2.41g/100g), while the LWP had the highest ash content (2.43g/100g). The obtained results in this study are slightly lower than those established by Rico *et al* (2016), whereby an average ash content of 2.5g/100g was reported. The total ash content of the roasted cashew nut butters (2.34 - 2.40g/100g) was slightly lower than their corresponding cashew nut pieces (2.41- 2.43g/100g), whereas the total ash content of the unroasted butter samples was slightly higher (2.43 - 2.48g/100g) (Table 1). The obtain range for total ash values in this study (2.34 - 2.48g/100g) are in agreement with the results on total ash established by Lima *et al.*, 2012 (2.3 - 2.8g/100g).

Protein content of the LWP (21.57g/100g) was observed to be the highest while that of S (19.90g/100g) was the lowest and this concluded a significant difference in protein content between raw cashew kernel pieces ($p \leq 0.05$).

The range for protein content of the cashew kernel pieces was 19.90 - 21.57g/100g, which is in line with the average protein content results of cashew kernel reported by Rico *et al.*, 2016 (21.30g/100g). In another study, Lima *et al.* (2012) reported a slightly higher protein content for cashew kernels, 20.60 - 26.90g/100g. On the other hand, the protein content of the cashew nut butter products was slightly lower than their corresponding cashew nut pieces; however, there was no significant difference (p > 0.05) in the protein content of the cashew butter products (18.18 - 18.43g/100g). The protein content of the RB and UrB samples ranged from 18.23 - 18.30g/100g and 18.18 - 18.43g/100g, respectively (Table 2). Cashew nut butter is a good source of protein, it contains up to 18g/100g. The product can easily be consumed by both the elderly and the children and thus playing a crucial role of supplying the proteins they need. In Tanzania peanut butter is the most common nut butter, the protein content of peanut butter is 22g/100g which is slightly higher than that of the formulated product however peanuts have been linked with high levels of aflatoxin (Kimanya & Tiisekwa, 2016) and therefore cashew butter can serve as the best substitute.

Table 2. Proximate composition of formulated cashew nut butter.

Cashew kernels	Moisture Roasted	Moisture Unroasted	Ash Roasted	Ash Unroasted	Protein Roasted	Protein Unroasted	Fat Roasted	Fat Unroasted
Splits	0.73^{aB}±0.01	1.51^{aA}±0.01	2.34^{aA}±0.06	2.43^{aA}±0.15	18.26^{aA}±0.22	18.18^{aA}±0.13	49.78^{cA}±0.75	48.77^{aB}±0.03
SWP	0.72^{aB}±0.20	1.39^{bA}±0.01	2.40^{aA}±0.15	2.48^{aB}±0.06	18.30^{aA}±0.10	18.43^{aA}±0.14	51.56^{aA}±0.01	50.79^{aB}±0.12
LWP	0.63^{bB}±0.01	1.74^{aA}±0.10	2.38^{aA}±0.06	2.48^{aB}±0.06	18.23^{aA}±0.11	18.19^{aA}±0.14	50.82^{bA}±0.15	49.19^{aB}±0.06

Values are means ± standard deviation (n=3). Means with same super script within the same column are not significantly different at (P>0.05). In the row for each analysis means with the same superscript are not significantly different (P>0.05). Key: SWP=Small white pieces, LWP=Large white pieces

Fat content of SWP (46.79g/100g) was observed to be the highest while that of S (45.12g/100g) was the lowest (Table 1), this concluded a significant variation ($p \leq 0.05$) between raw cashew nut kernel pieces.

The range for fat content of the cashew kernel pieces was 45.12 - 46.79g/100g. The findings of this study are slightly higher than the findings reported by Lima *et al* (2012). On the other hand the fat content of the cashew nut butters produced were slightly higher than the cashew nut kernel pieces.

The fat content of the cashew nut butters ranged between 48.77 - 51.56g/100g (Table 2). There was a significant difference (p >0.05) between the roasted and unroasted cashew nut butter. RSWP had the highest fat content (51.56g/100g). the results of this study are within the range (43.7 - 52.60g/100g) reported in a previous study (Lima *et al.*, 2012).

Factors such as location and crop varieties affect nutritional composition of a particular crop products (Akujobi *et al.*, 2018).

Microbial quality of cashew kernel pieces and the corresponding cashew butter

The microbial quality of the cashew kernel pieces and their corresponding cashew butter products is presented in Table 3. The most probable number (MPN) for total coliform and *E. coli* were both below 3 MPN/g for all the samples tested. The enumeration of coagulase *S. aureus* was below 100 CFU/g for both cashew kernel pieces and the cashew butters. *Salmonella* was not detected in all the cashew kernel pieces, and cashew butters products. Ready to eat foods contaminated with *Salmonella* are unsafe to eat and should be discarded immediately (Little *et al.*, 2009). The total plate count for all the samples was below 100 CFU/g except for the roasted LWP butter, which was 4.6 x 10^3 CFU/g, and unroasted splits butter, which was 2.6 x 10^3 CFU/g.

The counts of yeast and molds were also below 100 CFU/g for all the samples tested. The good microbiological quality of the cashew pieces and their corresponding cashew butters is attributed to good hygienic and manufacturing practices during the processing and storage of the kernels and butters.

Also, the low moisture content of both the kernels and the butter prevents microbial growth (Vera Zambrano *et al.*, 2019). The salt and sugar added in the cashew butter also contribute to the good microbiological quality of the products. Salt and sugar reduce the available water for microbial growth. The overall microbiological quality of the raw cashew nut kernel pieces and the six cashew butter samples can be ranked as satisfactory (FSANZ, 2018), and the products are therefore recommended to be safe for human consumption.

Table 3. Microbial quality of cashew kernel pieces and cashew butter.

Sample	Total plate count (CFU/g)	Total coliform (MPN/g)	*E. coli* (MPN/g)	*S. aureus* (CFU/g)	Salmonella (in 25/g)	Yeast and molds (CFU/g)
USWPB	4.0 X 10^1	< 3 x 10^0	<3 x 10^0	< 100	Negative	< 10
RLWPB	4.6 X 10^3	< 3 x 10^0	<3 x 10^0	< 100	Negative	< 10
RSWPB	2.5 X 10^1	<3 x 10^0	<3 x 10^0	1 x 10^1	Negative	2 x 10^1
SK	6.0 X 10^1	< 3 x 10^0	<3 x 10^0	1.5 x 10^1	Negative	1.2 x 10^1
SWPK	<10	< 3 x 10^0	<3 x 10^0	< 10^0	Negative	4 x 10^1
USB	2.6 x 10^3	< 3 x 10^0	<3 x 10^0	< 10^0	Negative	< 10
ULWPB	<10	< 3 x 10^0	<3 x 10^0	< 10^0	Negative	< 10
LWPK	1.1 x 10^2	< 3 x 10^0	<3 x 10^0	2.5 x 10^1	Negative	8.5 x 10^1
RSB	<10	< 3 x 10^0	<3 x 10^0	< 100	Negative	< 10 C

USWPB=Unroasted Small white pieces butter, RLWPB=Roasted Large white pieces butter, RSWPB=Roasted Small white pieces butter, SK=Split kernels, SWPK=Small white pieces kernels, USB=Unroasted splits butter, ULWPB=Unroasted large white pieces butter, LWPK=Large white pieces kernels, RSB=Roasted Splits butter

Table 4. Sensory analysis of cashew nut butter.

Sample	Spreadability	Color	Taste	Flavor	Mouth feel	Aroma	Overall Acceptability
Control	7.90±1.04^a	7.62±1.52^a	7.32±1.59^a	7.50±1.37^a	7.18±1.71^a	7.26±1.54^a	7.42±1.46^a
RSB	8.10±0.84^a	7.94±0.96^a	7.84±0.96^a	7.88±0.96^a	7.72±1.11^a	7.88±0.82^a	7.90±0.74^a
RLWPB	8.00±0.73^a	7.92±0.97^a	7.78±0.86^a	7.72±0.97^a	7.84±0.89^a	7.76±0.92a	7.92±0.80^a
RSWPB	7.86±0.81^a	7.92±0.80^a	7.64±0.86^a	7.94±0.84^a	7.84±0.71^a	7.72±0.70^a	7.78±0.65^a
USB	6.28±1.72^b	6.10±1.58^b	6.22±1.69b	6.36±1.79^b	6.44±1.54^b	6.42±1.59^b	6.34±1.49^b
ULWPB	5.86±1.56^b	6.00±1.74^b	6.22±1.79^b	6.44±1.54^b	6.24±1.74^b	6.44±1.67^b	6.38±1.47^b
USWPB	6.14±1.83^b	5.88±1.91^b	6.30±1.91^b	6.60±1.49^b	6.26±1.74^b	7.56±8.50^a	6.30±1.66^b

Data are represented as mean ± standard deviation. Means with the same superscript are not significantly different ($P \geq 0.05$). Key: USWPB=Unroasted Small white pieces butter, RLWPB=Roasted Large white pieces butter, RSWPB=Roasted Small white pieces butter, SK=Split kernels, SWPK=Small white pieces kernels, USB=Unroasted splits butter, ULWPB=Unroasted large white pieces butter, LWPK=Large white pieces kernels, RSB=Roasted Splits butter.

Sensory evaluation of cashew nut butter samples

The RSB and RLWPB had a higher preference for spreadability than control samples. The control samples had a mean value of 7.9, while RSB and RLWB had mean values of 8.1 and 8.0, respectively. RSWPB, USB, ULWPB, and USWPB had mean values lower than the control sample; however, there was no significant difference between the control sample and the butter made from roasted cashew nut kernel pieces (RSB, RLWP, and RSWPB), but there was a significant difference between the control sample and the butter made from unroasted cashew nut kernel pieces. With regard to the colour, sample RSB had the highest mean score (7.94) followed by RLWPB and RSWPB, which both had a mean value of 7.92. The mean values of cashew nut butter made from roasted cashew nut kernel pieces were higher than that of the control sample; however, the difference was not significant ($p \geq 0.05$).

The USB, USWP, and ULWP, which were made from unroasted cashew nut kernel pieces, had mean values lower than the control sample. Sample USWP had the lowest mean value (5.88). The mean values of the unroasted cashew nut kernel butters were significantly different ($p < 0.05$) from both the control sample and the samples made from roasted cashew nut kernel pieces. In the case of taste, the taste of the roasted and unroasted cashew nut butter samples were significantly different ($p \geq 0.05$). Roasted cashew nut butter samples made from splits (RSB) had the highest mean value (7.84), while unroasted cashew nut butter samples were made from splits (USB) and large white pieces (ULWPB) had the lowest mean value (6.22). The taste of cashew nut butter made from roasted cashew kernel pieces was highly preferred by the panelists than the unroasted ones. The panelists were able to differentiate the tastes of the roasted and unroasted cashew nut butter.

On the other hand, the flavor of RSWPB had the highest mean value (7.94) followed by sample RSB (7.88), while USB had the lowest mean value (6.36). There was no significant difference ($p \geq 0.05$) between the reference sample and the roasted cashew nut butter samples; however, cashew nut butter samples were made from unroasted cashew nut kernel pieces (USB, USWPB, and ULWPB) were significantly different ($p < 0.05$).

The roasted nut flavour of the roasted cashew nut butter samples was highly preferred by the panelists than the unroasted cashew flavor. The panelists ranked roasted cashew nut butter higher than the unroasted cashew nut butter in terms of mouth feel. A significant difference ($p \geq 0.05$) between the roasted and the unroasted butter was observed. Butter from roasted cashew nut kernels had a smooth and soft texture, which was highly preferred. RLWPB and RSWPB had the highest mean value (7.84), while ULWPB had the lowest mean value (6.24). The reference sample had a mean value of 7.26, which was not significantly ($p \geq 0.05$) different from butter made from roasted cashew kernel pieces.

The aroma of the roasted cashew nut butter was not significantly different ($p \geq 0.05$) from the reference sample but significantly different ($p < 0.05$) from the samples made from unroasted cashew nut kernel pieces. RSB had the highest mean value (7.88), while sample USB had the lowest mean value (6.42). Roasting of cashew nuts results in the nutty aroma of the butter, which was highly preferred by the panelists. For the overall acceptability of the cashew nut butter, all the samples were within the acceptance range. The mean values for overall acceptability ranged from 6.3-7.9. RSB had the highest mean value (7.90), while sample USWPB had the lowest mean value (6.30). Butter from roasted cashew nut kernel pieces, irrespective of the type of kernel grade used, were highly preferred than the butter from unroasted kernel pieces.

There was no significant difference ($P \geq 0.05$) between cashew butter made from roasted kernels and the reference sample, however, the samples made from unroasted cashew kernel grades were significantly different from the reference sample and the roasted samples.

The sensory evaluation of the samples using the 9 scale hedonic test implies that cashew butter made from both roasted and unroasted cashew nut kernel pieces will be accepted when introduced to the market. Similarly (Lima *et al.*, 2012) in his study reached a similar conclusion.

Willingness to buy, weekly consumption, and the proposed price

Results indicated that majority of the panelist about 58% were willing to buy cashew butter if they find it in stores/supermarket, while 36% said they would probably buy the product and 4% said they might buy the product. Only 2% claimed not to buy the product if they find it in stores.

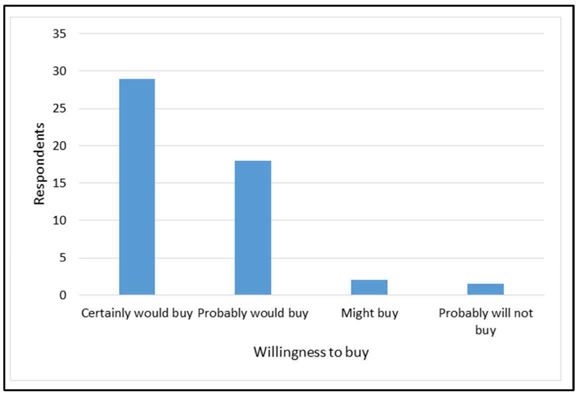

Fig. 1. Consumers' willingness to buy cashew nut butter.

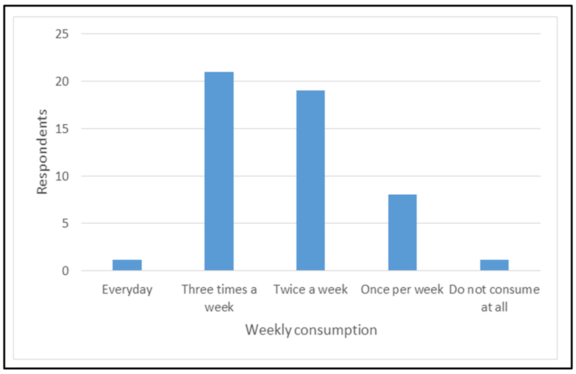

Fig. 2. Consumer's weekly consumption of nut butter.

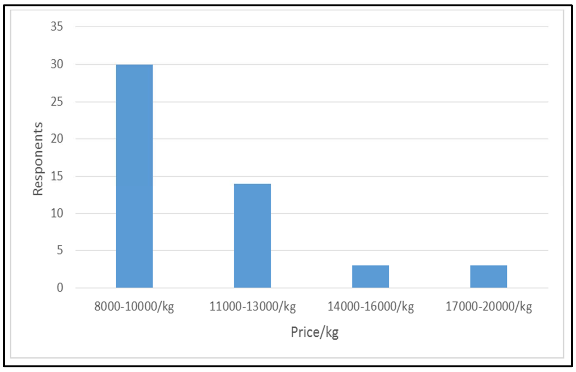

Fig. 3. Price/kg of cashew nut butter that the consumers are willing to pay.

With regard to consumption, the findings revealed that only 2% of the panelists reported the use of nut butters every day. It was also revealed that 42% of the panelists consumed nut butters at least 3 times a week while 38% indicated consumption of nut butters at least twice a week.

On the other hand, 16% of the panelists reported that they consumed similar products once per week, and only 2% doesn't consume nut spread at all.

The panelists also proposed the price per kilogram that they thought reasonable and would be willing to pay for. Out of the total panelists, 60% reported that they were willing to pay 8000 - 10,000 TZS/Kg of cashew nut butter spread, while 28 % indicated that a price between 11,000 to 13,000 TZS/Kg was reasonable. Moreover, the finding revealed that 6% of the panelist reported that they would be willing to pay between 14,000 to 16,000 TZS/Kg, and the remaining 6% were willing to pay 17,000 - 20,000 TZS/Kg of the product.

Conclusion

Cashew butter products were formulated from Cashew nut kernel pieces (splits, LWP and SWP). The butters displayed good microbiological and proximate composition. The low moisture content and good handling and proper storage of both the kernels and butters are some of the factors that help to inhibit microbial growth. The kernels were rich in fats, protein, and minerals, with some minor variation in content. The Fat content of roasted cashew butter was higher than the fat content of unroasted cashew butter. The cashew nut butters produced were accepted by the panelists, however the roasted cashew nut butters were highly preferred by the panelists due to the roasted nutty aroma of the butter. Also the panelists showed willingness to buy the products should they find the products in stores/supermarkets and they are willing to pay more than the price of cashew kernel pieces, this suggests that production of cashew butter is one of the ways to add value to the lowly priced cashew kernel pieces.

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