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Nutrient composition of selected seasonal food delicacies in Malawi

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Five locally available seasonal delicacies in Malawi were analysed for their nutrient content. The five delicacies included three insect types, one bird and a plant tuber. The proximate analysis using standard methods of analysis showed that *Nomadacris septemdasciata* (insect) has the highest protein content (69.78±2.0%) followed very closely by *Passer difusus* (bird) (67.59±1.2%). The protein content of the *Nomadacris septemdasciata* and *Passer difusus* is significantly differently from the rest of the food items. In the case of fat content, the results showed that *Carebara vidua* (insect) has significantly the highest amount (33.38±0.3%). The mineral analysis indicated that *Passer difusus* (bird) (516.68 ±8.6 mg/100 g) has significantly the highest amount of phosphorus followed by that of *Homorocoryphus vicinus* (insect) (359.53 ±6.2 mg/100 g). For Iron, *Satyrium buchanii* (plant) has significantly the highest content (37.31±1.4 mg/100 g). These results showed that consumption of the seasonal edible insects, birds and plants can provide the much-needed nutrients for proper growth throughout the year.

Key words: Nutrient, seasonal delicacy, edible insects, diet, food insecurity.

INTRODUCTION

In Malawi nutrition assessment data continue to show cases of chronic malnutrition (NSO and ICF, 2017). This is largely due to low income levels common to both urban and rural dwellers. Therefore, many households in Malawi experience food insecurity. A study by Thakwalakwa et al. (2020) showed that household food insecurity was associated with lower intake of grains, fruits, meat and eggs, oil/fat and snacks.

The indigenous diet of most people in Malawi is distinctively varied depending on the geographical location, affluence, ethnicity and religious inclination to some extent. Certain food items are eaten across all these distinct groups of people. Therefore, various plants, animals and insects derived products are major components of the diet. Generally, most of the plant and animal sources used in the diet are locally grown or raised by humans. However, some of the plant and animal derived food materials are derived from wild sources just like the edible insects (Kelemu et al., 2015). Most of these food items are seasonal in nature and are a sought-after commodity at a particular time in the country. Since it is possible to obtain these food items at different times of year this allows one to have a reasonable supply of nutrients throughout the year.

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Food items that are obtained from the natural environment include insects, insect larvae, eggs, mammals, birds, wild tubers, fruits and leaves. Collection of food items from environments is generally on the decline due to intensive land clearing as a result of urbanisation and need for farming space. Most of the insect populations thrive in dense forest and thick grass bushes that are fast disappearing due to massive land clearing for farming and urban development. In some countries efforts to start commercial faming of these insects or insect larvae are being explored (Odhiambo, 1994). Farming of some wild birds too, which were mostly sourced from the wild, for example quails, is now big business in Malawi. There is indeed need to find a sustainable way of using these valuable but underappreciated resources (Geldenhuys et al., 2013).

Insects occupy different range of environments: some emerge from the ground usually during the rainy season and others are caught in the surrounding bushes. Kelemu et al. (2015) reported that over 470 species of insects are eaten in Africa. Consumption of insects is prevalent in many countries in Africa and Asia where cases of undernourishment are rampant (Kelemu et al., 2015); Van Huis et al., 2013). It is also an important economic activity in parts of the world where people earn less than $1 per day and have difficulties accessing quality food (Folaranmi, 2012). Consumption of insects as a nutrient supplement is now being advocated by major institutions in the world more especially with regular food price increases due to reduction in production as a result of climate change and increased demand due to ever increasing world population (Van Huis et al., 2013).

In Malawi a number of insects are eaten both at larval and adult stage (Mumba and Jose, 2006). Edible insects are grouped into 8 orders which include Blattodea (cockroaches, termites), Coleoptera (beetles), Diptera (flies), Hemiptera (true bugs), Hymenoptera (ants, bees and wasps), Lepidoptera (butterflies and moths), Odonata (dragonflies, damselflies) and Orthoptera (grasshoppers, crickets and locusts) (Meyer-Rochow et al., 2021). Many researchers have reported crude protein content in insects to be ranging from 25 to 75% on dry matter (DM) basis (Oonincx and Dierenfeld, 2012). However, crude fat content falls between 10 and 70% with low carbohydrates content (Finke, 2013; Oonincx and Dierenfeld, 2012). Other authors reported that locusts, *Nomadacris septemfasciata*, popularly known as dzombe in Malawi, which fall under Orthoptera order of insects, contains 12-73% crude protein with 0.3-910 mg/100 g and 2.9±4.0 mg/100 g iron and vitamin C respectively (Hlongwane et al., 2020).

There are a number of different wild birds and burrowing mammals that are caught for human consumption. Two important seasonal animals that are readily available in large quantities are one bird species, *Passer difusus* and mice. *P. difusus* is mostly caught in rice fields during harvest time in areas where lowland rice is grown. These birds are one of the major pests in rice fields. The birds are caught during the harvest season in the months of June to July. The dressed and roasted birds can be seen being sold along the roads stacked onto a small piece of stick. The plant derived delicacy, *Satyrium buchananii* is obtained from tubers of wild orchids. It is mostly sold in the markets processed into small pan cake like. It is a popular and affordable food item to certain people and is eaten as a snack or used as relish (Kasulo et al., 2009).

The objective of this study was to analyse nutrient content of these seasonal food delicacies, *Homorocoryphus vicinus* (*Mbwanoni*), *Carebara vidua* (*Mafulufute*), *Satyrium buchananii* (*Chikande*), *Nomadacris septemfasciata* (Dzombe) and *P. difusus* (*Mpheta*) in order to enhance the nutrient data for and show the potential these food items can command in the diet of many people. With ever increasing food costs some of these food items can supplement meat and fish as the main protein source which is one of the critical food components in diets of children in Malawi. Indeed, cost has been shown to be one of the main important factors as drivers of dietary intake (Thakwalakwa et al., 2020).

MATERIALS AND METHODS

Sample collection and preparation

The samples were purchased from within Lilongwe city markets already in the prepared state and ready for consumption. The edible insect samples had their wings removed as this is not normally eaten. The samples were dried in the oven at 60°C for 48 h and were ground through a 1 mm sieve using a Thomas-WILEY model 4 Laboratory Mill (Arthur H. Thomas company, Philadelphia, USA) before doing the proximate analysis and mineral content determination.

Proximate composition

The ground samples were used to analyse for proximate composition; dry matter (DM), ash, crude protein (CP), crude fat and crude fibre (CF) using AOAC (2002) methods. Mineral composition was also analysed from the ground samples.

Dry matter using oven method

Dry matter was determined by drying the samples in a laboratory drying oven at 105°C for 5 h. The crucibles were thoroughly washed, dried in the oven (model OV-180, Blue M Electric Company, Illinois USA), cooled in a desiccator and weighed. Then, 2.5 g of the sample was weighed into the crucible and dried to constant weight. The sample DM in percentage was calculated as the fraction of the original dry weight multiplied by 100 (AOAC, 2002).

Ash using muffle furnace

Ash content was determined by igniting 2.5 g of the samples weighed in crucibles in the muffle furnace at 550°C for 2 h. The amount of ash content in percentage was calculated using equation 1.

$$\%Ash = [(W_a-W_t)/ (W_0-W_t)] \times 100 \text{ (AOAC, 2002)} \quad (1)$$

Where W_0 is weight of crucible and sample before igniting the sample, W_a is weight of crucible and ash and W_t is weight of crucible only.

Crude protein (CP) using micro-Kjeldahl method

Nitrogen (N) content of the samples was analyzed by using micro-Kjeldahl method and the N content was converted to CP by multiplying by 6.25. The method involves digestion of the samples in concentrated (98%) Sulphuric acid, distillation of the digests into weak acids (4% boric acid) and titration of the distillates with 0.1 M Hydrochloric (HCl) acid using mixed indicator (Methyl and Bromocresol green) as an indicator (AOAC, 2002).

Crude fat

Crude fat was analyzed by extracting 2.5 g of the sample weighed in porous extraction thimbles by using petroleum ether in a Soxhlet apparatus for 16 h. The Soxhlet apparatus was equipped with a water-cooled condenser fitted above the 250 ml flat bottomed flask containing petroleum ether as fat solvent. The solvent was boiled at 40°C and fat content was calculated as a percentage of the dry weight of the sample (AOAC, 2002).

Crude fiber

Crude fiber was determined by boiling 2.0 g of the samples in 200 ml of weak Sulphuric acid (1.25%) and Sodium hydroxide (1.25%), with few drops of anti-foaming agents being added, for 30 min respectively. The residues were filtered and washed for three times with hot water, then washed with 95% ethanol and dried at 105°C for 5 h to constant weight. The dried residues were ignited in a muffle furnace at 550°C for 2 h. The crude fiber, in grams, was calculated as the difference between the weight of the residues and ash and converted as a fraction of the sample weight in percentages (AOAC, 2002).

Phosphorus determination using UV-spectrophotometer

About 1.0 g of each sample was weighed in porcelain crucibles which were ignited in a muffle furnace at 550°C to constant weight. The ash was dissolved in 3 ml of 3 M Hydrochloric (HCl) acid, transferred to 100 ml volumetric flask and diluted to the 100 ml mark (Ogungbenle and Atere, 2014). Then, 0.75 ml of the diluted digested samples were placed in 20-25ml glass vials and diluted with 9 ml of distilled water. Standards were prepared by adding 0.0 ml, 0.1 ml, 0.2 ml, 0.3 ml, 0.4 ml and 0.5 ml into 20-25 ml vials and diluted with 9 ml of distilled water. To each vial 2.0 ml of phosphovanadomolybdate /molybdate reagent (solution) was added and thereafter absorbance was measured after 1 h of color development (AOAC, 2002). Phosphorus was determined by a DR 5000 WAGTECH projects ultra-violet visible spectrophotometer (PG Industries, London, UK) at 860 nm wavelength.

Iron determination using UV-spectrophotometer

Iron composition was determined by following the Danbature et al. (2015) method with minor modification. Into porcelain crucibles 1.0 g of each sample was weighed and then ignited in a muffle furnace at 550°C to constant weight. The ash was dissolved in 1 ml of water and 5 ml concentrated hydrochloric (HCl) acid and was boiled to dryness. The solution was mixed with 3 ml of 6 M HCL and was boiled for 2 min, cooled and transferred to a 100 ml volumetric flask and diluted to the 100 ml mark. Then, 10 ml of the diluted digested samples was placed in 25 ml volumetric flasks and 1 ml of hydroxylamine hydrochloride solution was added. The solution was left to stand for 5 min after which 5 ml of acetate buffer was added followed by 1 ml of O-phenanthroline solution and then made up to 25 ml with distilled water. The solution was left to stand for 30 min for colour development. Standards were treated as the samples. Absorbance was measured at 510 nm using a DR 5000 WAGTECH projects (PG Industries, London, UK) ultra-violet visible spectrophotometer.

Statistical analysis

Laboratory chemical analyses were done in triplicates and the mean value of each parameter was calculated in Microsoft Excel Tool Pak. The data was statistically analyzed using analysis of variance (ANOVA). Two sample student t-test of the means with unequal variances was used to compare the mean and significance was accepted at $p \leq 0.05$.

RESULTS AND DISCUSSION

Proximate content

The nutrient composition of seasonal delicacies is given in Table 1. The results show different levels of the various nutrients among the three major food categories, namely plant, insect and bird. Other researchers have reported that species, stage of life, diet, habitat and methods preparation and processing affect the nutritional content of edible insects (Van Huis et al., 2013; Kinyuru et al., 2009). In the case of protein content, the results showed that *Nomadacris septemfasciata* had the highest amount of protein (69.78 ±2.0) followed by *P. diffuses* at 67.59 ±1.2%. *Homorocoryphus vicinus* and *Carebara vidua* have reasonable amount of protein content around 50%. The least amount of protein (about 3%) was observed in *S. buchananii* derived from tubers of wild orchid. Thus, the insects are a potential source of protein if included as part of the diet. The determined crude protein content fell within the reported crude protein value for insects in the range 40-75% (Rumpold and Schluter 2013; Verkerk et al., 2007). Other researchers reported that locusts, *N. septemfasciata,* contains 39.8±21.1 g/100 g locust of crude protein (Hlongwane et al., 2020). Crude protein of *C. vidua* of 53.84 ± 0.7 reported in this study was higher than 42.5% but crude fibre (9.49 ± 0.2) was closely similar to 9.1 from another similar study (Hlongwane et al., 2020). This is very significant in light of the protein consumption data which indicate that Malawi has a protein consumption rate of 51.9 g per person per day (Gilbert et al., 2019). Among the three insect types *N. septemfasciata* (grasshopper) is still obtained in large quantities compared to *H. vicinus* and *C. vidua*). This

Table 1. Nutrient and mineral content analysis of some seasonal delicacies in Malawi.

Food item	Type/ source	Dry matter (%)	Ash (%)	Fat (%)	Protein (%)	Fibre (%)	Phosphorus (mg/100 g)	Iron (mg/100 g)
Satyrium buchananii (*Chikande*)	Plant origin	84.04 ±1.4[a]	14.42 ±0.1[d]	0.72[d]± 0.2	2.81±0.2[h]	3.04 ±0.0[l]	223.56±1.8[q]	37.31±1.4[u]
Nomadacris septemfasciata (*Dzombe*)	Insect	94.47± 0.4[b]	3.00 ±0.2[e]	2.40[d]±0.5	69.78±2.0[i]	6.75±0.4[m]	75.79±3.3[r]	4.59±0.1[v]
Homorocoryphusvicinus (*M'bwanoni*)	Insect	95.17±0.2[c]	6.39 ±0.1[f]	21.65 ±1.7	51.16±0.6[j]	7.00 ±0.2[m]	359.53±6.2[s]	6.65±0.1[w]
Carebara vidua (*Mafulufute*)	Insect	98.13±0.0[c]	2.20 ± 0.5[e]	33.38 ± 0.3	53.84 ± 0.7[k]	9.49 ±0.2n	224.61±1.0[q]	3.77±0.2[x]
Passer difusus (*Mpheta*)	Bird	97.66±0.2[c]	11.15 ±0.1[g]	4.92± 0.2	67.59±1.2[h]	0.18 ±0.0[p]	516.88±8.7[t]	5.44±0.2[y]

Values are mean ±standard deviation of each sample (n=3), Means with same superscript in the same column are not significantly different ($p \leq 0.05$).

makes the grasshopper to be relatively affordable in the urban setting. For those that cannot fathom the idea of eating insects then *P. diffuses* (bird) is the alternative source of protein. However, birds are relatively more expensive compared to insects. Thus, it is very clear that environmental destruction has impacted negatively on *C. vidua* available quantities. *C. vidua* is now considered an endangered species in Kenya (Ayieko et al., 2012).

Crude fat content

Fat content was highest in *C. vidua* (33.38 ± 0.3%) followed by *H. vicinus* (21.65 ±1.7%). The high fat content and the reasonable amount of protein in these two types of insects make them a potential nutritious food item to supplement other foods. Ayieko et al. (2012) in Kenya showed that *C. vidua* contain a lot of fat ranging from 42.07 to 49% depending on the body parts. The least amount of fat content was observed in *S. buchananii* (0.72± 0.2%). In terms of alternative food source for proteins and fats S. *buchananii*is may not be an ideal candidate because of the lowest crude protein content observed in this study. Consumption of the insects with reasonable amount of fats can aid in the absorption of fat soluble vitamins such as A, D and K. Consumption of oil that aid in absorption of fat soluble vitamins is low in typical tradition dishes that heavily rely on boiling in water. This level of fat consumption would complement the efforts being made in Vitamin A fortification in Malawi (Chimimba et al., 2016; Williams et al., 2021).

C. vidua had the highest amount of fibre (9.49 ± 0.2%) followed by *H. vicinus* and *N. septemfasciata (about 7%)*. The least amount of fibre was observed in *P. difusus (less than 1%)*. Fibre adds bulkiness to the food and is recommended for proper digestion. Consumption of these food items can supplement the processed foods consumed mostly in urban areas that contain few or very little fibre. The three food items with the highest fibre content are the insects compared to the animal (*P. difusus*) and plant (*S. buchananii*) food sources.

S. buchananii had the highest amount of ash (14.42 ±0.1%) followed by *P. difusus (*11.15 ±0.1*%)*. The least amount of ash was observed in *C. vidua* (2.20 ± 0.5%). Ash content is closely related to mineral content of food items and it is not surprising that *S. buchananii* and *P. difusus* had the highest iron and phosphorus content, respectively.

Mineral content

P. difusus had the highest content of phosphorus (516.88 ± 8.7 mg/100 g) followed by *H. vicinus (*359.53 ± 6.2 mg/100 g). *C. vidua* and *S. buchananaii* had medium content of phosphorus (about 220 mg/100 g) whereas *N. septemfasciata* has the least amount of phosphorus (75 mg/100 g). Phosphorus is an important element required for proper bone development and is a constituent of phospholipids and nucleotides in the cells. The nucleotides are building blocks of DNA and RNA two important biomolecules for genetic information (Serna and Bergwitz, 2020). Phosphorus is mostly obtained from milk and fish in the diet (Cordell and White, 2013). The insects are potential cheaper source of phosphorus than is milk which is consumed by only a few proportions of the population in Malawi (Akaichi and Roveredo-Giha, 2014). Malawi has a lower milk consumption rate and is ranked 142 out of 169 countries (Akaichi and Roveredo-Giha, 2014; Helgi Analytics, 2013: https://www.helgilibrary.com/indicators/milk-consumption-per-capita/malawi/). *S. buchananii* had the highest amount of iron (about 40 mg/100 g). *N. septemfasciata*, *H. vicinus*, *P. difusus and C. vidua* had comparable amount that was far less than that of *S. buchananii. S. buchananii*is is a potential source of iron which is another important mineral required as part of blood composition. Pregnant mothers are particularly encouraged to consume foods rich in iron (Brannon and Taylor, 2017). Generally, meat and fish are the main sources of iron in the diet. However, meat and fish are relatively more expensive compared to the insects and plants that can supply this mineral. Therefore consumption of *N. septemfasciata* (Dzombe), *H. vicinus (M'bwanoni*), *C. vidua* (Mafulufute), *P. difusus* (*Mpheta*) and *S. buchananii* (*Chikande*), cheap sources of minerals, could supply required iron for pregnant women.

The seasonal nature of the food stuffs discussed here make them ideal as nutrient supplements. One can get a continuous supply of the important food nutrients from consuming these readily available and affordable food resources. In Malawi there are a number of insects and insect larvae that are very nutritious and are consumed widely. Some of these were previously reported as a remedy to fight malnutrition (Mumba and Jose, 2006). During the onset of the rain season around November/December *C. vidua* and *M. subhyanlinus* (Ngumbi) are in season up to February. In the cool months of May to July a number of insects as well as insect larvae (caterpillar) come into season. The insects such as *H. vicinus* and *P. prasina* (tsetsenya) and caterpillars such as *U. terphrichore* (Nyamanyama) and *Imbrasiaertil* (Mphalabungu) are caught. In this period mice also start to be caught. This is also the period of rice harvesting when the birds are caught. As we move to the dry months from September to December the *S. buchananii* and *N. septemfasciata* and *Chaoburus edulis* (lake flies) are in season.

As a nutrient source it has been observed that *S. buchananii* had the least nutrients compared to the other food items. Its popularity may be linked to its perceived role as a medicinal plant that is used to treat a number of illnesses in certain areas in Malawi (Kasulo et al., 2009). In other countries insects also are regarded as possessing medicinal properties for cases such as improving fertility, curing asthma, heart disease and enhancing sexual desires (Musundire et al., 2014b; Teffo, 2006). However, in Malawi this has not yet been documented. There is also need to explore new processing technologies and developing of novel food products from these natural sources. This will allow the food products for example from insects to be available throughout the year and not just at a particular time of the year (Table 1).

Conclusion

The findings from this study have revealed that insects have high nutritional value, in terms of proximate composition and mineral content, and therefore consumption of edible insects and other seasonal delicacies is beneficial for the nutritional supplement for both children and adults living with threats of chronic malnutrition. Apart from the high nutrient content in insects there is also an advantage of affordability compared to other protein sources such as fish, beef and chicken which could not be easily obtained by poor rural people. The seasonal availability of these food materials ensures a reasonable supply of essential dietary nutrients throughout the year to the poverty stricken rural people in Malawi.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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