International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2019): 7.583

Nutritive Food Value and Clientele Preference of Termites (Isoptera: Termitidea: *Pseudocanthotermes Grandiceps*) in Western Kenya: Comparison with Conventional Red and White Meat

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Abstract: ***Kenya faces acute food shortages to satisfy the increasing population as traditional food stocks continue to be depleted as a result of environmental changes and increasing population. Faced with problems of food insecurity, increasing food prices and overreliance on the traditional food items, there is an urgent need for Kenyans to diversify their food sources. In western Kenya, the white ants have a long history of consumption as a delicacy during the rainy seasons. A major problem is that the white ants are varied in species and may not all contain the ingredients required by humans for nutrition. There are also very few studies that have attempted to evaluate the totality of white ants in Kenya. The aim of this study was to: (i) to determine the food value of the white ants in Western Kenya and (ii) to determine effects of preservation methods on the proximate composition of the white ants and (iii) to establish the consumer preferences for the white ants in various urban centers of Kenya. This was done with an overall aim of determining whether white ants can be declared as an alternative food source in Kenya. Data were collected and analyzed for proximate composition of moisture, protein, lipids, ash, crude fiber and nitrogen free extracts (NFE). Essential Amino Acid (EAA) profiles were evaluated to determine protein composition. The consumer preference and seasonal fluctuation was done through personal administered questionnaires that sought direct information on the issues of consuming white ants. Food value of the different species was analyzed by Analysis of Variance (ANOVA) while consumer preferences and effect of preservation methods on the proximate composition was analyzed by frequency distribution and cross-tabulations and hypothesis tested using chi-square. In all the analysis either a version of GenStat 4.0 S.E or SPSS 17.0 was used as appropriate. Results indicated that white ants have low levels of starch, 54% crude protein, 9.0% moisture, 10.8% ash, 9.5% crude fibre, which renders it a perfect substitute for beef and fish meals preferred by many households. The profile of Essential Amino Acid in the current study was found to be high and therefore white ants formed a very good source of essential amino acid to the local people. Under traditional and modern preservation methods, only sun drying resulted to loss of some nutrients, smoking only changed the texture while salting and freezing changed the moisture content and tastes. Frying and roasting improved the consumer appeal. Finally, many people had believed that white ants are additional food ingredients but should be considered an alternative food source to beef or fish. This study therefore concludes that white ants are suitable alternative food source to replace major protein food and nutritionists should start a campaign of making the white ants a delicacy. Given that white ants are neglected food in Kenya, it is recommended that the food items should be consumed as one of the food in the traditional diets in areas where the species occur.***

1. Introduction

Termites live in colonies consisting of a few thousands to several million individuals. Termites are a moderate sized insect order (2600 described species) accepted to be an extremely important part of tropical and sub-tropical ecosystems (Eggleton, 2001). The tropical environment is known for its rich fauna and enormous population of termites, which are supposed to play an important role in the rapid turnover of organic matter in the ecosystem (Onyonka, 2001). The seventh family, Termitidea, represents over 80% of all termite genera and 74% of all termite species. Due to location in the tropics and climate, Kenya, like most of the tropical environment possesses one of the most diverse biota in the world. The genus *Nasutitermes* is taxonomically diverse with over 180 species (Krishna, 2010) and broadly distributed, being found in six of the eight major biogeographically regions (Pearce and Waite, 1994).

Termites have been historically consumed in many parts of the world for time immemorial. Its delicacy is well known to be safe for consumption many people in Kenya (Onyonka, 2001) and its abundance is unquestionable. It is apparent in Kenya that there is problem of food insecurity, which has been a major issue that the Government has been addressing. The population growth rate in Kenya is increasing at a rate of 6%.

Historically, Kenya has relied intensely on agriculture to support more than 70% of her population. In the 1970s, sustained growth of agriculture above 10% per annum coupled with favorable weather patterns, witnessed unrivalled increase in Kenya's gross domestic product (GDP) by over 7% annually and therefore, the momentous economic growth was sustained, reducing food insecurity problems. Currently, the country continues to rely heavily on agriculture as an engine to drive most of its economic growth, provide food, employment and most of the basic needs required by the populace despite the myriads of problems that has continued to duck the sector (Odeny, 2006). However, in Kenya for quite some time now, food insecurity situation has been appalling because of frequent problems of unpredictable weather conditions as well as erratic and intermittent rainfall partly attributed to wanton dynamism in environmental conditions and poor agricultural policies put in place (Waiganjo et al., 2006; Were et al., 2008). With the liberalization of trade and introduction of structural adjustment programmes (SAPS), fertilizer costs

have increased to a level unaffordable to small-scale farmers. Rather than rely on agriculture to wholly engineer the economic growth other sources of foods need to be considered. In an effort to bridge the food gap that ails the country, several food sources have been evaluated. Many of these protein food sources have been based on meat and beef products and byproducts. They include animal protein sources such as chicken, beef, burgers, duck, turkey, pig meals among others as well as plant protein sources such as peas, beans, French beans, soybean etc. Whereas they have been providing protein sources for a long time now, they are increasingly becoming expensive and out of reach for many people. Furthermore, livestock are prone to diseases and drought as well as lack of pasture not to mention the constant conflicts that are associated with rearing large heard of cattle. Kenya depends on agriculture to satisfy its food demands. In recent years there have been foreseen and unpredictable weather changes that have exposed the people to poor harvest and declining yields from agriculture. There is therefore, the grave danger of chronic and sometimes acute food shortage that is likely to affect the nutritional and health status of the people. To reduce the chronic food shortages in Kenya, variety of food sources are required white ants being one of them. However, consumer preference and nutritional composition of the white ants that would render it suitable as a food source is unknown, hindering the protocol of declaring it a national food item.

2. Materials and Methodology

This study was carried out in Western Kenya Covering Western Province, Nyanza Province and part of the North Rift. In presence of diverse livelihood mainly in the agricultural sector, close to 4 million people have settled in the region, attributable to employment prospects while others are in the District due to immigration. The study area is situated about 300-800 km North West of Kenyan Capital, Nairobi. It lies at an average altitude that ranges between 1800-2600 meters above sea level. The area covers an approximate area of 19200 km2. Climate within the study area is strongly influenced by altitude and physical features such as escarpments and volcanic peaks mainly from the Cherangani Hills, to Kakamega forest and hills of Mount Elgon. The area has a high variation in temperature ranging from 10.5 –25.5ºC within the year thus favoring growth of agricultural crops within the area. There is a bimodal rainfall; the mean being just over 1000 mm annually.

2.1 Populations and land tenure

It is estimated that the area has slightly over 4 million persons with a density of about 320 persons per square kilometer (KNBS, 2010). The number of households within the study area according to 2010 census is approximately 822,850. Land is under individual ownership and partly through cooperates such as the several forest farms spread along the breath of the area.

2.2 Research design

Food value of the white ants was done by proximate analysis of moisture content, nitrogen free extracts, crude protein, crude lipid, ash and crude fibers. Fatty acid profiles and amino acid profiles were also evaluated to determine the protein components. The consumer preference was done through personal administered questionnaires that sought direct information on the issues of consumer preference of the white ant species.

2.3 Collection of white ant samples

White ants were collected from various parts of Western Kenya during long rain periods when they are expected to be available. Colonies were marked and mapped, and 50% of the colonies were re-sampled during any time there was white ants. The selection of the sampling sites was guided by past experience and after interview with various stakeholders in the region who are expert in identification of areas where white ants predominate. Collection of the white ants was done using traps which were mounted on the termite mound to trap the alates. Collections were also made by breaking open the termite mound. Some of the alates and a number of small or large soldiers and workers were preserved (in 70-80% ethanol) for identification at the National museums of Kenya. Approximately 100 live individuals from each colony were Sun-dried after suffocating them in polythene bags. They were also stored in containers with tight lids. Collections did not discriminate between small or large workers, or soldiers.

2.4 Proximate analysis

The collected white ants were analyzed for proximate composition of crude protein (N_2×6.25), crude lipid content, moisture, and ash content using standard methods detailed in AOAC (1995). Dry Matter (DM) was determined by oven drying them at 110°C for 24 h. Crude protein (N ×6.25) was determined by Kjehdal method after acid digestion. Crude lipid was determined by the Soxhlet apparatus. Ash content was determined by incineration in a furnace at 550°C for 24 hrs. Crude fibre was determined by digestion with 1.25% H_2SO_4 and 1.25% NaOH solutions. Nitrogen Free Extracts (NFE) was calculated from the differences. Gross energy was calculated using conversion factors for protein, lipids and carbohydrates provided in Tacon (1998) and confirmed by adiabatic bomb calorimeter. Amino acid compositions of the white ants were determined by automated amino acid analyzer after hydrolyzing the sample for 24 h with 6 M HCl at 110˚C. Sulphur-containing amino acid was oxidized using performic acid before acid hydrolysis. All analyses were performed, in duplicate, on the sub samples of white ants.

2.5 Consumer Preference Data

Research design
Interviews and questionnaires were used to collect data through a cross-sectional survey. Such designs are often used for descriptive, explanatory and exploratory purposes (Labovitz and Hagedorn, 2006; Kothari, 2004). It was used to investigate the consumer acceptance of the white ants in the region.

Target population and sample size
The target population consisted of all the people who consume white ants. The number is estimated at 1,000, 000. Sample size was determined from the target population

using the formula by Mugenda and Mugenda (1999) $n = z^2 (pq)/d^2$
n = the desired sample size
z = Standard normal deviation (at 95% = 1.96)
d = the acceptable range of error (0.05)
p = the proportion of people who consume white ants in Western Kenya (80%)
q = the proportion of people who do not consume white ants in Western Kenya (20%)
Based on the calculation, the sample size for this study consisted of 240 people from the study area. This number was deemed representative of the target population from each of the heterogeneous sub-groups within the area.

2.6 Sampling strategy

This study employed systematic sampling technique in combination with purposive sampling method to select the respondents for the interviews and those who will answer to the questionnaires. Currently, there are 45 administrative districts in the region. At least 5 people from each district were selected from areas where there are high densities of termites at random until the desired 240 respondents was obtained. The random sampling technique ensured a representative sample was selected on probabilistic criterion and thus allowing each person an equal chance of selection. Additional 10 key informants were included in the sample to provide desired information of the subject at hand.

2.7 Research tools and instruments

Questionnaires and interviews were used as the main tool for data collection. The selection of these tools was guided by the nature of the data to be collected, the time available as well as the objectives of the study. Since the research was concerned with views, opinions, perceptions and feelings, such information was best collected using questionnaires and interview schedule (Touliatos, 1998) since such variables cannot be directly observed. Semi-structured instruments questionnaires were used so that a balance between the quantity and quality of data was collected. Data were collected at designated times at household levels. Questionnaires were given to people who can read and write and they were given the opportunity to fill the questionnaires.

2.8 Data analysis

Qualitative data from the questionnaires and interviews collected during this study were analyzed by descriptive statistics employing tools of central tendencies, frequency distributions, cross tabulations and chi-square (χ^2) of goodness of fit tests using SPSS version 17.0. Chi-square test was suitable here since enabled the identification of any significant differences in the frequencies of the alternative response. All data was analyzed at a level of $p < 0.05$. After analysis, data were presented using table, bar graphs and pie charts. The median ingredient uptake volumes were calculated based on the respondents responses, which were then used to calculate the daily ingredient intake according to the formulas:

$$DI_{ingredient} = \sum_{i=1}^{n} C_{food} x I_{food}$$

$$I_{ingredient} = \frac{SS_{median} x FF_{food}}{30.4}$$

Where $DI_{ingredient}$: the daily intake of ingredient from food (µg/L)
C_{food}: the average metal concentration of the item (µg/L); I_{milk}: daily food intake (L/day); SS_{median}: the median quantity of the food item consumed (g/day); FF_{food}: food frequency i.e. the number of days in a month that the food was taken by the respondents (days/month). One month was assumed to be 30.4 day (365/12).

3. Results

Socio-economic Backgrounds of the Respondents

	Variables	Frequency	Percent
Age (Years)	< 25	28	11.7
	25-35	68	28.3
	36-45	72	30.0
	46-55	47	19.6
	> 55	25	10.4
	Total	240	100
Gender	Female	162	67.5
	Male	78	32.5
	Total	240	100
Levels of Education	None	21	8.8
	Primary	61	25.4
	Secondary	105	43.8
	College	47	19.6
	University	6	2.5
	Total	240	100
Income (Kshs.)	< 1,000	18	7.5
	1,000-5,000	97	40.4
	5,001-10,000	72	30.0
	10,001-20,000	45	18.7
	> 20,000	8	3.3
	Total	240	100

The socio-economic backgrounds of the respondents are shown in Table 4.1. The distribution in sex, levels of education and salary were significantly different among the respondents ($p < 0.05$) while age distributions among the respondents were not significantly different ($p > 0.05$). Many respondents were females, with secondary levels of education. Salary earned by most of the respondents was over Kshs. 1001-5000 per month.

Proximate composition of white ants used as food in Western Kenya

The ingredient compositions and the profile of the essential amino acids (EAA in g/100 g feed) of the white ants when compared with two other protein diets commonly consumed by the local residents in the study are provided in Table 4.2. Moisture content was similar for all the three tested diets at about 10% of the body weight of the white ants. Protein content of the white ants was found to be 54% which was, significantly the lowest among the food items analyzed ($p < 0.05$). Crude lipid content of the white ants was about 9%, which was, significantly ($p < 0.05$) the highest when compared to the beef and fish by factor 4.5 ×. Ash content of the white ant ranged from 9.2 to 10.9%, but was found to be

significantly ($p < 0.05$) the highest when compared to beef and fish. 8-10% of the ants, beef and fish were found to be crude fibres, but the differences were not significant ($p > 0.05$). The total content of carbohydrates was significantly higher in beef than ants and fish feeds ($p < 0.05$). Gross energy derived from consumption of 100 g of ants was 4.2 kcal, which was significantly ($p < 0.05$) the lowest than the gross energy derived from fish and beef. The profile of the amino acid of the white ants were also analyzed and based on the essential amino acid scores, EAA of the white ant was the lowest (24.5 g/100g) while that of fish was the highest. However, the profile of the EAA score as a percentage of the crude proteins in the feeds was similar for all the feeds at 46%.

Table 4.2: Proximate composition (g100 g^{-1}) of the white ant meal and two other common protein feeds with their amino acid profiles. Values are means ± SEM. Amino acids were not analyzed in triplicate

	Food items			ANOVA	
Ingredients (% as fed basis)	White ant	Fish	Beef	F-value	p-value
Dry matter	90.2 ± 1.32	89.6 ± 1.21	90.21 ± 1.02	0.432	0.532
Crude protein	53.9 ± 0.21^{a}	66.9 ± 1.76^{c}	62.22 ± 1.32^{b}	5.42	0.004
Crude lipid	9.35 ± 1.11^{b}	5.54 ± 1.04^{a}	6.23 ± 1.07^{a}	9.785	0.000
Ash	10.81± 0.12^{b}	3.31 ± 0.08^{a}	3.30 ± 0.09 ^{a}	10.225	0.000
Crude fiber	9.53 ± 2.32	8.27 ± 2.22	10.24 ± 2.94	1.954	0.094
NFE	6.61 ± 1.22^{a}	5.58 ± 1.21^{a}	8.03 ± 1.25^{b}	3.963	0.013
Gross energy (kcal 100 g^{-1})	4.19 ± 0.22^{a}	4.53 ± 0.23	4.43 ± 0.24	1.562	0.234
Essential Amino acids (g 100g^{-1})					
Histidine	3.02	3.95	2.25		
Isoleucine	2.56	2.98	3.31		
Leucine	2.36	2.64	2.41		
Lysine	5.79	5.21	5.04		
Methionine	2.78	3.56	3.51		
Phenylalanine	4.01	5.39	4.92		
Threonine	2.64	4.01	4.22		
Valine	1.32	3.87	2.99		
Total EAA	24.5	30.6	28.6		
Ratio:EAA:CP	45.4	46.2	46.0		

Values for fish and beef adapted from Cherop *et al.*, 2009

The estimated median consumption of the of white ants was 0.15 g per day, beef was 0.11 g per day and fish was 0.08 g per day for the sampled population based on the food frequency questionnaires (FFQ). Based on the table 4.3, crude protein levels taken by the respondents per day was 80 g/100g in white ants and lowest in beef at 50 g/100g feed. Crude lipid uptake was also highest in white ants and lowest in beef. However, consumption of white ants provided more ash and crude fiber to the locals than fish and beef. Concerning the essential amino acid uptake, white ants provided the highest levels of all the essential amino acids compared to the fish and beef. However, except for lysine, none of the food (fish and beef) consumed provided the required daily intake of the EAA.

Table 4.3: The calculated average dietary intake (g/100 g/day) of the various ingredients and essential amino acids

Ingredients (% as fed basis)	Food items			
	White ant	Fish	Beef	
Dry matter	135.30	98.56	72.17	
Crude protein	80.85	73.59	49.78	
Crude lipid	14.03	6.09	4.98	
Ash	16.22	3.64	2.79	
Crude fiber	14.30	9.10	8.19	
NFE	9.92	6.14	6.42	
Essential Amino acids (g 100g^{-1})				Requirements (g/100g)
Histidine	4.53	4.35	1.80	10
Isoleucine	3.84	3.28	2.65	20
Leucine	3.54	2.90	1.93	39
Lysine	8.69	5.73	4.03	4
Methionine	4.17	3.92	2.81	10
Phenylalanine	6.02	5.93	3.94	25
Threonine	3.96	4.41	3.38	15
Valine	1.98	4.26	2.39	26

Effects of preservation methods on the proximate composition of the white ants in urban centers of Kenya

The white ants were then subjected to common methods of preservation found in Kenya and the subsequent changes in the proximate composition analyzed. The results are presented in Table 4.4. Freezing was the only preservation method that increased moisture content in the white ants. Roasting and sundrying resulted to most significant increase in moisture loss in the white ants. On the other hand, freezing did not produce significant reduction in the protein content while roasting and sundrying resulted to most apparent loss of crude protein content in the white ants. Highest ash content was obtained in frozen product while lowest ash content occurred in sundried and roasted ants. Crude fibre content in the diet were enhanced by freezing while sundrying and roasting resulted to significant reduction in the crude fibre content in the white ant. Finally gross energy did not significantly change in all the preservation methods.

Table 4.4: Variation in the proximate composition of the white ants in various preservation media

Proximate composition	Normal	Sundried	Smoked	Salting	Freezing	Roasting
Dry matter	8.8^{d}	4.8^{b}	6.9^{c}	7.5^{c}	11.8^{e}	3.8^{a}
Crude protein	52^{d}	48.6^{b}	50^{c}	50.1c	52.1^{d}	44.5^{a}
Ash	9.4^{c}	7.1^{a}	9.4^{c}	8.3^{b}	9.8^{d}	7.3^{a}
Crude	4.2^{c}	2.3^{a}	4.2^{c}	4.2^{c}	4.7^{d}	3.3^{b}

fibre						
Gross energy (MJ Kg^{-1})	18.4	18.1	18.2	18.2	18.0	18.2

Mean values in each row with a common superscript letter are not significantly different from each other ($P > 0.05$).

Consumer preferences for the white ants in various urban centers of Kenya

To determine the consumer preference of the white ants, information concerning criteria of preference was used and reasons why consumers do not prefer other traditional food sources. The first survey identified that local consume beef, poultry, vegetables mainly traditional, cabbages, fish, and white ants. The consumers were asked to rank foods that should be considered a delicacy and should be advocated for all the Kenyan to take as long as they are available. The results are as shown in Figure 4.1. fish and beef ranked highest followed by white and brown ants respectively. Bacon and wild birds ranked lowest.

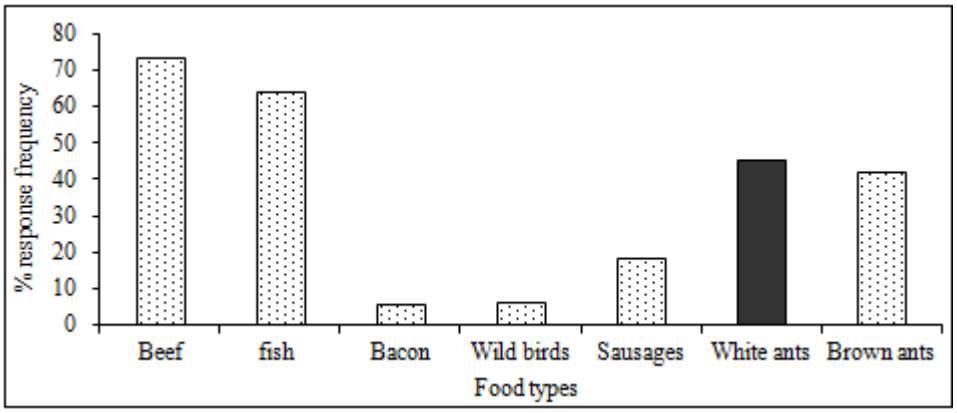

Figure 4.1: Preferences for various food items among the sampled respondents

Information was also sought why they prefer white ants over other sources of proteins. Information concerning the criteria used for ranking white ants among the consumers surveyed is as shown in Figure 4.2. Most consumers preferred white ants because of their cultural attachments (54.2%) followed by their nutritional contents (35.2%) while others believed that it is less costly than other food items. The least number believed that its medicinal values are likely to make it more preferable.

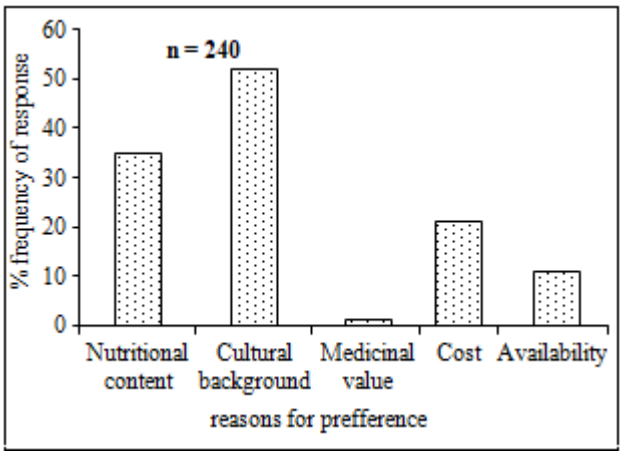

Figure 4.2: Criteria used to rank the white ant as food sources

Further information on why consumers do not prefer 'traditional protein' including white ants is shown in Table 4.5. The main reasons cited by the consumers for not preferring the white ants among other traditional food sources included: high cost of obtaining some of these foods though white ants are not expensive, many people believed that the ants are seasonal and therefore their costs may be relatively higher. Others wanted to abandon old and traditional cultures by embracing the modern food types. Yet others still believed that it is time consuming to prepare the white ants meals, though this seems to be an answer out of ignorance.

Table 4.5: Reasons why the consumers do not prefer white ants

	Frequency	Percent
Abandonment of culture and tradition	67	27.9
Expensive	28	11.7
Time consuming during preparation	86	35.8
Seasonality	58	24.2
Total	240	100

4. Discussion

Proximate composition of white ants used as food in Western Kenya

Fish and beef are the popular market value foods for the local community members in rural and urban areas, and belong economically to the different traditional grades, according to consumer preference in Kenya. However, in many parts of Western Kenya, especially during the rainy seasons, there has been an unrecognized role of white ants, which swarm in high density and has traditionally been used as food for decades in the areas. Therefore, analyzing the proximate content of the white ants relative to the traditional protein contents is important component of increasing the traditional food items to the local community members. Proteins, lipids, ash, crude fibre, NFE and moisture contents as well as the caloric values were the major constituents, which had been considered in evaluating the nutritional value of the food items studied. Analysis of the ingredient composition and the profile of the essential amino acids (EAA in g/100 g feed) of the white ants when compared

with two other protein diets commonly consumed by the local community members indicated that protein content of the white ants was 54% compared to 66% and 62% respectively of fish and beef. The high protein content in the white ants compares well with that of the meat and poultry product (Cherop *et al*., 2009). This is in-line with the report of Steffens (2006), that protein forms the largest quantity of dry matter in many insects, fish and beef. The variations recorded in the concentration of the different proteins in the white ants, fish and beef examined could have been as a result of the rate in which these components are available in the environment as food items (Yeannes and Almandos, 2003), and the ability of these organisms to absorb and convert the essential nutrients from their diet or the environment where they live. This is supported by the findings of Window et al. (1987), Adewoye and Omotosho (1997), Prapasri et al. (1999), Ricardo et al. (2002), Adewoye et al. (2003) and Fawole et al. (2007). Although the protein content of the white ants was lower than that of beef and fish, it provided the required optimal protein content required for the humans (WHO, 2005). This makes the whiteant important living resource of dietary protein as other food like fish and beef.

Fats and oils (hereby referred to as lipids), and thus triglycerides, are present in both animals and plants. Some fat is required within the diet to supply important fatty acids, which are essential regulatory elements. Body fat is needed within our diet as indicators of delivering two essential fatty acids, linoleic acid, an ω-6 PUFA, and α-linolenic acid, an ω-3 PUFA (http://EzineArticles.com/4727184). In this study, the lipid content of the white ants was about 10% and due to the consumption by the local community members, the total intake of lipids in diet was found to be 14 g/100g which was lower than 25 g/100g per day recommended by the WHO (2002). The other food items had lower than 7% crude lipid, which makes their contribution to the overall fatty acids to be somewhat lower.

The dietary requirements of other food items such as ash and crude fiber are not known in humans because these are not essential to the diet but fibres are important in digestion of the food items. Therefore the values presented in this study of the content of ash and crude fibre are only useful in the context of their secondary roles in the human body and in this context the high fiber in white ants are important to enhance digestion of the food in the body.

In this study the whiteants supplied 4.2 kcal energy per 100 g feeds and up to 14.3 g per 100 g energy after consumption. Adequate carbohydrate stores are critical for optimum body energy requirements. While the amount of carbohydrate required to avoid ketosis is very small (about 50 g/day), carbohydrate provides the majority of energy in the diets of most people (Stephen *et al*., 2005). There are many reasons why this is desirable. In addition to providing easily available energy for oxidative metabolism, carbohydrate-containing foods are vehicles for important micronutrients and phytochemicals. Dietary carbohydrate is important to maintain glycemic homeostasis and for gastrointestinal integrity and function. Unlike fat and protein, high levels of dietary carbohydrate, provided it is obtained from a variety of sources, is not associated with adverse health effects. Diets high in carbohydrate as compared to those high in fat, reduce the likelihood of developing obesity and its co-morbid conditions. An optimum diet should consist of at least 55% of total energy coming from carbohydrate obtained from a variety of food sources. When carbohydrate consumption levels are at or above 75% of total energy there could be significant adverse effects on nutritional status by the exclusion of adequate quantities of protein, fat and other essential nutrients. In arriving at its recommendation of a minimum of 55% of total energy from carbohydrate, the consultation realized that a significant percentage of total energy needs to be provided by protein and fat, but that their contribution to total energy intakes will vary from one country to another on the basis of food consumption patterns and food availability. Consuming adequate carbohydrate on a daily basis is necessary to meet the energy (calorie) requirements of the humans to replenish muscle and liver glycogen. Costill et al. (2010) found a direct and positive relationship between the quantity of carbohydrate consumed (188 to 648 g carbohydrate/day) and the amount of muscle glycogen synthesized during 24 hours of recovery from glycogen-depleting exercise. A diet providing 525 to 648 g of carbohydrate (7 to 10 gm of carbohydrate/kg) promoted glycogen synthesis of 70 to 80 mmol/kg and provided near maximal repletion of muscle glycogen within 24 hours. The Institute of Medicine recommends 130 grams (520 kilocalories) of carbohydrate per day. In comparison to the current feeds, white ants, fish and beef had low carbohydrates content resulting in low gross energy than the overall requirements for the humans (WHO, 2002). However, comparatively, the whiteants had the highest content of gross energy partly attributed to the highest consumption of the whiteants during the sampling period rather than due to levels of nitrogen free extracts (NFE) in the food item.

The profile of the amino acid of the feeds were also analyzed and based on the essential amino acid scores, essential amino acids (EAA) of the white ant was the lowest (24.5 g/100g) while that of fish was the highest. However, the profile of the EAA score as a percentage of the crude proteins in the feeds was similar for all the feeds at 46%, which implies an excellent amino acid profile in the diet. The high lipid content in the diet (through observation) compares well with high lipid food items like fish oils (Nowak, 2006). Such lipids will result to the protein sparing effects when being used and therefore it is possible to obtain higher energy from the food and sparing the high protein in the diet for growth. The present work has elucidated more on the importance of white ants as good sources of protein and lipids and has also broadened our knowledge on the nutritional value of some

Changes in nutrient composition of the white ants following traditional and modern preservation methods

Food is a highly perishable commodity and if not properly handled, quality deteriorates which can have detrimental consequence for the health of the consumers. Various preservation methods have been used worldwide. In Africa, mostly in the sub-Saharan countries, drying, smoking, frying and chilling, enhances preservation. In this study, the white ants were preserved and changes in the proximate composition analyzed. Food diets which are not balanced

cause up to 30% of the food borne illnesses in the world (Piel, 2003).

Lack of advanced methods of technology in preservation like canning and deep freezing is openly evident in Kenya (Odero, 2000) though they have been greatly effective as used in Japan, U.S.A., Netherlands and other developed countries. Although technologies for the control of spoilage of animal food and other food products have been well established, tropical countries have been unable to apply them due to the cost, the sophistication of such technology or social cultural factors (Ledward, 1993).

Kenya being a developing country has not put into place these advanced preservation methods like freezing and caning. This has left the use of traditional methods like sun drying, smoking, and frying into great use. Food preserved using these methods has been degraded in quality as stated by the food vendors hence they have been seen to be probably not completely effective. According to Gerasimov (1979), fresh food transported in ice was seen to deteriorate due to temperature, type of transport and duration of transport making the ice to thaw. More so poor quality of ice that is contaminated by coil forms has been a cause of contamination. Sun drying food on the bare ground, mats and nets expose the food to contamination by sand and dirt.

Freezing was the only preservation method that increased moisture content in the white ants. Roasting and sundrying resulted to most significant increase in moisture loss in the white ants. On the other hand, freezing did not produce significant reduction in the protein content while roasting and sundrying resulted to most apparent loss of crude protein content in the white ants. Highest ash content was obtained in frozen product while lowest ash content occurred in sundried and roasted ants. Crude fibre content in the diet were enhanced by freezing while sundrying and roasting resulted to significant reduction in the crude fibre content in the white ant. Finally gross energy did not significantly change in all the preservation methods.

Post-harvest losses on small-scale can be among the highest for all commodities in the entire food production system. When the processing, distribution and marketing system cannot cope with the large quantities of foods that are sometimes realised due to seasonal and inter-annual variations of availability or abundance. Appropriate preservation methods can significantly reduce this loss.

Consumer preferences of the white ants against conventional food sources

Many Kenyan communities have been observed to use traditional food sources that are highly nutritious without having any scientific attachment to the observed phenomenon. In many parts of the Kenya, white ants are being consumed in many forms. It is the preference of using the white ants that differ in many parts of the country. In Kamukuywa, many people use white ants as a delicacy. The consumers ranked white ants as the third most preferred food item than beef and fish. Though no studies is currently available on the food value of the ants, many Kenyan cherish beef and fish and therefore if white ants ranked third after these food then it is probable to suggest that white ants are actually a preferred foods item. Probably because it is less available, many people do not understand how to obtain it and this could explain why it is not ranked above fish and beef that are frequently available. One of the possible reasons for the reduction in the consumption of white ants could be related to reduction of quantity of the white ants, encroachment of many vegetated zones that were once habitats of white ants as well as changes in the production and consumption patterns of many communities in Kenya.

Preferences of traditional food items in Kenya have been documented to be variable and a function of many interrelated factors. The main reasons however, why the white ants were more preferred was because of their cultural attachments (54.2%) followed by their nutritional contents (35.2%) while others believed that it is less costly than other food items. As already pointed out, no research has been conducted in Kenya to determine the preference of white ants but other reasons for preferring traditional foods are available. Abdala *et al*. 2007 reported preference of local traditional foods in many parts of inland and hinterland parts of Kenya in Murang'a. Furthermore, Wanjiku (2004) also documented after series of field surveys that Kenyans of certain age brackets mainly the old, prefer traditional food items than the young ones. Awiti (1991) documented that between 1960-1980, over 40 varieties of traditional food sources were being consumed across the country. The present study however cannot confirm or deny any reduction in diversity of the traditional food sources in relation to earlier studies because it was only limited to Western Kenya. In his earlier work Awiti considered all traditional food items in Kenya, which was out of current study scope. However, considering the preferences for the few species of established foods such as beef and using evidence from many published literature of the great diversity of traditional food items, in many parts of Western kenya, all evidence suggest non-preference for a number of traditional food items even though white ants were preferred. This seem to suggest that even though many people are consuming the white ants as a cultural obligation, a vast majority of the consumers who seem to be drifting away from the cultural obligation are the major culprit in the consumption of the indigenous white ants

Consumers did not prefer the white ants among other traditional food sources due to a combination of factors including: high cost of obtaining some of these foods though white ants are not expensive, many people believed that they are seasonal and therefore, its costs may be relatively higher. Others wanted to abandon old and traditional cultures by embracing the modern food types. Yet others still believed that it is time consuming to prepare the white ants meals, though this seems to be an answer out of ignorance. The demand driven supply of product is a principle law governing production and marketing of many products outside convectional agriculture or horticulture (Todaro, 2002). This guarantees by the fact that the people will be willing to purchase what is supplied in the market and sellers will be willing to supply what the people are willing to purchase. Though supply and demand laws seems to be the driving force behind the production and the consumption, other intrinsic factors like flavour, nutrition status and acceptability are also important factors that are

worth considering. This therefore implies that sustainability in the production of white ants will be achieved if many people determine the critical role played by these white ants in the diet. It is now more recognized that sustaining the production of white ants will not focus on increasing land area for production but intensification of production per unit area since this is done in situ

5. Conclusions

White ants are a valuable source of nutrition in rural areas and contribute substantially to protein and lipids intake. This was evident from the availability of high quality protein content and other ingredients that would render it suitable food to be used overally by the communities.

Freezing was the only preservation method that increased moisture content in the white ants, roasting and sundrying resulted to increase in moisture loss; roasting and sundrying resulted to loss of crude protein, freezing accounted for most loss in ash and crude fibre. Gross energy did not significantly change in all the preservation methods.

Consumers' preference of the white ants ranked after poultry and beef mainly because of cultural attachments and nutritive values of the white ants. White ants were not consumed mainly because of the availability.

6. Recommendations

White ants should be considered a delicacy and be advocated for all Kenyans to take as long as they are available to reduce over-reliance on poultry and beef.

The chemical composition could influence the post-harvest processing and storage and could assist in determining the suitability of the different species to specific processing and storage techniques.

Ways of enhancing commercial production of the white ants should be improved to ensure that the ants are available as a major food source. Campaign of making the white ants a delicacy should be started by all the relevant stakeholders.

Further determination of quantity of carbohydrates and lipids should be undertaken in the various species of white ants at an advanced stage to enhance its wide acceptability using nutritional information.

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