QUANTIFICATION AND NUTRIENT COMPOSITIONS OF CARROT (*DAUCUS CARROTA* L.) AND CABBAGE (*BRASSICA OLERACEA* L.) WASTES AND ITS UTILIZATION IN FORTIFICATION OF MAIZE-BASED MASA

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Abstract: This study was designed to investigate the quantitative, proximate composition as well as vitamin C component for carrot peels and cabbage wastes and their possible utilization in food fortification. The results revealed higher content of ash and carbohydrates with 2.0 ± 0.283 % and 6.03 ± 0.0354 % respectively in carrot while fiber, protein, and vitamin C content were higher in cabbage with 1.35 ± 0.0707 %, 1.775 ± 0.0354 % and 16.12 ± 1.040 mg/100g respectively. The quantity of wastes was considerably high in cabbage than in carrot with a general waste range of 22.7-44 %. It was therefore concluded that these wastes were high in quantity and were very rich in nutrients and were used in the fortification of masa. Maize-based masa fortified with 10 % of 1:1 ratio of wastes of carrot and cabbage was the most preferred. This shows that the use of cabbage and carrot wastes to fortify masa can help reduce these nutritional and quantitative losses and thus improve food security and health of the population.

Key words: Nutrients, Carrot, Cabbage, and food losses.

Introduction

As reported by Food and Agricultural Organization (FAO, 2014) roughly one third (approximately 1.3 tones) of the food produced in the World for human consumption every year get lost or wasted, amounting to roughly 680 billion US dollars in the industrialized countries and 310 billion US dollars in developing countries, with each consumer in Sub Saharan Africa throwing away 6-11kg of food per year. As insinuated by FAO Save Food (2015) global quantitative food losses and wastes per year are highest in fruits and vegetables, ranging from 40-50% and occurring along the entire supply chain. This unfortunate situation does not only make food unavailable to the ever increasing consumers but also amount to major wasting of resources including water, land, energy, labour and capital and needlessly produce Green House gas emissions, contributing to Global warming and Climate change (FAO, 2019a). World Economic Forum (WEF,2019) identified food waste reduction as the number 3 (three) way to reverse climate change and that with the expected 9 billion World population by 2050, food security can be guaranteed for every one if we simply distribute the food we produce more efficiently through reducing wastage to minimal. As inscribed in goal 12 of the United Nations' Sustainable Development Goals, halving of the global per capital of food waste at the retail and consumer levels should be accomplished by 2030 (Gheoldus, 2019). African leaders also pledged in what is known as the ''Malabo Declaration'' to half postharvest losses by 2

025 ((FAO, 2019b). The total loss and waste in Sub Saharan Africa (SSA), has been reported to be between 5-50 %, with less than 8 % occurring on farm, 8 % at postharvest, 18-38 % during processing, 10 % during distribution, and less than 5 % during consumption (FAO, 2011). The losses and wastes in fruits and vegetables include wastes from carrot and cabbage which are produce daily during preparation of the vegetables for human consumption. Ajila *et al*. (2007, 2010) reported that most of the wastes that are produced from fruits and vegetables, which are between 25 % -30 % which are not often use.

In Adamawa State and in most parts of Nigeria, many people do not consume all parts of carrot and cabbage. Traditionally, during preparation for home use, the peels are removed from the carrot. During the preparation of cabbage on the other hand, the midrib and the stock are not consumed. Many consumers complain that they find these parts unpalatable. These ''non edible'' portions of these vegetables may contain substances which can be useful in many ways including for human consumption by making them as a constituent of food. Some research has been done already in the determination of composition of wastes of carrot and cabbage. Shyamala and Jamuna, (2010) analyzed pulp wastes of carrot to identify nutrient content and anti-oxidant property. Surbhi *et al.* (2018) analyzed carrot for utilization, Olalude *et al.* (2015) carrot juice for possible industrial application. Mahgoub *et al*. (2018), analyzed cabbage wastes for potential as livestock feed, Khattak and Rahman, (2017) as a natural source of vitamins and minerals, Kamau *et al.* (2020) for policy to avoid food wastes. None of the authors analyzed wastes for food fortification (such as masa) at domestic level.

Masa is a very popular and cheap local food consumed as snacks and breakfast by about 80 % of Nigerians, and is also consumed in, Burkina Faso, Ghana, Niger and Mali (Nkama, 1993; Nkama *et al*. 1998). Nilson and Piza (1998) reported that about 2 billion people in the World suffer from micronutrient deficiency. Richardson, (1997), reported that vitamin C has a low risk and high safety acceptability for use in food fortification but was highly unstable in the presence of heat especially over a long time. Masa is a fermented bread-like food made of rice or maize by frying for 5-8 minutes. This makes masa ideal for fortification with vitamin C since it is cooked for a very short time, as was equally described by WHO, (1999) that cooking at high temperature for a short time retained much of the vitamin C content. The fact that it is equally largely consumed by everyone makes it ideal for fortification since the target population will be met. Equally, vitamin C content of maize used for masa production is very low, constituting 0.12 mg/100g of maize which is equally reduced during masa production (Shah *et al.* 2015; Gopalan *et al*. 2007). Akande and Jolayemi, (2018), reported that rice-based masa enriched with grain amaranth and carrot powder had high protein, fat, ash and fiber contents, in addition to vitamin C. This implies that fortification of masa with carrot and cabbage wastes may also lead to the increase in these nutrients.

Most of the work published on qualitative and quantitative wastes are on global estimates of the wastes rather than on wastes from specific produce and most emphasis has also only been made on wastes from industrial food processing rather than from domestic food processing. These wastes from domestic food processing may have huge potentials for use in many ways. This usefulness can only be exploited when the nutritional composition and quantities of these wastes are known. This work was therefore design to determine the proximate composition of carrot peels and cabbage wastes, and also to determine their magnitude following processing of carrot and cabbage for home consumption. The wastes were then used for fortification of *masa* and the best combination of the wastes for maize-based masa fortification was then determined.

Materials and Methods

The experiment was conducted in the Department of Crop Production and Horticulture Modibbo Adama University Yola, Nigeria. Is located on latitude $9^0$20' 43'' N and longitude 12^0 30' 8'' E, at an altitude 203.5m above sea level. Yola has an annual mean minimum and maximum temperature of 15.2^0C and 39^0C respectively (Adebayo, 1999).

Thirty (30) carrot and cabbage portions each were purchased from 30 randomly selected retailers, each time from Jimeta market in Yola. This was done in two phases, first in December 2019 (HT1), when prices of these vegetables were highest and later on in May 2020 (HT2) when prices were moderate. A portion of carrot was purchased at N300 and cabbage at N400.

Determination of quantity and economic value of wastes

The weight in grams of each portion of the vegetables was taken in triplicates. Cleaned samples of the vegetables were carefully prepared by removing the non-edible portions, which are traditionally thrown away. The weight in grams of the wastes was equally taken in each of the triplicate portion of the vegetables.

The weight of vegetables was determined by the formula

Weight of vegetables = $\frac{AWV(HT1)+AWV(HT2)}{2}$

The weight of wastes was obtained by using the formula;

Weight of wastes =

$$\frac{AWV(HT1) - AWW(HT1) + AWV(HT2) - AWW(HT2)}{2}$$

Where; AWV=average weight of vegetables, AWW= average weight of wastes, HT1= period of highest price, HT2= period of lowest price. Adapted from Kikulwe *et al*. (2018).

Percentage wastes = $\frac{\text{Weight of wastes}}{\text{Weight of vegetable}} \times \frac{100}{1}$

Determination of composition of the wastes

Proximate analysis

Fresh samples of parts of the wastes were carefully cleaned and were prepared for analysis of nutrients composition. This was done in accordance with the Association of Official Analytical Chemists International (AOAC), (2005), where, moisture content was determined by oven drying, ash by sample ignition method at 550°C, fat using Soxhlet apparatus, protein by Kjedahl's method using the formula (N x 6.25), the sample was digested to determine the crude fiber content. The carbohydrate content was determined according to FAO (1982) by difference as follows:

Carbohydrate % = 100 – (moisture % + protein % + ash % + lipid % + crude fiber %).

Determination of dry matter

Dry matter was determined by using the formula;

%Dry Matter = 100 - % Moisture.

Determination of Vitamin C

The vitamin C content was determined by titration, based on the equation below, followed by calculations to determine the concentration of ascorbic acid in mg/100g in accordance Benderitter *et al*. (1998).

Ascorbic acid + $I_2 \rightarrow 2I^-$ + dehydroascorbic acid

Utilization of the carrot and cabbage wastes in masa production

Masa preparation was done in line with the method used by Igwe *et al*. (2013). Raw maize was cleaned, washed and then soaked for 12 hours at 30^0 C. The soaked maize was then removed, washed and milled into powder. A 1 % baker's yeast (raising agent) was then added to the milled powder, following by clean water to form a batter. This was then allowed to ferment for 12-14 hours at 30^0 C. Sugar (6%) and salt (5g) were added to 2 kg of the mixture, followed by 10 cm^3 of 23 % trona, while stirring vigorously with a mortar. Fresh carrot peels and cabbage wastes each, were blended using an electric blender separately. The following portions of the blended wastes were added successively into each 2 kg batter; the treatments were four (4) different ratios of carrot and cabbage wastes which were C1= 75 g carrot and 75 g cabbage wastes (7.5 %), C2 = 100 g carrot and 100 g cabbage wastes (10 %), C3 = 125 g carrot and 125 g cabbage wastes (12.5 %) and C4, mixture without wastes (0 %), while continuing vigorous stirring. About 10 cm^3 of vegetable oil was added into cuplike depression in a local pot made from clay and was then fried for 3 minutes on either side, to produce masa. Sensory attributes of the masa (taste, colour, flavor, texture, appearance as well as the general acceptability), were evaluated later by a 20 member panelists (food scientists) from the Modibbo Adama University of Technology Yola, Nigeria. The sensory attributes were evaluated using Nine Hedonic scale (1 to 9 for dislike extremely, dislike very much, dislike very moderately, dislike slightly, neither like nor dislike, like slightly, like moderately, like very much, like extremely, respectively). The width and the thickness of the masa was measured using a ruler and micrometer respectively. The volume of masa loaf was computed by dividing the volume of loaf by the weight of masa in accordance with Gomez *et al*. (1997). The loaf volume was determined using the small seed-displacement method, in accordance with Ayo, (2003), and calculations were made using the following equations:

Loaf volume = $\frac{W2 \times W1}{V1}$

Where w_2= weight of samples that filled the container,
w_1= weight of samples displaced by the loaf sample,
v_1= volume capacity of the container.

Specific volume (cm^3/g) = $\frac{\text{Loaf volume}}{\text{Loaf weight}}$

Proximate analysis for masa from each treatment was carried out in accordance with prescriptions of the Association of Official Analytical Chemists International (AOAC), (2005), where, moisture content was determined by oven drying, ash by sample ignition method at 550°C, fat using Soxhlet apparatus, protein by Kjedahl's method using the formula (N x 6.25), the sample was then digested to determine the crude fiber content. The carbohydrate content was determined according to FAO (1982) by difference as follows:

Carbohydrate % = 100 – (moisture % + protein % + ash % + lipid % + crude fiber %).

The energy content was established following the method employed by Emmanuel and Folasade, (2011) by applying the formula;

Energy (K cal /100g) = (Crude lipid X 8) + (Crude protein X 2) + (Carbohydrate X 4).

The vitamin C content was determined by titration, based on the equation below, followed by calculations to determine the concentration of ascorbic acid in accordance Benderitter *et al*. (1998).

Ascorbic acid + $I_2 \rightarrow 2I^-$ + dehydroascorbic acid

Data analysis

Data were analyzed by one-way Analysis of Variance (ANOVA). The Duncan New Multiple Range Test (DNMRT) was used to assess significant differences between means of samples. Results were reported as mean ± standard Error (SE) of triplicate measurements.

Results

Quantitative losses: Table 1 shows that wastes from cabbage and carrot are considerably high in quantity and could be used in the fortification of maize-based masa. Cabbage wastes percentage was in the range 35.2 – 44 % while carrot wastes were in the range of 22.7 – 30 %. The mass of wastes with respect to the edible portions for cabbage and carrot are presented in figures 1 and 2 respectively, below. There was a high significant difference between the means of carrot wastes and edible portion in terms of quantity, with p-value of <0.001 with the weight of edible portion higher than that of the wastes. There was a significant difference between the means of cabbage wastes and the edible portion in terms of quantity, with the edible portion having much weight than the wastes, with p-value of 0.029. Despite the statistical higher content in the edible portions than in the wastes of cabbage, the amount of wastes was comparatively high

Table 1: Mean wastes from cabbage and carrot

Vegetables	Mean waste/g	% Loss range
Cabbage	533.7g	35.2 – 44 %
Carrot	331.7g	22.7 – 30 %

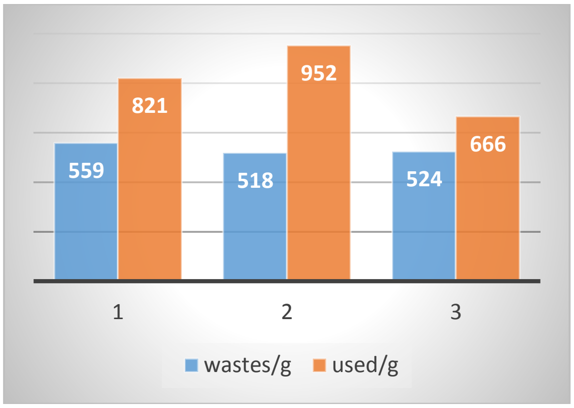

Figure 1: showing average quantity of wastes and used portion in cabbage

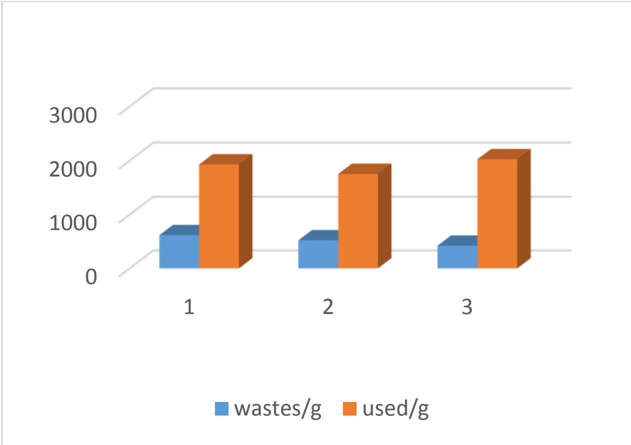

Figure 2: showing average quantity of wastes with respect to edible portion in carrot

Proximate analysis and vitamin C content: The results from proximate analysis and vitamin C content of the carrot and cabbage peels are presented in Table 2. The results revealed that carrot peels had low levels of crude fiber and fat with 0.15 % each and was rich in proteins of 1.675 ± 0.1061 %, carbohydrates of 6.03 ± 0.0354 %, ash of 2.0 ± 0.283 % and vitamin C of 8.32 ± 0.5205 mg/100g. Though cabbage waste was reported to have lower dry mass than carrot peels, it was richer in crude fiber of 1.35 ± 0.0707 %, protein of 1.775 ± 0.0354 %, fat of 0.35 ± 0.0707 % and vitamin C of 16.12 ± 1.040 mg/100g about twice the content of that of carrot peels, but lower than carrot peels in carbohydrates of 4.0 ± 0.000 % and ash of 1.0 ± 0.000, twice less than ash in carrot peels as indicated in figure 3 below.

Table 2: Proximate analysis and vitamin C content (%) of the carrot and cabbage peels

	Carrot/mean ± SE	Cabbage mean± SE
Moisture content	88.3 ± 0.707	91.5 ± 0.424
Dry matter	11.7 ± 0.707	8.4 ± 0.424
Ash	2.0 ± 0.283	1.0 ± 0.000
Carbohydrates	6.03 ± 0.0354	4.0 ± 0.000
Fiber	0.15 ± 0.0707	1.35 ± 0.0707
Protein	1.675 ± 0.1061	1.775 ± 0.0354
Fat	0.15 ± 0.0707	0.35 ± 0.0707
Vitamin C	8.32 ± 0.5205	16.12 ± 1.040

Values are means ± standard error of three replicate amounts

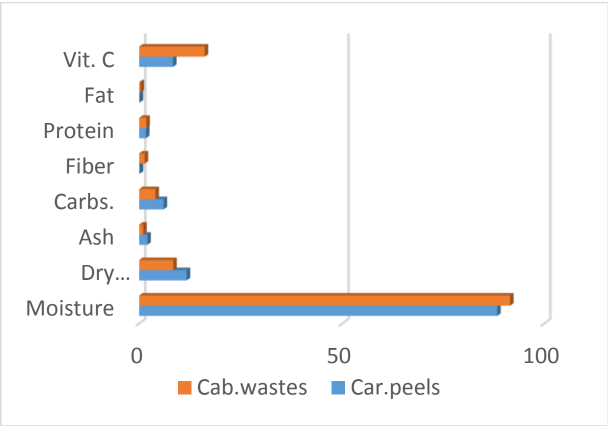

Figure 3: components of carrot and cabbage wastes

Key: Carbs= carbohydrates, Fat= lipids, Cab= cabbage and Car= carrot.

Nutrient Composition of masa obtained from treatments C1 – C4: The proximate composition, vitamin C and energy content of masa obtained from the four treatments (C1 – C4) are presented in Table 3. The total ash content ranged from 0.07 % - 1.6 %, crude fiber from 1.1 % - 2.0 %. The content of total ash was higher in the fortified treatments than in the unfortified treatment. The vitamin C content was in the range of 0.0001 mg/100g to 3.2 mg/100g of masa. The vitamin C content of the fortified masa (C1 – C3) were lower than 8.32 ± 0.5205 and 16.12 ± 1.040 in carrot and cabbage wastes that were used for fortification of the masa. The energy content in masa was in the range of 402.2 Kcal/100g to 418.6 Kcal/100g, with treatment C3 (12.5 % wastes) in the masa having the highest energy content, that was statistically different from the one with 0 % wastes (unfortified masa). Despite highest energy and vitamin C content, masa made from C3 had lower content of total ash and crude fiber and also reported the lowest protein composition of the four treatments. The vitamin C content of C2 (10 % wastes) was not significantly different from that of C3, but had higher content of crude fiber and total ash than C3 with statistical difference in their means at 5 % probability. These results equally revealed that unfortified masa has extremely low levels of vitamin C. The levels of crude fat were higher in the fortified masa than in the unfortified masa, with a statistical difference only in the means between C2 (10 % wastes of carrot and cabbage) and the unfortified masa C4.

Table 3: Proximate composition (%), vitamin C (mg/100g) and energy (Kcal/100g) content in treatments C1-C4.

Content	C1	C2	C3	C4
Moisture	9.21 ± 1.83^{ab}	9.90 ± 1.071^{ab}	8.60 ± 0.328^{b}	11.2 ± 1.047^{a}
Total ash	1.2 ± 0.284^{b}	1.6 ± 0.359^{a}	0.9 ± 0.1411^{bc}	0.07 ± 0.0265^{d}
Carbohydrates	61.3 ± 3.07^{a}	57.1 ± 8.34^{a}	62.3 ± 2.60^{a}	61.1 ± 2.02^{a}
Crude fiber	1.1 ± 0.300^{c}	2.0 ± 0.226^{a}	1.2 ± 0.306^{bc}	1.6 ± 0.392^{ac}
Protein	8.95 ± 1.461^{a}	9.2 ± 0.490^{a}	7.9 ± 1.185^{a}	8.5 ± 0.656^{a}
Crude fat	18.1 ± 0.745^{bc}	20.1 ± 0.496^{a}	19.2 ± 0.373^{ac}	17.6 ± 0.766^{b}
Vitamin C	1.23 ± 0.1253^{b}	2.833 ± 0.490^{a}	3.20 ± 0.219^{a}	0.0001 ± 0.00^{c}
Energy Kcal/100g	407.9 ± 12.19^{ab}	407.6 ± 5.89^{ab}	418.6 ± 6.29^{a}	402.2 ± 1.358^{b}

Values are means ± standard error of three replicate amounts, the means that do not share a letter, written as superscript on the same row, are significantly different at P < 0.05. C1 = 7.5 %, C2 = 10 %, C3 = 12.5 % and C4 = 0 %, of 1:1 ratio of carrot and cabbage wastes.

Physical characteristics of masa: The physical characteristics in fortified masa were in many cases not significantly different from that of unfortified masa as shown in Table 4. The weight of Masa was in the range 26.75 g – 30.31 g, with that of C2 (10 % of wastes) having the highest weight. The loaf volume and loaf volume index were in the range of 129.65 cm^3 to 151.32 cm^3 and 4.54 cm^3/g to 5.63 cm^3/g respectively in masa prepared using C1 – C4 treatments, with masa made from 0 % wastes (C4) having the highest loaf volume and C2 low loaf volume, while C1 had the lowest loaf volume. The loaf volumes index of fortified masa did not differ significantly (P>0.05) from masa made from 0 % wastes.

Table 4: Physical characteristics of masa fortified with carrot and cabbage wastes

Physical characteristics	C1	C2	C3	C4
Length (cm)	7.67 ± 0.753^a	7.83 ± 0.366^a	7.79 ± 1.295^a	7.92 ± 0.601^a
Weight (g)	28.84±1.446^{ab}	30.31±1.482^a	26.75±0.711^b	27.21 ±0.78^b
Thickness (cm)	1.25 ± 0.476^a	1.56 ± 0.330^a	2.35 ± 1.084^a	2.29 ± 0.193^a
Loaf volume (cm^3)	129.65 ± 2.96^c	139.31± 2.93^b	150.6±0.979^a	151.32 ±3.39^a
Loaf volume index(cm^3/g)	4.54 ± 0.577^a	4.59 ± 0.429^a	5.63 ± 0.901^a	5.56 ± 0.39^a

Values are means ± standard error of three replicate amount, the means that do not share a letter, written as superscript on the same row, are significantly different at P < 0.05.
C1 = 7.5 %, C2 = 10 %, C3 = 12.5 % and C4 = 0 %, of 1:1 ratio of carrot and cabbage wastes.

Sensory attributes: The study revealed that the unfortified (C4) masa had better sensory attributes than the fortified except C2 for aroma as shown in Table 5. Though C2 (10 % wastes) treatment had colour, taste, appearance and texture, that were not comparable to that of the unfortified masa, their general acceptability was as good as that of the unfortified masa with statistical difference in their means at 5 % probability. Masa from the treatment C2 also had the best aroma.

Table 5: Sensory attributes of masa fortified with vitamins from carrot and cabbage wastes

Sensory attribute	C1	C2	C3	C4
Colour	5.11±0.0656^c	6.51 ±0.903^b	5.72 ± 0.660^{bc}	8.65 ± 0.642^a
Taste	6.01 ± 0.726^c	7.61 ± 0.547^b	5.21 ± 0.291^c	8.94 ± 0.514^a
Texture	5.23 ± 0.327^b	6.25 ± 0.442^b	5.41 ± 0.1637^b	8.42 ± 0.956^a
Aroma	5.64 ± 0.255^b	8.22 ± 0.442^a	5.72 ± 0.233^b	8.24 ± 0.384^a
Appearance	5.11 ± 0.299^c	6.63 ± 0.1217^b	5.21 ± 0.221^c	8.62 ± 0.387^a
General acceptability	5.72 ± 0.370^b	7.82 ± 0.769^a	5.73 ± 0.433^b	8.72 ± 0.587^a

Values are means ± standard error of three replicate amount, the means that do not share a letter, written as superscript on the same row, are significantly different at P < 0.05. C1 = 7.5 %, C2 = 10 %, C3 = 12.5 % and C4 = 0 %, of 1:1 ratio of carrot and cabbage wastes.

Discussion

Quantitative losses: The range 35.2 – 44 % in cabbage wastes concurs with the 40-50 % described by FAO Save Food (2015) in vegetables. The value ranged of 22.7 – 30 % wastes reported in carrot was in accordance with the works of Ajila *et al*. (2007, 2010) who reported that 25-30 % of fruits and vegetables are wasted and that much if not all of these wastes are not used in anyway. Though the amount of nutrients in the edible portions of both carrot and cabbage were higher than that in the wastes, the wastes could potentially be very useful, since the amount needed to fortify food is not too much.

Proximate analysis and vitamin C content: The moisture content of carrot peels was 88.3 ± 0.707 % which was in accordance with the works of Holland *et al*. (1991) who reported 88.8 % moisture in carrots, this was comparable to the 84.23 ± 0.18 % reported by Shyamala and Jamuna (2010) in pulp wastes of carrot. This shows that the peels in carrot contain as much moisture like the carrot itself. The dry matter was reported at11.7 ± 0.583 % which was not consistent with the 7.54 ± 0.44 % reported by Shyamala and Jamuna (2010) in pulp wastes of carrot, suggesting that peels are richer in dry matter than pulp wastes.

The ash content of 2.0 ± 0.283 % was comparable to 1.333 ± 0.153 described by Olalude *et al.* (2015) from analysis of carrot juice. This was however, not in harmony with 5.78 ± 0.06 % reported by Shyamala and Jamuna (2010) in pulp wastes of carrot, suggesting that carrot pomace has high ash content than the peels and juice. This result also was not in harmony with 5.05 ± 0.32 % described by Gazalli *et al.* (2013) in carrot powder confirming that carrot peels is lower in ash than carrot powder and juice.

The carbohydrates content of 6.03 ± 0.0354 % was incoherent with 32.22 % described by Shyamala and Jamuna (2010) in pulp wastes of carrot. This shows that the carbohydrate content of carrot peels is lower than that of pomace. This result was however, in accordance with 6.0 % reported by Holland *et a*l. (1991) and 6.100 ± 0.346 % stated by Olalude *et al.* (2015) in carrot juice. The crude fiber content of 0.15 ± 0.0707 % was incoherent with, 24.66 ± 0.83 % reported by Gazalli *et al*. (2013) in carrot powder. The protein content of 1.675 ± 0.1061 % was not in accordance with 0.9 %, reported by Gapolan, (1991), but was comparable with 1.067 ± 0.058 % reported by Olalude *et al.* (2015) from analysis of carrot juice, but not in accordance with 10.06 g observed by Sharma *et al*. (2016) in carrot pomace and 6.21 ± 0.09 % recounted by Shyamala and Jamuna (2010) in pulp wastes of carrot. The crude lipid content of 0.15 ± 0.0707 % was in accordance with 0.2 % reported by Gapolan (1991), but was however, not in harmony with 2.72 ± 0.09 reported by Shyamala and Jamuna (2010) in pulp wastes of carrot. Vitamin C content was observed to be, 8.32 ± 0.5205 mg/100g on dry weight basis which was incoherent with 61.3 mg/100g reported in carrot peels by Khattak and Rahman, (2017) and was comparable to the 4mg/100g reported by Holland *et al*. (1991) in edible carrot portions and 3.53 ± 0.11 mg described by Shyamala and Jamuna (2010) in pulp wastes of carrot, but inconsistent with 16.667 ± 1.332 mg/100g obtained by Olalude *et al.* (2015) in carrot juice. The results indicated that the component of peels from this study were in many cases different from that of carrot pomace, powder, juice and wastes pulp. The moisture content of 91.5 ± 0.424 %, was incoherent with 94.87 ± 2.56 % reported in cabbage wastes by Kamau *et al*. (2020).

The dry matter content was not in harmony with 11.00 % and 10.86 % detected by Mahgoub *et al*. (2018) in green and red cabbage wastes respectively. The ash content was equally not concurring with the 0.49 ± 0.02% detected in cabbage wastes by Kamau *et al*. (2020), 8.75 ± 0.03 % and 7.04± 0.02 % reported respectively in green and red cabbage wastes by Mahgoub *et al*. (2018). The content of carbohydrate was comparable to the 3.22 ± 0.092 % observed by Kamau *et al*. (2020) in cabbage wastes. The crude fiber, fat and proteins content were incoherent with 0.54 ± 0.06 %, 0.05 ± 0.01 % and 0.83 ± 0.07 % respectively, reported by Kamau *et al*. (2020) in cabbage wastes. The discrepancies observed in the above results could have been due to differences in the vegetables parts used by the different authors. This could also be due to differences in cultural activities involved in the growth of the plant, where most of the cabbage and carrot farmers practice irrigation farming and hardly apply enough fertilizer as well as possible differences in the carrot and cabbage cultivars used by different authors.

Composition of masa obtained from treatments C1 – C4: The higher ash content in the fortified treatments than in the unfortified treatment concurs with the works of Akande and Jolayemi, (2018) who reported that rice-based masa fortified with grain amaranth and carrot powder had higher total ash content than the control. The crude fiber content, however, was quite high in the control, disagreeing with works of Akande and Jolayemi, (2018) who reported that rice-based masa fortified with grain amaranth and carrot powder had higher crude fiber content than the control. This high crude fiber could be explained by the fact that maize (raw material used in masa production) has higher fiber content than rice, 6.60 % and 3.36 % respectively for maize and rice reported by Meherunnahar *et al.* (2018).

The high amount of vitamin C in the carrot and cabbage wastes compared to that in masa could be explained by the fact that vitamin C is unstable to heat and was lost during the frying process of masa (Stešková *et al*., 2006). Lower content of total ash and crude fiber and also lowest protein composition in C3, though highest energy and vitamin C content, of the four treatments suggest that increase in the concentration of the wastes maybe negatively affecting the concentration of total ash, crude fiber and protein. This observation on protein levels in C3 from these findings, contradicts the report by Akande and Jolayemi, (2018) in rice-based masa enriched with grain amaranth and carrot powder and Ayo *et al*. (2008) who observed that enriched samples had higher proteins than the control. The vitamin C content of C2 (10 % wastes) was as good as that of C3, but had higher content of crude fiber and total ash than C3. This suggests that C2 (10 % wastes of carrot and cabbage), could be a better fortification treatment than C3 treatment with 12.5 % wastes. The crude fiber could be important in managing obesity, constipation, heart diseases, colon cancer, diabetes among others (Karma *et al*. 2009; Chinma *et al.* 2007). Low levels of vitamin C in unfortified masa, was in agreement with the works of Akande and Jolayemi, (2018), who reported that rice-based masa fortified with grain amaranth and carrot powder had higher vitamins C content than the control. The vitamin C is very important as an anti-oxidant in humans (Erdman *et al*., 2012), while the minerals are very important in our bodies as the aid in growth, development and health. This implies that for masa consumers to benefit from these, masa fortification with these wastes is imperative.

Higher levels of crude fats in fortified masa was in harmony with the works of Akande and Jolayemi, (2018) who reported that rice-based masa fortified with grain amaranth and carrot powder had higher crude fat content than the control. The presence of fat in food contributes to energy requisite for humans (Moss *et al*., 1987)

Physical characteristics: The highest loaf volume in unfortified masa was in accordance with the observation of Akande and Jolayemi, (2018) and fortified masa with 12.5 % wastes (C3) had the highest loaf volume index. The low loaf volume in C2 was possibly due to its high crude fiber content, concurs with the observation of Akande and Jolayemi, (2018) who reported that rice-based masa fortified with grain amaranth and carrot powder, with treatments with high crude fiber content had poor baking quality. In the same vein, Kohajdová *et al.* (2012), also reported that high crude fiber negatively affects loaf volume upon addition of pomace of carrot to wheat rolls. The similarity in the loaf volumes index of fortified and unfortified masa, shows that the crippling effects which is a situation where the gas retention during raising of the dough is lowered as a result of the addition of wastes (Sivam *et al*. 2010), was less, indicating that these wastes are good for fortification.

Sensory attributes: The study revealed that the unfortified masa had better sensory attributes than the fortified except C2. The unfortified masa had better sensory attributes than the unfortified concurring with the observation made by Akande and Jolayemi, (2018) who reported that rice-based masa fortified with grain amaranth and carrot powder were less acceptable than the control. This observation implies that C2 (10 % wastes), which was equally best in aroma, highest weight among the four treatments, high total ash, crude fiber and vitamins and though with a smaller loaf volume than C3 (12.5 % wastes), was found to better for the use in masa fortification than C1 and C3. The best aroma and best in fortified treatments was possibly due to its high fat content, as attested by Aiyesanmi, (1996) that high amount of fat help to improve flavor and is beneficial in enhancing the tastiness of foods to which it is added. The masa made from C3 (12.5 % wastes) had higher loaf volume and the highest energy content among the four treatments, though the weight and total ash were lower than that of C1 (7.5 % wastes) with statistical difference in their means at 5 % probability, it fiber content was as good as that of C1. Equally, the vitamin C content of C3 was higher than that of C1 with statistical difference in their means at 5 % probability hence C3 rather than C1 could also be a second option for fortification of masa made from maize though C3 was not generally accepted.

Conclusion

It can be concluded from this study that carrot and cabbage wastes from domestic processing are equally as nutritious in terms of quality, rich in vitamin C, ash, crude fiber and protein. These wastes are a cheap source of minerals, proteins, fiber, as well as vitamins C, and could be useful in the fortification of maize-based masa. Maize-based masa made from the treatment C2 (10 % of 1:1 ratio of wastes of carrot and cabbage) was the most preferred among the treatments that were used for fortification.

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