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Full Length Research Paper

Process development, sensory and nutritional evaluation of honey spread enriched with edible insects flour

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The study was aimed at improving existing methods of processing of, commonly consumed insects in Lango sub region of Northern Uganda to enhance consumption and improve the nutrition of the people. Insects (crickets, soldier and winged termites) flour processed by either pan frying or boiling followed by sun drying was substituted into honey. The resulting spreads were evaluated by fifty panelists to screen for acceptability by insect species and their processing methods in stage one. Subsequently, the insect and processing method combination most preferred by panelist for spread enrichment was used to determine; the effect of insect flour inclusion level (8, 16 and 24%) and processing temperature (80, 90 and 100°C) on acceptability and nutritional quality. Data was analyzed using analysis of variance (ANOVA), means were separated using least significant difference test at 5% and results reported as mean ± Standard Deviation (SD). Honey spread enriched with soldier termite flour processed by pan frying was most preferred. Increased substitution level decreased acceptability; nutrient content increased significantly ($p<0.05$) with increased insect proportion while processing temperature had a significant ($P<0.05$) effect on the nutritional quality. Protein digestibility decreased with increase in processing temperature from 59.19 to 45.28%, Fe and Zn solubility increased from 14.09 to 42.89%; 3.06 to 27.17% at 80 and 100°C, respectively. Spreads enriched with 8% soldier termite flour processed by pan frying at 100°C had good nutritional and sensory qualities. The study signifies the potential of termite flour in fortifying food products with acceptable sensory and nutritional qualities.

Key words: Edible insects, honey spread, sensory acceptability, nutritional quality.

INTRODUCTION

Edible insects represent a rich source of protein for the improvement of the human diet. Ramos -Elorduy et al. (1997) analyzed several insects that are currently eaten and concluded that, the species provide high quality proteins and supplement the diet significantly with minerals and vitamins that are often in short supply in developing countries. Indeed insects have played an important part in the history of human nutrition in Africa, Asia and Latin America (Kampmeier and Irwin, 2009; Ramos-Elorduy et al., 1997: Van Huis et al, 2013). However, the greatest challenge in limiting entomophagy (practice of eating insects) is the seasonal availability and perishability. Insects such as termites (*Macrotermes spp.*) come in plenty at the onset of the rainy season, but can only be utilized within a day or two after collection (Ayieko et al., 2010). Processing of perishable foods increase their shelf life and can make them available all year round without developing undesirable characteristics. Production of value added products is a way of reducing post-harvest losses, increasing supply and stabilizing availability of the insect food.

In the Sub Saharan Africa, processing of edible insects mostly involve removing the wings, legs and other appendages, followed by frying without oil, roasting or boiling followed by sun drying (Ayieko and Oriaro, 2008; Illgner and Nel, 2000; Kinyuru et al., 2009; Ssepuuya et al, 2016 a & b). Insects such as termites are prepared by frying in their own fat under low heat (Ayieko et al., 2010; Christensen et al., 2006: Defoliart, 1999; Ssepuuya et al., 2016 a & b). Boiling is a method used for handling large quantities of edible insects so that they can be kept for consumption at a later date after harvest. Boiling is usually followed by sun drying which achieves preservation by reducing the water content of food to about 10 to 15%, making food less prone to microbial deterioration and enzymatic spoilage.

Boiling followed by preservation with salt is also common (De Foliart, 2002; Huis, 2003). Illgner and Nel (2000) reported that mopane catterpillars are boiled for about 20 to 60 min after which salt is added and they are put on the ground to dry. Dried catterpillars are stored in bags in the hut and eaten for several months (Johnson, 2010b; Lukiwati, 2010). Most seasonally available edible insects' species are often preserved for later consumption in seasons of scarcity.

Processed insects are usually consumed as part of a meal or as a complete meal with tapioca, bread and toast corn or eaten as a snack (Ekpo and Onigbinde, 2007; Kinyuru et al., 2009). Van Huis (2003) presents a summary of the practice of pounding insects into powder/flour or paste and mixing with other food ingredient in different societies in Africa. The Naro in D'kar make grasshopper powder by, pounding them in a mortar, to mix it with maize flour in porridge; while caterpillars are pounded into powder and mixed together with stewed watermelon by the San women in the Central Kalahari. On the islands of Lake Victoria in Uganda, aquatic insects from the genera of Chironomidae, Chaoborus and Povilla are processed to flour which is used to make insect cake. The insect cake is prepared by mixing the flour with water and allowing the mixture to sun dry (Bergeron et al., 1988).

A survey on knowledge, attitudes and practices regarding to edible insects in Lango sub region, Northern Uganda revealed that dried termites are pounded using a mortar into paste/flour and eaten as such or mixed with other food ingredients like honey, peanut and plant oils. Similar preparation method was reported for termites (*Macrotermes* spp.) in Kenya and Nigeria (Ayieko et al., 2010; Ekpo and Onigbinde, 2007). This is a process of enrichment of food such as honey with nutrients in edible insects, to obtain a quality food product. Honey is rich in carbohydrates and yet deficient in proteins, essential fats and minerals (Kaakeh and Gadelhak, 2005; Murray et al., 2001).

While it is locally known in the Lango sub region, Northern Uganda that insects can be made into flour and blended with honey, information on production process, sensory and nutrient characteristics is not available. This study was therefore designed to: Develop honey spreads enriched with flour from commonly consumed insects in the Lango sub region of Northern Uganda; evaluate suitability of insects and processing methods for the honey spread development; determine the effect of insect flour inclusion levels and processing temperature on sensory and nutrient characteristics of the spreads. The significance of this research is related to the need to identify native foods which may be valuable in providing third world countries with inexpensive and nutritionally complete dietary constituents.

MATERIALS AND METHODS

Selection of insect species for honey spread development

The study was conducted using edible insects consumed in the Lango sub region, formally known as Lango district, located in Northern Uganda. This area was split into districts of Apac and Lira and subsequently into several other districts (Amolatar, Dokolo, Kole, Otuke, Oyam and Alebtong). The sub-region is home mainly to the Lango ethnic group with a population of about 1.5 million (National Population and Housing Census, 2002). Lira district which is one of the mother districts in the sub-region was purposely selected for this study. It had a population of 515,666 people in 108,691 households. A sample of three hundred and sixty (360) households was purposively selected. Sample size was determined in reference to Watson (2001), according to the formula:

$$n = [p(1-p)/(A^2/Z^2 + p(1-p)/N)]/R$$

Where: **n**= sample size, **N**=Number of households in Lira district (108,691), **P**= estimated variance (0.3), **A**=desired precision, 5% (0.05), **Z**= confidence level, 95% (1.96), **R**=estimated response rate, 90% (0.9). Therefore n=357, a figure of 360 was used. consumed. Selection of insect species for honey spread enrichment

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Figure 1. Figures of edible insects used in honey spread enrichment.

was guided by availability of the species, frequency of consumption, local preference, market value, perceived nutritional value by the community and extent of anthropogenic pressure on species. Information obtained from the survey was validated by three Focus Group Discussions (FGDs) held in the area. Each focus group consisted of ten (10) key informants (5 males and 5 females) in the age bracket of 45 to 60 years. During the FGD, home based value addition practices were also identified and this was the basis for enrichment of honey spreads with edible insects. Based on the inclusion criteria three species were selected; winged termites (*Macrotermes bellicosus*), soldier termites (*Syntermes soldiers*) and crickets (*Branchytrupes spp.*) (Figure 1).

Collection of insects and process development

The insects were harvested between March to early May 2013, by the locals from cropland using traditional methods as described by Van Huis (2003) which involve attraction to light at the termite mound in the case of winged termites; "termite fishing" in the case of soldier termites and location by sound or digging out of the hole in case of crickets. Harvested insects were transported in iced boxes to the laboratory at the school of Food Technology, Nutrition and Bio-engineering, Makerere University prior to processing. A processing procedure for honey spread enriched with insect flour was developed and is outlined (Figure 2).

Insects were prepared according to the description by Menzel et al. (1998). The procedure involved cleaning, blanching and freezing to slow down the rate of metabolism to cater for delay in processing. In the rural areas insects are processed promptly after capture and freezing is not a necessary step. Insects were processed using two traditional processing methods; pan frying until crisp dry and boiling in little water. Both processes were done for 15 to 20 minutes on a hot plate set at 100°C. Boiling was followed by draining the water and sun drying for 3 to 4 consecutive sunny days. Choice of the processing temperature and time were based on the need to crisp dry the insects in the case of panfrying; induce development of good flavor and aroma of insects and at the same time minimize the nutrient loss associated with heat treatment. Dried insects were milled and sieved using a 250 µm mesh sieve to fine consistency. Insect-honey spreads were developed by substituting honey with insect flour/paste at 8%. Substitution rate was decided upon after trying 5, 10 and 15% honey substitution levels while observing changes in the product color, aroma and spreadability.

At 5%, the color and aroma was good but the product was thin hence poor spreadability, while at 10%, spreadability and aroma of the spread was good but the color was dark and at 15% the spread was thick, the color was dark and the aroma of the insect flour was quite intense.

Suitability of insect and processing methods for development of spreads

In stage one, spread from different insects and processing methods were sensory evaluated to determine sensory attributes and overall acceptability. This was the basis for screening the insects and processing methods combination most suitable for the spread. Fifty un-trained panelist consisting of males (20) and females (30) in the age bracket of 18 to 40 years with no history of food allergies evaluated the products. Half (25 panelist) were familiar with consumption of edible insects in their communities. Evaluation was done based on 9-point hedonic scale (1=dislike extremely, 2=dislike very much, 3=dislike moderately, 4=dislike slightly, 5=neither like nor dislike, 6=like slightly, 7=like moderately, 8=like very much, and 9=like extremely).

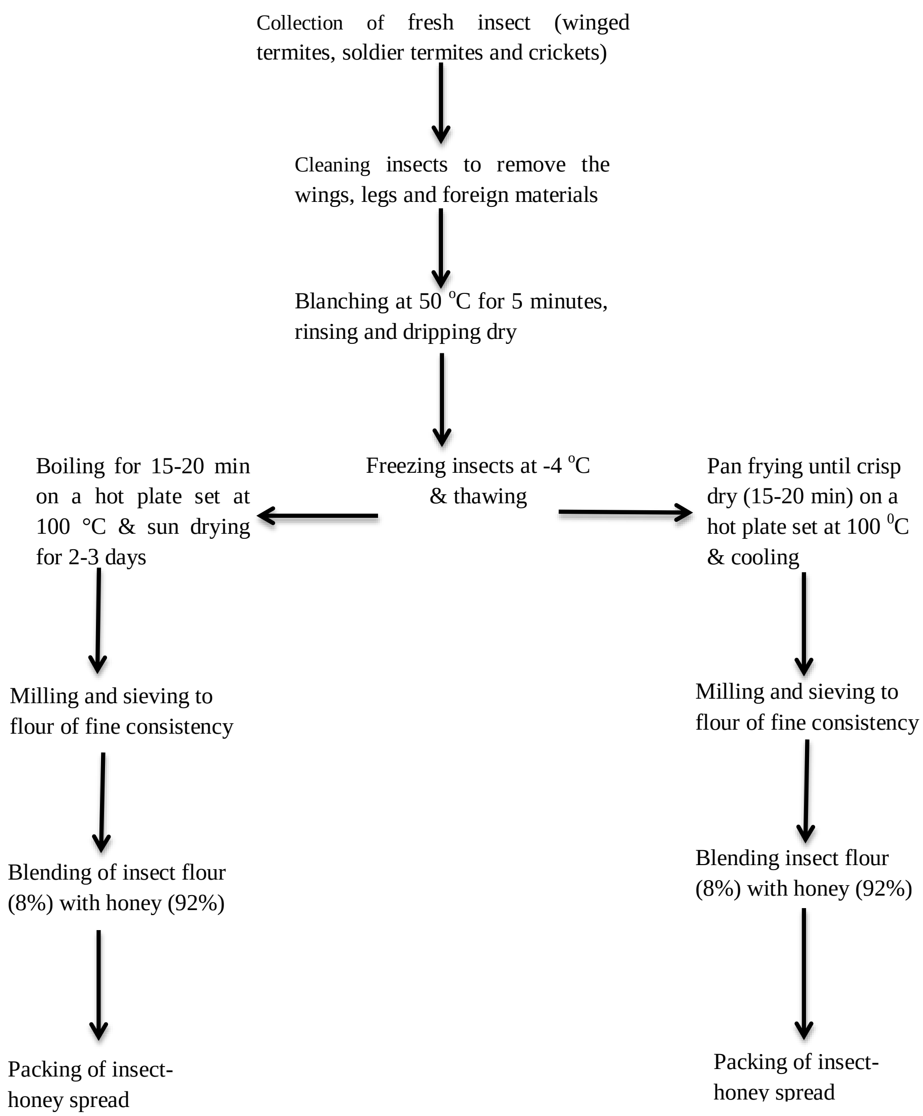

Figure 2. Processing procedure for insect-honey spread.

Effect of proportions and processing temperature on sensory and nutrient characteristics

In stage two, the insect and processing method combination most preferred by the panelist for spread enrichment (soldier termites processed by pan frying), was used to determine the effect of insect flour inclusion level and processing temperature on consumer acceptability and physiochemical properties of spread (Figure 3). Soldier termites were processed by pan frying and 8, 16 and 24% of the flour was substituted into honey. The resultant spreads were subjected to sensory evaluation while the nutrient (protein, calorific value, Fe and Zn) contents were analyzed using Nutri-survey 2007, a software which calculates the nutrient composition and quantity of food based on the ingredients in the food. The most preferred proportion by panelist (8% enrichment) was used to determine the effect of processing temperature on sensory and nutrient characteristics of spread. Honey spreads were enriched with 8% flour from soldier termites pan fried at 80, 90 and 100°C for 20min. Sensory evaluations of the spreads were done and nutrient characteristics (*in vitro* protein digestibility, energy value, Zn and Fe solubility) was determined in triplicates

Determination of nutrient characteristics of spread

In vitro protein, digestibility was determined by digesting about 0.2 g of each sample using pepsin according to Butts et al. (2012). Protein digestibility was calculated as;

$$\textit{In vitro}\ \text{ptotein digestibility}\ (\%) = [(A - B)/A] \times 100$$

Where; A= Protein in the sample, B= Protein after digestion

Total calories were determined by combusting one gram of the sample in a bomb calorimeter (Gallenkamp Auto Bomb, UK) according to (AOAC, 1999). The initial temperature of the calorimeter was recorded (Ti), the sample was ignited and the final temperature was recorded (Tf). The energy value of the sample

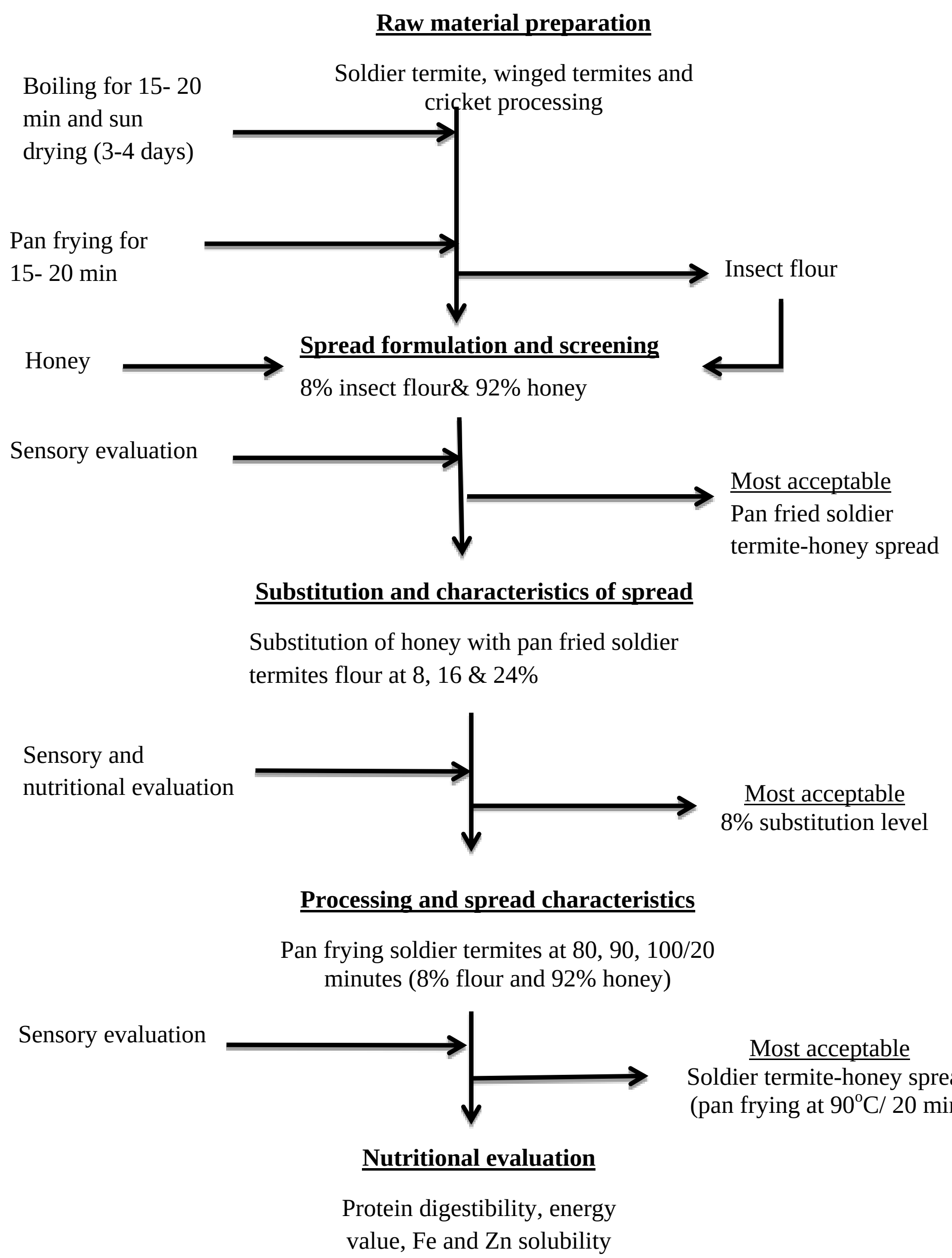

Figure 3. Product processing and characteristics of insect- honey spread.

was computed as:

$$\text{Total energy (Kcal/g)} = [(\Delta T \times C_s) - \text{length of wire burnt}]/(W_t \times 1000)$$

Where; ΔT = Temperature change (T_f- T_i), W_t = Weight of sample, Cs = Energy equivalent of the bomb system (2464 Cal/g)

Iron and zinc solubility was determined using the method of Miller et al. (1981). Peptic digestion was stimulated at pH 2 by adding pepsin and HCl to the sample and incubating at 37°C for 2 h. pH was adjusted to 7 using $NaHCO_3$, pancreatin and bile salt was added and samples incubated at 37°C for 4h. Soluble iron and Zinc was measured using atomic absorption spectrophotometer and the results were presented as a percentage.

$$\text{solubility (\%)} = [S/C] \times 100$$

Where; S= soluble iron/ zinc content (mg/100 g DM of sample), C= total Iron/zinc content (mg/100 g DM of sample).

Data on the sensory and nutritional characteristics of the different treatments were subjected to analysis using Statistix version 9.0 analytical software. Analysis of Variance (ANOVA) was performed and difference between mean was separated using Least Significant Difference (LSD) test at 5% (P=0.05). Treatment values were reported in means ± standard deviations.

Table 1. Edible insects consumed in the Lango sub region.

Edible insect (Scientific name)	English name	Local name	Percentage response
Macrotermes spp.	winged termites (White ants)	*Ngwen*	97
Syntermes soldiers	Soldier termites	*Okok*	73
Brachytrupes spp.	Crickets	*Odir*	69
Ruspolia nitidula	Cone head and long horned grasshoppers	*Ocene*	55
Apis mellifera	Honeybee	*Kic*	44
Cyrtacanthacris aeruginosa unicolor	Short horned grasshoppers	*Bonyo*	19
Zonocerus variegatus	Grasshoppers	*Ajojot*	16

Table 2. Sensory acceptability of insect-honey spread from different processing methods.

Sensory attributes	Soldiers termites		winged termites		Crickets	
	Pan frying	Boiling & sun drying	Pan frying	Boiling & sun drying	Pan frying	Boiling & sun drying
Taste	$7.13±1.57^{a}$	$6.67±1.52^{ab}$	$6.50±2.11^{ab}$	$5.47±2.30^{b}$	$6.30±1.71^{ab}$	$7.17±1.56^{a}$
Flavor	$6.90±1.29^{a}$	$6.47±1.63^{ab}$	$6.50±1.83^{a}$	$5.20±2.11^{b}$	$6.17±1.72^{ab}$	$6.80±1.63^{a}$
Color	$6.50±1.46^{a}$	$6.03±1.71^{a}$	$6.33±1.56^{a}$	$5.73±1.82^{a}$	$6.37±1.67^{a}$	$6.30±1.99^{a}$
Aroma	$7.27±1.05^{a}$	$6.67±1.27^{ab}$	$6.07±1.68^{ab}$	$5.93±1.82^{b}$	$5.77±2.09^{b}$	$6.20±1.81^{ab}$
spreadability	$7.13±1.31^{a}$	$6.93±1.78^{a}$	$6.93±1.34^{a}$	$6.43±2.14^{a}$	$7.03±1.03^{a}$	$7.00±1.64^{a}$
Texture	$6.33±1.75^{a}$	$6.27±2.12^{a}$	$6.83±1.68^{a}$	$6.33±1.75^{a}$	$6.87±1.74^{a}$	$6.77±1.72^{a}$
Appearance	$6.23±1.78^{a}$	$6.33±1.65^{a}$	$6.13±2.05^{a}$	$5.43±2.09^{a}$	$6.50±1.72^{a}$	$6.73±2.13^{a}$
Overall acceptability	$\mathbf{7.30±0.99^{a}}$	$\mathbf{6.67±1.49^{ab}}$	$\mathbf{6.73±1.70^{ab}}$	$\mathbf{5.80±1.92^{b}}$	$\mathbf{6.77±1.57^{ab}}$	$\mathbf{7.00±1.72^{a}}$

Results are expressed as mean ± standard deviation. Mean values with different superscript letters along each row differ significantly (p<0.05).

RESULTS

Selection of edible insects for enrichment of honey spread

The household survey and focus group discussions identified, seven consumed insects in the Lango sub-region (Table 1). The most commonly consumed and often preferred insects were; *Macrotermes spp* commonly referred to as winged termites (97%), Syntermes soldiers (soldier termites) (73%) and Branchtrupes spp (crickets) (69%). *Macrotermes spp* (white ants) (98%) and *Brachytrupes spp* (crickets) (78%) were reported as seasonally abundant. Equal number of respondents reported that Syntermes soldiers (soldier termites) were abundant (50%) as well as seasonally abundant (50%). *Ruspolia nitidula, Cyrtacanthacris aeruginosa unicolor, and Zonocerus variegatus*) were reported to be rare in the sub region.

Suitability of insects and processing methods for spread development

Processing method of insects did not affect the overall acceptability of the enriched spread significantly (p>0.05) as presented in Table 1. Flavor acceptability of the spreads enriched with pan-fried and boiled-sun dried winged termites is the attribute that differed significantly (p<0.05). However, pan frying of soldier termites produced spread with the highest score of acceptability which also ranked highest in all the sensory attributes investigated.

Effect of enrichment levels on sensory acceptability and Nutrient profile of spreads

Consumer acceptability of honey spread enriched with termite flour varied significantly (p<0.05) with the proportion of termite flour incorporated in the spread. Increased substitution level resulted in to decreased acceptability (Table 2). Rankings for color and spreadability varied with the substitution level. At 8% substitution, the color of the spread was liked, at 16% substitution, the color of the spread was neither liked nor disliked. Substituting honey with soldier termite flour at 8% yielded the highest acceptability scores for all the sensory attributes investigated. Scores of flavor and taste of spreads were not significantly (p>0.05) affected by the

Table 3. Effect of Inclusion level of termite flour on sensory acceptability of honey spread.

Sensory attributes	Insect flour inclusion level		
	8 (%) inclusion	16% inclusion	24 % inclusion
Appearance/color	6.53±1.89[a]	5.90±1.90[ab]	5.23±1.85[b]
Flavor	7.03±1.63[a]	6.63±1.54[a]	6.47±1.41[a]
Taste	7.03±1.72[a]	6.87±1.66[a]	6.57±1.65[a]
Texture/spreadability	7.37±1.79[a]	7.00±0.91[a]	5.90±1.65[b]
Overall acceptability	**7.17±1.64[a]**	**6.80±1.22[ab]**	**6.27±1.36[b]**

Results are expressed as mean ± S.D. Mean values with different superscript letters along each row differ significantly ($p < 0.05$).

inclusion level of termite flour.

Nutrient profile of honey spreads enriched with different proportions of soldier termite flour is presented in Table 3. Energy, protein, Fe and Zn content (per 100 g) of spread increased significantly ($p<0.05$) with increase in the proportion of soldier termite flour. The level of Fe in the spread doubled Zn for all the proportions. Spreads enriched with soldier termite flour had higher nutrient quantities when compared with non-enriched honey. Protein levels in honey was almost negligible (0.45 g) but increased with insect flour proportion into honey. Energy, Fe and Zn levels also increased significantly ($p<0.05$). Contribution of enriched spread to the recommended intake of individuals with high nutrient requirement such as pregnant women also increased with the increase in the proportion of insects in the spread.

Effect of processing temperature on sensory and nutrient characteristics of honey spreads

Increased processing temperature of termites had no significant ($p<0.05$) effect on the acceptability of honey spread (Table 4). Spreadability was the attribute that ranked highest among the spreads which was enriched with flour, processed at different temperatures, followed by taste. *In vitro* protein, digestibility of the spreads decreased with increase in the processing temperature (80 to 100°C) of soldier termites. Energy value of the spread was low at 90°C, while iron and zinc solubility increased significantly ($p<0.05$) with increase in the processing temperatures (Table 6).

DISCUSSION

Insects chosen for honey spread enrichment were most commonly consumed in the study area; winged termites, soldier termites and crickets. These insects are seasonally abundant, hence facilitating their use as food in the seasons of availability. Sensory evaluation of honey spreads enriched with the three insect species and two traditional processing used in this study indicated that, all the products scored above 5 and were therefore considered acceptable to the consumers (Table 5).

This implies that insects studied can be processed using traditional methods to suitable flour for fortification of other food products, which agrees with previous studies (Ayieko et al., 2010; Kinyuru et al., 2009). Pan frying of soldier termites produced the most acceptable spread, possibly due to the flavor, aroma and color developed during the pan frying as a result of the Maillard reaction. When sugars and some proteins are heated, they break down into simpler forms in a series of reactions that create more complex flavors than are in the original food (Mottram, 1998, 2007; Van Boekel, 2006). Flavor and color play an important role in consumer appeal (Shakerardekani et al., 2013).

Enrichment of honey with 8, 16 and 24% soldier termite flour yielded spreads that were acceptable to consumers. However, acceptability scores decreased with increase in substitution. Enrichment of wheat buns with termite flour also showed a similar trend in acceptability (Kinyuru et al., 2009). Product color and spreadability was rated high (6.53) and (7.37) at 8% and low (5.23) and (5.90) at 24% substitution respectively. Decline in spreadability was probably due to the adhesiveness of the product that increased with the quantity of the flour incorporated. A similar observation was made in the characteristics of peanut soy spreads (Dubost et al., 2003; Mazaheri-Tehrani and Yeganehzad, 2009). However, scores of flavor and taste were not affected by the inclusion level of termite flour.

Nutrient content of spread (per 100 g) increased with the quantity of soldier termites flour incorporated. Energy increased from 322.40 to 353.80 kcal, protein from 5.55 to 15.85 g, Iron (Fe) from 3.80 to 8.80 mg and Zinc (Zn) from 1.75 to 4.45 mg at 8 to 24% inclusion level respectively. Increase in nutrient content of spread was attributed to soldier termite flour as a rich source of essential nutrients (Ajayi, 2012; Banjo et al., 2006; Ntukuyoh et al., 2012; Paoletti et al., 2003; Raksakantong et al. 2010). Comparison of enriched to non-enriched honey spread presents soldier termite flour as a suitable ingredient for supplementation of the nutrient deficiency in honey. Honey is a good source of carbohydrates mainly glucose and fructose, but a poor source of proteins, fat, and essential elements like Fe and Zn

Table 4. Nutrient contribution of Termite enriched honey spreads to the recommended intake of pregnant (>month) women.

		Levels of insect flour incorporated and contribution to Recommended intake[a]							
Parameter Per 100 g	**RDI[a] (per day)**	**Percent (0)% ***		**Percent (8)%**		**Percent (16)%**		**Percent (24)%**	
Protein (g)	71	0.45±0.05[d]	(0.6)	5.55±0.07[c]	(7.8)	10.70±0.14[b]	(15.1)	15.85±0.21[a]	(22.3)
Energy (kcal)	3350	303.3±3.00[d]	(9.1)	322.40±0.14[c]	(9.6)	338.10±0.42[b]	(10.1)	353.80±0.71[a]	(10.5)
Iron (mg)	30	1.68±0.38[d]	(5.6)	3.80±0.28[c]	(12.7)	6.30±0.57[b]	(21.0)	8.80±0.85[a]	(29.3)
Zinc (mg)	10.5	1.33±0.03[cd]	(12.7)	1.75±0.071[c]	(16.7)	3.15±0.07[b]	(30.0)	4.45±0.07[a]	(42.4)

Results are expressed as mean ±SD. Mean values with different superscript letters along each row differ significantly (p<0.05). * Values for honey adapted from Bogdanov (2011). Values in bracket are % contribution of different enrichment levels to DRIs. [a]Dietary Reference Intakes (DRIs): recommended dietary allowances and adequate intakes, minerals, Food and Nutrition Board, Institute of Medicine, National Academies 2006.

Table 5. Effect of processing temperature on sensory acceptability of honey spread.

Sensory attributes	**Processing temperature and time**		
	80°C/ 20 min	**90°C / 20 min**	**100°C/ 20 min**
Appearance/color	6.59±2.31[a]	6.56±1.93[a]	6.67±1.78[a]
Flavor	6.44±1.93[a]	6.52±1.63[a]	6.85±1.54[a]
Taste	6.93±1.59[a]	7.04±1.51[a]	7.15±1.59[a]
Texture/spreadability	7.48±1.53[a]	7.59±1.39[a]	7.15±1.68[a]
Overall acceptability	**7.15±1.51[a]**	**7.22±1.19[a]**	**7.07±1.21[a]**

Data is expressed as mean ± standard deviation. Mean values with different superscript letters along each row differ significantly (p<0.05).

Table 6. Effect of processing temperature on nutrient characteristics of spread.

Parameter	**Processing temperature and time**		
	80°C/20 min	**90°C/20 min**	**100°C/20 min**
Protein digestibility (%)	59.19±0.35[a]	54.34±1.76[a]	45.28±3.053[b]
Energy value (kcal)	343.98 ±3.19[a]	316.63±0.50[b]	346.62±0.05[a]
Iron solubility (%)	14.09±0.04[c]	21.70±0.78[b]	42.89±2.83[a]
Zinc solubility (%)	3.06c±0.49[c]	12.62±0.51[b]	27.17±1.47[a]

Results are expressed as mean ± standard deviation. Mean values with different superscript letters along each row differ significantly (p<0.05).

(Bogdanov, 2011; Murray et al., 2001; Saif-ur-Rehman and Maqbool, 2008).

Soldier termite-honey spread could have both nutritional and health benefit as honey is both a nutritive and functional food. Consumption of honey spread enriched with 8% soldier termite flour (the most preferred) along with other food staff supplements were recommended for daily intake of Fe and Zn for women of child bearing age who often have high requirements. *In vivo* studies using diets fortified with termites (*Macrotermes nigeriensis*) up to 70% to feed rats showed that, animals fed with fortified diets had a comparable body weight gain with the control fed growers mash, which is a standard diet. The study recommended fortification of diets for human food and animal feed with termite flour especially in, weaning diet of growing children and nursing mothers to combat food insecurity and malnutrition (Igwe et al., 2013).

Enriched spreads can be consumed by people of all categories; however, consumption of this product is recommended for pregnant mothers who have high Fe and Zn requirements. Otten et al. (2006) recommends consumption of 30 and 10.5 mg/per day of Fe and Zn respectively in pregnant mothers. In developing countries, deficiency of protein, iron, zinc and energy in pregnant women has often been reported (FAO/WHO, 2001, 2007). This product is expected to be safe for consumption to pregnant mothers, as honey is known to have a low water activity and a range of inhibitory agents that limit the growth of microorganisms (Olaitan et al., 2007). Honey spreads enriched with termite flour from various processing temperatures were accepted by the consumers. Processing temperatures affected the nutrient characteristics of the products significantly; *In vitro* protein digestibility decreased with increase in the processing temperature. Depending on the processing conditions, heat processing may reduce or increase protein digestibility. Exposure to denaturation temperatures may increase digestibility of the native proteins by unfolding of the polypeptides chains and rendering the protein more digestible (Opstvedt et al., 2003). However, roasting conditions (high temperature and low moisture content) favors Maillard reaction which leads to a decrease both in protein digestibility and availability of amino acids involved (Björck and Asp, 1983). This perhaps explains the reduction in digestibility for spreads enriched with flour processed at 100°C. Energy value of the honey spread enriched with soldier termite flour processed at 80°C (343.98 Kcal/ g) and 100°C (346.62 Kcal/ g) did not vary significantly. Energy value in food is a function of protein, fat and carbohydrate (Ademulegun and Koleosho, 2012). This may change according to the changes in the food components as a result of heat treatment. Prochaska et al. (2000), reported a decrease in the energy value of food as a result of heat treatment.

Fe and Zn solubility of soldier termite enriched spreads increased with processing temperatures of termite flour; probably as a result of effect of heat treatment on anti-nutritional factors like phytate. Adeduntan (2005) reported phytates concentration of 112 mg/100 g and tannin content of 25 mg/100 g of winged termites. Bioavailability of trace elements is affected by phytates and tannins that form in soluble complexes with Fe, Zn and Ca (Lönnerdal et al., 1994). Hydrolysis of phytate during food processing, increases the mineral availability (Frontela et al., 2011). In a previous study, roasting significantly reduced phytic acid and tannins concentration of peanut and sesame seeds (Embaby, 2010). Intense heat treatment reduces the concentration of anti-nutrient factors (Ejigui et al., 2005; Fagbemi et al., 2005; Singh and Singh, 1991). This subsequently improves on Zn and Fe solubility (Frontela et al., 2011; Hotz and Gibson, 2007). In a previous study on infant porridges, Zn solubility increased with decrease in phytate content (Kayode et al., 2006). Fe solubility of products processed at 90°C was in the range reported for infant porridge.

Conclusion

Edible insects can be processed using traditional methods into flour for fortification of food products. Enrichment of honey with soldier termite flour processed by pan frying yielded spread with good nutritional and sensory qualities. The process developed for production of insect-honey spread is expected to be easily adapted for local production of nutritious, convenient and appealing products so as to encourage insect consumption.

Conflict of Interests

The authors have not declared any conflict of interests.

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Full Length Research Paper

Oxytetracycline residue levels in beef in Dodoma region, Tanzania

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Antibiotic residues in food of animal origin pose a threat to both human and animal's health due to an increasing level of resistant strains of pathogenic bacteria to a wide range of antibiotic drugs. A cross-sectional study was conducted to assess the levels of oxytetracycline (OTC) residues in raw beef in Dodoma region, Tanzania. The OTC levels were determined by using liquid chromatography-mass spectrometry (LC-MS). A total of 60 beef samples were collected from various slaughterhouses and butcheries. Twenty-one out of 60 samples (35%) had OTC residues and no samples had OTC levels above the maximum allowed residues limits (200 µg/kg). The highest OTC concentration was 4.95 ng/g, while the mean concentration was 0.69 ± 0.09 ng/g. The obtained levels were not expected to induce adverse effects and the beef is safe for consumers. Though the findings indicates the meat in the market is safe for consumers, it calls for a proper management of antimicrobial drugs use for animal production as an additional advantage to consumers.

Key words: Liquid chromatography-mass spectrometry (LC-MS), residues levels, raw beef, oxytetracycline.

INTRODUCTION

To obtain sound animal products from milk and meat, animals have to be kept healthy. The care includes feeding, management and control of animal diseases. Some of the drugs used for treatment of animal diseases in Tanzania include tetracyclines (TCs) and beta-lactams like penicillins and cephalosporin (Katakweba et al., 2013). The TCs which are among the first antibiotics, have bacteriostatic activity against both Gram-positive and negative bacteria and are widely used for the treatment of livestock (Nonga et al., 2009). The commonly used antibiotics in livestock production is the oxytetracycline. The presence of OTC, residues in raw beef may cause health problems to consumers, such as bone and teeth problems in children, gastrointestinal disturbance and hypersensitivity reactions (Larkin et al., *2004*). The OTC is named [4S-4a,4a,5a,5a,6b,12a)]-4-(dimethylamino)-,4, 4a, 5, 5a, 6, 11, 12a-octahydro-3, 5, 6, 10, 12, 12a-exahydoxy-6-methyl-1, 11-dioxo-2-

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naphtacenecarboxamide with Molecular weight of 496.5. When antibiotics are not used correctly, there is a possibility of losing the efficiency of these drugs in the management of ailment in human and animals (Bilatu 2012). The Food and the Agriculture Organization (FAO) and the World Health Organization (WHO); recommend the maximum OTC residue of 200, 600 and 1200 µg/kg in muscles, livers and kidneys, respectively (Food and Agriculture Organization/World Health Organization, 2014). Tetracycline residues levels in animal products depend on the initial dosage and the duration between the drug administration and animal product collection (Uekane et al., 2011; Abbasi et al., 2012). The antibiotic residues can remain in the animal's body after slaughtering if withdrawal period is insufficient (Hemmat et al., 2014). Hence, the aim of this study was to analyze the levels of OTC residues in raw beef samples collected from Dodoma region, Tanzania.

MATERIALS AND METHODS

A total of 60 raw beef samples were randomly collected from different dictricts (Bahi, Mpwapwa, Kongwa, Dodoma Urban and Rural and Kondoa) in Dodoma region, Tanzania. A Purposive sampling was used to select these districts, then random sampling was used to pick the beef samples from slaughterhouse and butchers, 30 samples from slaughterhouse and 30 samples from butchers. A total of 10 beef samples were collected from each district. A standard sample size calculation was used to calculate the sample size. Antibiotic-free meat samples (blank matrix) were collected from the Central Veterinary Research Institute of Zambia.

Sample pretreatment and extraction

The samples were kept at -20°C until analysis and were allowed to defrost at room temperature. A representative portion of the defrosted sample (10 g) was weighed and mixed with 25 mg of EDTA per gram sample. The sample and the EDTA were homogenized for 1 min using a blender. The blended sample was further ground using a mortar and pestle. One gram of homogenized sample was accurately weighed into 15 mL polypropylene centrifuge tube. To the sample, 10 µL of 10 ug/mL carbamazepine D10 internal standard solution equivalent to 100 ng/g concentration was added.

Five milliliters acetonitrile were added to the sample and vortexed for 1 min. Each sample was centrifuged for 10 min at 7000 rpm and the supernatant was collected into a separate 15 mL centrifuge tube by decantation. 5 mL acetonitrile were again added to the residue and vortexed for 1 min. The samples were then centrifuged for 10 min at 7000 rpm. Both supernatants were combined in a 15 mL centrifuge tube bringing the total volume to 10 mL. All samples were briefly mixed using a vortex and dried under a stream of nitrogen gas to 2 mL, then sample clean up was done by Supelclean ENVI-carb active coal (Mgonja et al., 2016).

Sample analysis by LC-MS method

The HPLC was equipped with DAD detector and mass spectroscopy (Model Agilent Technologies 6130 Quadrupole LC/MS) to target the flowing parent ions using Single Ion Monitoring (SIM) mode 461 mass per charge ratio (m/z) for OTC. The analytical column was reversed-phase Eclipse XDB C-18. 4.6 x 150 mm set at a flow rate of 0.5 ml/min. The column temperature was 25°C. Mobile phase A was HPLC water with 0.1% formic acid and solvent C was acetonitrile with 0.1% formic acid. The starting mobile phase composition at 0 min was 85% water: 15% acetonitrile at 0.5 ml/min, which are other mobile phase composition. The wavelength of the DAD detector was set at 275 and 355 nm, respectively. Internal calibration curves were prepared by spiking the blank matrix with pure chromatographic standard solutions in the range between 200 and 2500 ng/g injected for each compound and estimates of the amount of the analyte in samples were interpolated from these graphs.

Validation

To test the analytical method trueness, 14 samples were prepared. Each contained 1 g of homogenized muscle tissue of the negative control sample (blank matrix). Seven samples were spiked with 20 µL of 10 ng/mL solutions, equivalent to 200 ng/g of analyte. The other seven samples were spiked with 250 µL equivalent to 2500 ng/g of the analyte. All samples were processed using the described LC-MS method.

Recovery experiment

Samples recovery was determined with blank bovine muscle spiked at 200 ng/g. To test the recovery, 10 samples that contained 1 g of homogenized muscle tissue of the negative control were prepared. They were spiked with 20 µL of 10 ug/mL spiking solution equivalent to 200 ng/g of the analyte. Four samples were used to calculate the recovery mean and six samples were used to calculate the recovery-corrected content.

Ethical issues

Permission for this study was granted by the Ethical Committee of the Sokoine University of Agriculture.

Data analysis

The data were analysed using SPSS version 20. Descriptive statistics were used to compute means, standard deviations and range, a p-value of less than 0.5 was considered statistically significant.

RESULTS AND DISCUSSION

A validated method was capable of detecting OTC residues in raw beef samples. In this method, the most complicated step was during the meat clean up, due to the fact that meat is a complex matrix. Therefore, clean up by Supelclean ENVI-carb active coal could be enough to remove the interfering substances. In addition, carbamazepine D10 was used as internal standard to correct internal and external error.

The concentrations of residue levels in each sample were calculated in ng/g. The obtained mean concentration was then compared with that of WHO

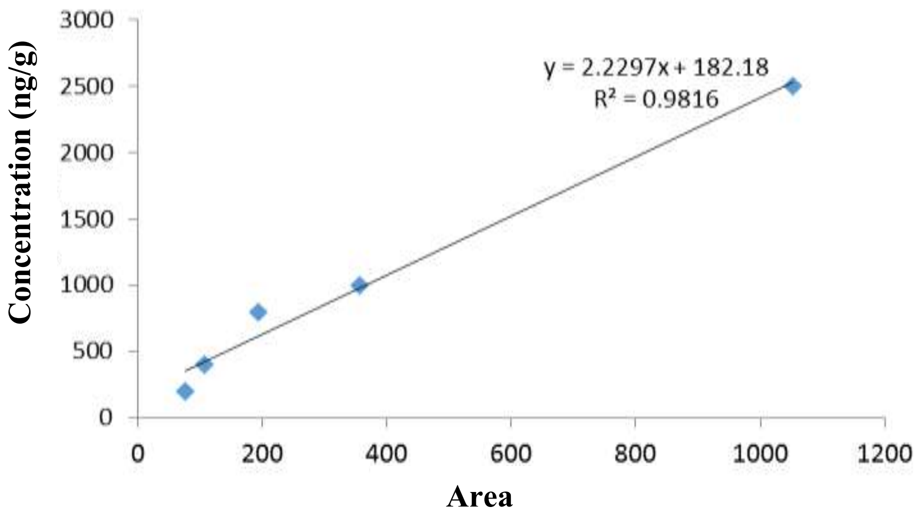

Figure 1. Linear calibration curve of the LC-MS method for OTC residues in beef.

(200 µg/ kg). Of the 60 beef samples, 21 (35%) tested positive to OTC residues and 39 (65%) had no OTC residues. However, none of them had residue concentrations above the acceptable levels for muscle (Food and Agriculture Organization/World Health Organization, 2014).

The mean concentration of OTC residues was 0.69 ± 0.09 ng/kg. The detection and quantification limit were 18.2 and 54.6 ng/g, respectively. The correlation coefficients associated with the linear regression for the analytical OTC standard was 0.9816 (Figure 1). The retention time of the standard was 3.624 min.

TCs are important class of antibiotics in food, animal health and production. These antibiotics have been used for many decades in the treatment of diseases, promote growth and to maintain animals health (Olatoye and Ehinmowo, 2010; Bedada and Zewde, 2012). Katakweba et al. (2013) reported that OTC is one of the most commonly used antibiotics in livestock production in Tanzania. The easy access to these antibiotics and lack of awareness may lead to improper management of these drugs.

The results of this study indicate the presence of OTC residues in 35% of the samples and no samples had OTC residues concentration above the acceptable maximum residue levels recommended by the WHO and FAO. The OTC levels in this study were lower than that reported in other studies (Olufemi and Agboola, 2009; Bedada and Zewde, 2012); even though, Donkor et al. (2011) reported a comparable proportion of 21% OTC levels in beef samples from cattle in Ghana. On the other hand, a study conducted on beef from Morogoro and Dodoma municipalities, Tanzania showed 41.2% of the samples tested positive to OTC residues (Mmbando 2004) which is comparable to this study.The reasons for these differences might be due to the method used, in this study, a simple and sensitive method (Mgonja et al. 2016) was used. In addition, samples collection season and type of TCs used might contribute to the differences. This is due to the fact that during the rain season, the animals are prone to diseases and where by more antibiotics are used during this time which can contribute to misuse of antibiotics. Another reason for these differences may be cold storage as Pavlov et al. (2005) reported decreased level of tobramycin in the poultry products stored at -18°C.

OTC residues in beef samples were also reported in 71.3 and 76.4% in studies conducted in Ethiopia (Addisalem and Bayleyegn 2012) and in Tanzania (Nonga et al. 2013),respectively which were both relatively higher as compared to the percentages obseved in the current study. The presence of high levels of antibiotic residues in meat, may be the results of misuse and overuse of antibiotics which may cause microbial resistance (Nisha, 2008). Biswas et al. (2007) also revealed the presence of OTC residues up to 13.3% of the samples, but no sample had OTC residues concentration above MRLs.

Conclusions

OTC residues were detected in 35% raw beef samples from Dodoma, Tanzania by using LC-MS. The results show that beef samples had OTC level below the FAO/WHO MRLs (200 µg/kg), a mean concentration of 0.69 ± 0.09 ng/g. The obtained levels were not expected to induce adverse effects and the beef is safe for consumers. Though, the finding indicates the meat in the market is safe for consumers, it calls for a proper management of antimicrobial drugs use for animal production, as an additional advantage to consumers.

Conflicts of Interests

The authors have not declared any conflict of interests.

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Nutritional, functional and sensory attributes of jam from velvet tamarind pulp

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Velvet tamarind pulp of *Dialium guineense* have been used as medicinal remedies, as source of vitamin C and as flavour in snacks and non-alcoholic beverages. The nutritional, functional and sensory attributes of velvet tamarind pulp jam was assessed. Proximate, mineral profiles, beta-carotene, riboflavin, niacin, thiamin, ascorbic acid and phytochemical profiles in jam samples were determined. Sensory evaluation of the jam samples was carried out using a 7-point hedonic scale. Moisture content of the jam was 74%, fat 0.47%, protein 2.3% and ash 0.85%. Some essential elements including Ca (0.97 mg/100 g), Mg (1.04 mg/100 g), K (1.44 mg/100 g), Na (0.21 mg/100 g) and P (0.35 mg/100 g) were contained in the velvet jam, while energy value was 499 KJ/100 g. The results indicated that the velvet tamarind jam would provide essential valuable minerals, energy and vitamin C, needed for good body development.

Key words: Velvet pulp, jam, vitamin C, proximate composition, overall acceptability.

INTRODUCTION

Dialium guineense Wild with English name black velvet or velvet tamarind tree is commonly called 'Awin' among the Yorubas, and icheku by Igbos. The fruit pulp which is red, with a sweet-sour, astringent flavour similar to baobab, but sweeter, is eaten raw when dry by man and animal (Matsuda, 2006).

Velvet tamarind is an important multipurpose agroforestry crop (Nwaoguala et al., 2007). It is made up of two species (*Dialium indium* or *Dialium cochichinense* and *D. guineense* wild) (Ubbaonu et al., 2005). *D. guineense* commonly known as African black velvet tamarind, is a large tree found in many parts of Africa, such as West Africa, Central African Republic and the Chad. The tree belongs to the family *Fabaceae*-caesalpinioidaea, it is 30 m high, with a densely leafy crown, but often shrubby. The leaves are finely hairy, broadly elliptic, blunt at the apex, leathery and are a sunken midrib. Its flowers appear whitish and the branches are horizontally spread (Szolnok, 1985).

Fruits are usually circular and flattened, black in colour with stalk 6 mm long, a little collar is seen near the apex and a bristle shell encloses one or two seeds embedded in a dry, brownish edible pulp (Hong et al., 1996). Wild fruits are dietary supplement for rural dwellers in Nigeria during the - dry season when fruits are scarce (George Mateljan Foundation, 2011). The fruits are

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used as source of vitamin C, as flavour in snacks and non-alcoholic beverages (Effiong et al., 2009; Adame, 2002).

Fruit pulps supplies high amount of micronutrients like sodium, magnesium and potassium. Bark and leaves are used against several diseases such as malaria (Effiong and Udo, 2010). Velvet tamarind is a tall, tropical, fruit bearing tree which belongs to the leguminosae family that has small and grape-sized edible fruits with brown hard inedible shells. It grows in savanna regions of West Africa and widely spread in Nigeria (Ogungbenle and Ebadan, 2014). The fruit is used as a candy-like snack food in Thailand, often dried, sugar coated and spiced with chilies.

Awin, as this fruit is called by the Yoruba people of Nigeria, has an orange coloured pulp which has a sweet and sour taste and a dry powdery texture. The fruit is also called *Icheku* by the Igbos, *Tsamiyarkurm* by the Hausas (Gbile, 1980; Burkill, 1985). The fruit is rich in minerals (magnesium, sodium, iron, potassium and beta-carotene (Vitamin A), copper, sugars and tartaric acid, citric acid, malic acid, ascorbic acid and Niacin. As anticipated, this fruit also has high levels of anti-oxidants. The pulp is believed to improve appetite and is used as a gargle for sore throats, dressing of wounds and is said to aid the restoration of sensation in cases of paralysis. The unique sweet/sour flavor of the pulp makes it popular in domestic cooking and flavorings. The thirst quenching, refreshing fruit pulp can also be soaked in water and drank as a beverage and also provides chewing sticks, jams and jellies (FAO, 2004).

In Nigeria, however, velvet tamarind pulp is normally consumed fresh; which could be the reason why at its peak period, the surplus fruit suffers post-harvest losses due to poor handling and weevil infection (CTA, 2012). There is urgent need to explore an affordable and easily adoptable food processing method that can be used to convert the surplus fruits into shelf stable products like juices, jams and jellies which are easy, cheap and economically reliable alternative that will reduce post-harvest losses and in the long run reduce vitamin C deficiency in individuals.

This study was conducted to investigate the potential of velvet tamarind pulp in jam production with a view to improving utilization efficiency of the fruits pulp; thereby, adding value to the tree and encouraging its cultivation and sustainable management.

This study was therefore designed to develop jam from velvet tamarind pulp.

MATERIALS AND METHODS

Velvet tamarind fruit source

The velvet tamarind (*D. guineense)* fruits used for the present work were purchased from three different markets (Ndioru, Orie-Ugba and Ubani) in Abia State, Nigeria.

Sample preparation

The fruits were washed thoroughly in tap water to remove extraneous materials. The fruits were then air-dried. Bruised and spoilt fruits were discarded. A randomly selected clean sample of the fruit pulp was extracted from the fruits by soaking in clean water for 20-30 min. The pulp was separated from the seeds by sieving. Samples were pooled to obtain the sample for the preparation of the jam. The pulp was separated from the shell and seed. Potable water (1125 ml) was added to 400 g de-hulled fruit and allowed to rest for 1 h at room temperature (29-30°C) to dissolve the pulp. A sieve (5 mm) was used to separate the pulp from the seed.

The jam preparation process

The jam was produced by using the open kettle process. Sugar (200 g) was added gradually as boiling continued and twenty milliliters (20 ml) of lemon juice to enhance gel formation, improve colour and flavor of the jam. The jam produced was then cooled at 80°C before pouring into bottles. The jam was stored under refrigeration condition (12^{o}C) for further analysis.

Chemical analyses

The proximate compositions of the sample were determined using AOAC (2006) methods. Moisture content of the jam was determined gravimetrically. The protein content was determined by micro-Kjeldahl method, using 6.25 as the nitrogen conversion factor. The fat content was determined by Soxhlet extraction method using petroleum ether. The ash content was determined by incinerating the samples at 600°C in a muffle furnace. Carbohydrate was obtained by difference, while gross energy (KJ and Kcal per 100 g) was calculated based on the formula by Eknayake et al. (1999). Gross energy (Kcal per 100g dry matter) = (crude protein x 17) + (crude lipid x 37) + (crude carbohydrate x 17) for protein, carbohydrate and lipid, respectively.

Mineral elements were determined using wet-acid digestion method for multiple nutrients determination as described by the method of AOAC (2006). About 0.2 g of the processed sample material was weighed into a 150 ml Pyrex conical flask. Five milliliters (5 ml) of the extracting mixture (H_2SO_4 – Sodium salicylic acid) was added to the sample. The mixture was allowed to stand for 16 h. The mixture was then placed on a hot plate set at 30°C and allowed to heat for about 2 h. Five milliliters (5 ml) of concentrated perchloric acid was introduced to the sample and heated vigorously until the sample was digested to a clear solution. Twenty milliliters of distilled H_2O was added and heated to mix thoroughly for about a minute. The digest was allowed to cool and was transferred into a 50 ml volumetric flask and made up to the mark with distilled water. The digest was used for the determinations of calcium (Ca) and magnesium (Mg) by the ethylenediamine ditetraacetic acid Versanate Complexiometric titration method (AOAC, 2006). AOAC (2006) method was used to determine sodium (Na) and potassium (K) by using a flame photometer (model PFP7 Digital, Jenway, UK). All other minerals were determined by atomic absorption spectrophotometer (model 3030, Perkin Elmer, Norwalk USA)

The β-carotene, riboflavin, niacin and thiamin of the products were determined spectrophotometrically as described by AOAC (2006). Ascorbic acid was determined using titration method as described by AOAC (2006). Gravimetric method (Harborne, 1973) was used to determine alkaloids. Saponin was determined by gravimetric oven drying method as described by the method of AOAC (2006). Tannin content of the sample was determined spectrophometrically as described by Kirk and Sawyer (1991). Phenol was determined by the Folin-Ciocalteu method (AOAC

Table 1. Energy and proximate composition of velvet tamarind (*D. guineense)* jam (dry basis).

Nutrient	Velvet jam
Moisture (%)	74.4±0.67
Protein (%)	2.3±0.08
Fat (%)	0.47±0.03
Ash (%)	0.85±0.01
Crude fiber (%)	0.66±0.04
CHO (%)	21.3±0.51
Energy(KJ/100 g)	136.38/499

Values of means ± standard deviation of duplicate determinations.

2006). Flavonoid was determined by gravimetric oven drying method as described by Harborne (1973).

Sensory evaluation

Twenty member panels of assessors with two jam samples were used. Panelists were asked to score samples based on the intensity of organoleptic quality attributes of appearance (colour), flavor, consistency and overall acceptability using the 7-point hedonic scale where 7 = like very much and 1 = dislike very much (Iwe, 2002).

Statistical analysis

Data were expressed as means ± standard deviation (SD) of two replications, and one factor ANOVA was used for the statistical analysis using SPSS program (version 20 SPSS Inc., USA). The values of sensory evaluation were considered to be significantly different when $P<0.05$.

RESULTS AND DISCUSSION

Energy and proximate composition of jam developed from velvet tamarind (*Dialium guineense)*

The proximate composition of velvet tamarind is presented in Table 1. The moisture obtained for velvet jam was 74.4%. When compared with other work, the value of moisture in this study was lower than the value (96.3%) reported for commercial orange jam (Tanwar et al., 2014). The moisture content of any food is an index of its spoilage (Dewole et al., 2013); this implies that velvet tamarind jam may have a longer shelf life than orange jam. The total ash (0.85%) was found to be lower than those of velvet tamarind pulp (1.47%) (Niyi, 2015). Ash value has been regarded as an indicator for food quality evaluation. The crude fiber (0.66%), and crude fat (0.47%) obtained for velvet tamarind jam were lower than the crude fiber and crude fat values (2.2 and 3.4%) reported for pineapple jam, but the crude protein (2.3%) obtained for velvet jam was higher than the value of crude protein (0.8%) reported for pineapple jam (Aina et al., 2015). Protein has been identified as one of the deficit nutrient in the developing countries; this implies that consuming velvet jam along with other protein food sources will increase protein intake. Protein malnutrition is one of the serious challenges in Africa continent especially Nigeria.

The carbohydrate and energy obtained for velvet jam were 21.3 g/100 g and 499 KJ, respectively. The calorific value of the sample was fairly high. The human body needs considerable energy when at rest. The amount required has been determined to be about 1 Kcal per kg of body weight per hour or 1,500 to 2,000 Kcal per day. This depends on the individual's metabolism. The largest part of human energy consumption via food is used for manufacturing essential life processes and body temperature (Osborne and Voogt, 1978). The energy that the body derived from food is lower than the amount of energy produced when food is burned or completely oxidized in a bomb calorimeter. This is due to calorie producing nutrients, which are mainly protein, fats and carbohydrates that are not completely digested, absorbed or oxidized to yield energy in the body (Akubugwo et al., 2007). The present value was lower than those of velvet tamarind pulp (761.4 KJ/100 g) (Niyi, 2015). Based on the required amount per day recommended (1,500 - 2,000 Kcal per day) (Osborne and Voogt, 1978), velvet tamarind may only supply a part of energy required per day when consumed.

Mineral composition of jam developed from velvet tamarind (*D. guineense*) jam

The results of mineral profile of velvet tamarind jam are presented in Table 2. The most concentrated mineral was potassium followed by magnesium while calcium took the third position. Both calcium and magnesium are mostly found in the skeleton. In addition to its structural role, magnesium is an activator of various enzymes. The calcium is an essential component in bone formation. The value of calcium was greater than those values reported for velvet tamarind pulp (44.1 mg/g) (Niyi, 2015). This suggests that the amount of calcium present in the sample would be adequate for infant development of bones and teeth. Sodium and potassium control water equilibrium level in the body tissue and are also important in the transportation of some non-electrolyte. The Na/K ratio was 0.15. The ratio of 0.60 is recommended for intake (Niemann et al., 1992). The value reported for the sample was lower than the recommended value. This indicates that velvet tamarind would not support hypertension. Phosphorus is required for most chemical reactions in the body especially in the teeth. The Ca/P ratio of >0.5 is required for favourable calcium absorption in the intestine for bone formation (Niemann et al., 1992).

Table 2. Mineral composition (mg/100 g) of velvet tamarind (*D. guineense)* jam (dry basis).

Nutrient	Velvet jam
Calcium (Ca)	0.97±0.03
Magnesium (Mg)	1.0±0.08
Phosphorus (P)	0.35±0.01
Potassium (K)	1.44±0.02
Sodium (Na)	0.21±0.42
Iron (Fe)	0.25±0.02
Na/K	0.15
Ca/P	2.77

Values of means ± standard deviation of duplicate determinations.

Table 3. Vitamin composition (mg/100 g) of velvet tamarind (*D. guineense)* jam (dry basis).

Nutrient	Velvet jam
Vitamin C	27.7±0.13
Thiamin	0.10±0.01
Riboflavin	2.0±0.01
Niacin	1.4±0.02

Values of means ± standard deviation of duplicate determinations.

The Ca/P that was greater than 0.5 obtained for the sample would enhance high absorption of calcium in the digestive system, when consumed. The imbalance of calcium and phosphorus may also lead to adult rickets called osteomalacia and deficiency of calcium may equally result to bone thinning called osteoporosis, which is common among older people (Moldawer et al., 1965). This indicates that when the daily consumption of calcium is insufficient, the body utilizes the available calcium in the blood serum and bones to maintain constant body activities. Therefore, consumption of calcium should be maintained at optimal level over human life span. The value of iron was higher than those of velvet tamarind pulp (19.1 mg/g) (Niyi, 2015). Iron is essential for the formation of blood. Iron deficiency anaemia (IDA) is a major cause of low birth weight and maternal mortality and has been identified as an important cause of cognitive deficit in infants and young children (Nnorom et al., 2007). Bassa et al. (2003) reported that IDA is one of the major public health diseases in the world at large, most especially in Asia, sub-Saharan African countries; Nigeria inclusive. The iron level in velvet tamarind will therefore, alleviating IDA when fortified with other human enhance the formation of red blood cells in the body and foods of low iron value. Iron element is essential for blood cell particularly hemoglobin.

Vitamin composition of velvet tamarind jam (*D. guineense)*

The vitamin composition of the jam developed from velvet tamarind is presented in Table 3. The vitamin C level of velvet tamarind jam was 27.7 mg/100 g. The high vitamin C value obtained from velvet tamarind makes it an important product to be incorporated in diet plan in the developing countries where most people depend on plant for their iron source. Okegbile et al. (1991) found high content of vitamin C and other micronutrients in wild fruits when compared with nutrition supplied by other fruits such as oranges, Avogadro pear, pineapple, pawpaw and commercially produced fruits. Other vitamins obtained in velvet tamarind jam were thiamin (0.10 mg/100 g), riboflavin (2.01 mg/100 g) and niacin (1.5 mg/100 g). The B-vitamins are known for their roles in energy metabolism *in vivo* (Wardlaw and Hampl, 2007). The value of vitamin C in velvet tamarind jam was fairly high. The deficiency in man may cause scurvy. The value currently reported for the sample was in close agreement with those values reported for velvet tamarind pulp (33.3 mg/100 g) (Niyi, 2015) but higher than that of beach pea (1.60 mg/100 g) and green pea (6.50 mg/100 g) (Chavan et al., 1999). The vitamin C value for velvet tamarind jam was also lower than that of cashew apple (203.5 mg/100 g) (Akinwale, 2000). The high value of ascorbic acid in velvet tamarind pulp makes it useful in the prevention of scurvy, bleeding gums, limbs pain and blindness. The daily dietary allowance for vitamin C is 45 mg/day as reported by NAS (1974).The vitamin C content in velvet tamarind will meet the recommended daily requirements (NAS, 1974) when consumed.

Phytochemical composition of velvet tamarind (*D. guineense*) jam

The results of the phytochemical composition of the product are shown in Table 4. Tannin was the highest phytochemical obtained in the product (0.55 mg/100 g). When compared with other study, the value of tannin (0.55 mg/100 g) in this study was higher than the tannin value (0.19 mg/100 g) reported for pineapple jam (Aina et al., 2015). Phytic acid (0.06 mg/100 g), HCN (0.07 mg/100 g), saponin (0.4 mg/100 g), alkaloid (0.3 mg/100 g) and flavonoid (0.1 mg/100 g). Flavonoids are a class of secondary plant metabolites that exert beneficial health effects through their antioxidant activity (Heim et al., 2002). Though phytochemicals such as phytic acid, saponin, alkaloid and hydrogen cyanide were found in the product, it is important to note that their values were

Table 4. Phytochemical composition (mg) of velvet tamarind (*D. guineense*) jam (dry basis).

Phytochemical	Velvet jam
Tannin	0.55±0.01
Phytic acid	0.06±0.00
HCN	0.07±0.00
Saponin	0.04±0.00
Alkaloid	0.3±0.02
Flavonoid	0.1±0.00

Values of means ± standard deviation of duplicate determinations.

Table 5. Sensory attributes of velvet tamarind and pawpaw jam.

Sample	Colour	Flavor	Taste	Texture	Overall acceptability
Velvet tamarind jam	6.5±1.3[b]	7.1±1.5[a]	7.1±1.4[a]	6.1±1.9[b]	7.2±1.2[b]
Pawpaw jam	7.7±1.6[a]	6.4±2.1[b]	6.9±1.7[b]	6.9±1.6[a]	7.3±1.3[a]

Means with different superscripts along the same row are statistically different from each other (P<0.05).

within the permissible level (<1%). This implies that the jam developed from velvet tamarind is safe for human consumption.

Sensory attributes of velvet tamarind jam

The organoleptic evaluation remains the final judge of food quality. The results of sensory evaluation of velvet tamarind jam are presented in Table 5. The scores for colour (7.7) and texture (6.9) obtained for pawpaw jam were significantly higher than scores obtained for velvet tamarind jam (6.5 and 6.1, respectively). The preference of the colour of pawpaw jam to that of velvet tamarind jam may be due to its high carotenoids content which give attractive red or yellow colour and also contribute to food quality (Sharma et al., 2011). The smooth nature of pawpaw jam must have contributed to it been preferred to velvet tamarind jam in terms of texture. The taste and flavor of velvet tamarind jam were preferred to those of pawpaw jam, but the generally acceptability of velvet tamarind jam was comparable to that of pawpaw jam. The taste and flavor of velvet tamarind jam may be due to a combination of high contents of tartaric acid and reducing sugars found in velvet tamarind (Minh, 2015).

Conclusion

The study showed that velvet tamarind jam contained substantial amount of protein, potassium, magnesium, vitamin C and riboflavin. The taste and flavor of velvet jam were preferred to those of pawpaw jam, but the generally acceptability of velvet tamarind jam was comparable to that of pawpaw jam. There are appreciable levels of vitamin C in velvet tamarind jam which in the nutrition of humans could prevent the manifestation of diseases. Food industries may therefore consider the adoption of these indigenous fruit tree for jam production. The data suggest that the jam is nutritionally good for children, adult and also may supply some nutrition deficiencies.

Conflict of interest

The authors have not declared any conflict of interest

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