Effect of *Amaranthus* leaf powder (ALP) addition on the nutritional composition, physical quality and consumer acceptability of instant noodles

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Abstract

Noodles are popular starchy foods among youth and children. However, they are not nutritionally adequate as a single meal. The present study aimed to determine the effect of *Amaranthus* leaf powder (ALP) addition on the nutritional composition, physical quality and consumer acceptability of instant noodles. Instant noodle samples were developed by substituting wheat flour used in a common noodle recipe with 1%, 2% and 3% (w/w) of ALP. The sampless were analyzed for nutritional composition using AOAC methods. Physical quality was evaluated by analyzing the color (CIELAB color values) and texture (g). Consumer acceptability was evaluated by 60 panelists using a 9-point hedonic scale. Increasing ALP from 0% to 3% had no significant effect on the total glycemic carbohydrate, protein, fiber and mineral contents of the noodles. However, the fat content significantly increased with the inclusion of ALP (4.57%), leading to a higher energy value. ALP-fortified noodle samples were significantly softer in texture (271.39 g cutting force) than conventional noodles (control) (609.08 g force), and a significantly greener color was observed with ALP addition. All noodle sampless were as acceptable as the control , which suggests that ALP could be used to improve the nutritional value of instant noodles.

Keywords: *Amaranth;* convenient foods; nutrition security, sensory evaluation, underutilized plants.

1. Introduction

Traditional vegetables play an important role in food security, income generation and food culture for poor people. These promising crops have an ability to resist the adverse effects of climate change and can tolerate marginal upland conditions (Capuno et al., 2015). Considering that *Amaranthus* is widely available in many temperate and tropical regions and has been praised for its nutritional value, it would be beneficial to explore its use as an inexpensive supplement for instant noodles. *Amaranthus* is an ancient plant that has been consumed in different regions globally for over eight thousand years. This climatic resilient plant has been widely ignored over the years and has been stigmatized by the youth labelling it as “food for the poor or backward people” (Qumbisa et al., 2020). This has reduced its utilization and consumption amongst this group despite its nutritional benefits. The study further recommends that there is a need to promote the use of *Amaranthus* leaves as a healthy food which can help fight hunger and malnutrition and further suggest the use of ALP as a fortificant to also help reintroduce the plant back to the food system (Qumbisa et al., 2020).

Amaranthus grain and leaves are a good source of protein (32.51 g/100 g) and minerals such as magnesium (248 mg/100g), calcium (159 mg/100g), potassium (508 mg/100g), phosphorus (557 mg/100g), iron (68.77 mg/kg), zinc 31.33 mg/kg and sodium (2.87 mg/100g) with grains being significantly richer than other grains such as maize (\Alegbejo, 2013, Beswa et al., 2016, Mampholo et al., 2015, Soriano-Garcia et al., 2018). The use of this ingredient is steadily gaining popularity in fortifying products low in nutrients, especially protein (Cárdenas-Hernández et al., 2016). *Amaranthus* grains are used as a source of lipids and *Amaranthus* grain powder is used as a base of noodles, pancakes and other *Amaranthus*-based products (DAFF, 2010, Sanz-Penella et al., 2013, Ogrodowska et al., 2014). According He and Corke (2004), the average fat content of dried mature *Amaranthus* was 1.63% ranging from 1.08-2.18%. Although there are no reports of their use in instant noodles, *Amaranthus* leaves can be used with wheat flour to produce nutritionally enhanced food products (Ogrodowska et al., 2014). The powder from the leaves blends well with wheat flour (Odunlade et al., 2017).

Instant noodles have gained popularity to become one of the most popular starchy foods world-wide (Birt et al., 2013). The concern about the dominance of such foods is that they are often consumed in undiversified and unbalanced diets, which exposes consumers to malnutrition and diet-related health problems. A single serving of instant noodles is usually high in glycemic carbohydrates but low in fiber, vitamins, and minerals (Sikander et al., 2017). Research-based evidence has shown that many of the chronic health conditions could be prevented or managed through dietary changes: for example, type 2 diabetes can be addressed through dietary changes (Hu, 2011). Food fortification is regarded as a sustainable strategy for malnutrition alleviation. It can prove a cost effective and convenient intervention. The success of this intervention is based on the fact that it does not require the target population to change its consumption patterns or diet (Barkley et al., 2015). The South African Food Based Dietary Guidelines (SAFBDGs) recommend that individuals make starchy food the basis of their meals. This allows for a sufficient intake of dietary carbohydrates to meet an individual's caloric needs (Vorster et al., 2013). Women need about 1600 and 2400 calories a day whilst men require 2000 to 3000 calories depending on various body and lifestyle factors (Ismail, 2018). The World Health Organization (WHO)/FAO also suggested that about 50% of the dietary energy should be provided by carbohydrates (Mann et al., 2007). The rest of the SAFBDG guidelines encourage diversification to acquire a balanced diet. However, susceptibility to malnutrition persists as starchy foods remain the staple for most households and a substantial proportion of the population consumes undiversified meals. According to the literature, instant noodles generally contain about 250 kcal, 51 g of carbohydrates, 8 g of protein, 2 g of fat, 2 g of dietary fiber and 192 mg of sodium per 100 g serving (Sikander et al., 2017). The high calorie content of the instant noodles, poor protein quality and lack in vitamins, as well as mineral availability, compromises the nutritional value of this product.

Instant noodles are considered an unbalanced meal. Qumbisa et al. affirm that "instant noodles are convenience food, particularly for students. Therefore, improvement of their nutritional value could provide health benefits to this population" (Qumbisa et al., 2020) p6. This has led to several attempts through research and development to improve their nutritional profile. Most research done in this area has soughtto achieve this by substituting the basal wheat flour used to prepare the product with flours from buckwheat (Choy et al., 2013), gathotan (Purwandari et al., 2014) , brown rice (Wu et al., 2017), rice bran (Yılmaz Tuncel et al., 2017), mung bean (Liu et al., 2018), banana (Adebayo et al., 2018), cassava (Sanni et al., 2007) and pomegranate (Koca et al., 2018). Fortification studies have explored the inclusion of poultry-based food ingredients (Pal et al., 2017) and powders from vegetables such as beetroot (Koca et al., 2018) and carrot (Singh et al., 2018). However, the use of traditional vegetables such as *Amaranthus* in the fortification of instant noodles has been very limited.

Consumer acceptability of *Amaranthus*-fortified food products has been investigated with the youth and a low preference and acceptability was reported (Beswa et al., 2016). This was despite, the snacks being rich in protein and having an increased ash content against the control. Therefore, the aim of this study is to investigate the effect of *Amaranthus* leaf powder inclusion on the nutritional and physical quality of instant noodles, and to determine consumer acceptability of *Amaranthus*-fortified noodles.

2. Materials and Methods

2.1 Preparation of Amaranthus leaf powder

Amaranthus cruentus leaves were sourced from local vendors at eSikhawini (28.8677° S, 31.9160° E) KwaZulu-Natal, South Africa. These leaves were sorted, graded and thoroughly washed under running tap water to remove dirt. The cleaned leaves were then spread over paper towel to get rid of excess water. They were then dried in a hot air oven at 70°C for 2 hours as suggested by Singh et al. (2009). The dried leaves were then milled into a fine powder using a blender (Wz-Q10S Multifunctional Blender). The powder was kept in airtight labelled plastic bags for 24 hours for further use.

2.2 Preparation of instant noodles

Amaranthus-fortified instant noodles were developed in a food preparation and processing facility. The samples and ingredients were collected according to Gulia et al. (2014) and were prepared according to a method modified from Adegunwa et al. (2012). Ingredients were procured from Indlovu multi-sales company in Richard's Bay and are given in Table 1. Wheat flour (WF) was used to produce standard noodles (control) and the samples were developed by partially substituting wheat flour with *Amaranthus* leaf powder (ALP) at levels 1%, 2%, & 5% as suggested by Zungu (2016) in a study of fortifying snacks through supplementation with Moringa leafy powder (this was a preliminary trial). A descriptive sensory test was done with five trained panelists using a descriptive score card. The samples with 5% ALP was found to be bitter as a result of the bitter tastes from *Amaranthus*. Standardization was done and the proportions were reduced down to 1, 2 and 3% ALP, respectively, and other adjustments such as the reduction of the egg content were done before the samples were subjected to pilot testing. Dry ingredients were mixed and liquids were added. The combination was mixed and kneaded for 10 min to form a dough ball. The dough was rolled into a thick sheet and extruded using the pasta machine (Imperia Italian SP150 Double Cutter, Yuppie Chef) to form noodle sheets. The sheets were cut into noodle strands using the pasta machine and the strands were lined in a gastronome pan and were put in the steaming machine (Hobart, HC24EA Series Steamers) at 100°C for 5 min. Once cooked, the strands were dried for 2 hours in an oven at 70°C. The dried samples were allowed to cool to room temperature (±25°C) and packaged in clear plastic bags further used. Each noodle sample was produced in bulk and was distributed and analyzed as follows.

Table 1: Ingredients used for noodles production

Ingredients	Amounts
Golden Cloud Wheat flour	750 g
Homemade Onion Powder	3.8 g
Fam PackSodium Bicarbonate	7.5 g
Cerebos Iodated Salt	7.5 g
Maizena Corn Starch	15 g
Supreme Lemon Juice	37.5 mL
Homemade Garlic Powder	3.8 g
Taj Mahal Cumin Powder	3.8 g
Helios Oil	37.5 mL
Nulaid grade 1 large Eggs	37.5 mL
Warm tap water	232.5 mL
ALP	7.5 g, 15 g, 22.5 g (1, 2 and 3%, respectively)

2.3 Proximate analysis

A 100g of each sample with 0, 1, 2, and 3% ALP was powdered using a mortar and pestle, packed in tubes and sent to the laboratory for proximate analysis. Büchi 810 Soxhlet Fat extractor (Büchi, Flawil, Switzerland) was used to determine the fat content of the freeze-dried samples according to the AOAC Official Method 920.39 (Thiex et al., 2003). For extraction petroleum, ether was used. The following equation was used to calculate crude fat:

$$\% \, crude \, fat = \frac{beaker + fat - beaker}{sample \, mass} X \, 100$$

LECO Tsuspec Nitrogen Analyzer was used to measure protein content (LECO Corporation, Michigan, USA) using the AOAC official method 990.03109 (Thiex et al., 2003). A combustion chamber with autoloader was used to place the samples briefly at 950°C. To convert nitrogen content obtained to percentage the following equation was used:

$$\% \text{ crude protein} = \% \text{ N} \times 6.25$$

All samples mineral content was determined as ash according to the AOAC official method 942.05 (Thiex et al., 2003). Furnace was used to place the samples at 550°C after then were weighed. After volatilization of the organic matter from the samples minerals remained as residues of ash in the crucibles. The percentage of ash content in the samples was calculated using the following equation:

$$\% \, ash = \frac{(Mass\ of\ sample + crucible\ after\ ashing) - (mass\ of\ pre\text{-}dried\ crucible}{(mass\ of\ sample + crucible) - (\ mass\ of\ pre\text{-}dried\ crucible)} X\ 100$$

Fiber was determined as neutral and acid detergent fiber using the Dosi-Fiber machine (JP Selecta, Abrera, and Barcelona, Spain) (Mertens, 2002). Total glycemic carbohydrates were calculated by difference. The total energy was calculated using Atwater factors (Mertens, 2002). Individual mineral elements were determined by the inductively coupled plasma optical emission method as described in Method 6.5.1 of the Agricultural Laboratory Association of Southern African. Briefly, HCl was used to digest freeze-dried samples, which were ashed overnight at 550°C in a furnace, the ash content calculated. Nitric acid (HNO3) was added to the ashed samples and then inductively coupled plasma optical emission spectrophotometer (Vista-MPX 2004, Mulgrave, Varian, Australia) was used to determine the concentration of individual mineral elements.

2.4 Physical quality assessments

2.4.1 Texture

The texture of cooked noodles was evaluated using a TA-XT2 texture analyzer (Stable Micro Systems, UK) within 5 min after cooking. Fifty grams (50 g) of noodles were cooked by soaking them in boiled tap water (150 mL) and soaked for 5 min. The broth was drained and kept for color assessments. A set of three cooked noodle strands were placed parallel to a flat metal plate and measured using the HDP/PFS metal blade (Ma et al., 2014). Five replicates per sample were analyzed.

2.4.2 Color

Noodle color was measured using a pre-calibrated Hunter Lab colorimeter (Hunter Associates Laboratory, Inc., Reston, VA). The prototypes were placed on the centre of a dry and clean glass sample cup, placed in a sample port, then covered and readings taken on a CIELAB color space where L*, a*, and b* values were recorded (L*= lightness and ranges from 0 [black] to 100 [white], a*= redness and ranges from green [–] up to red [+], b*= yellowness and ranges from blue [–] to yellow [+]). Three color readings were taken from wet and dry noodle sheets, bundles of cooked noodle strands and the broth drained after cooking (Ma et al., 2014). All measurements were taken at room temperature.

2.5 Antioxidant activity

Four dry samples of noodles, i.e. those with 1, 2 and 3% *Amaranthus* leaf powder, those without), were ground into fine powder using a mortar and pestle. The finely ground noodle samples (1.0 g) were extracted with 10 mL 80% methanol in an ice-cold sonication (Branson Model 5210, Branson Ultrasonics B.V., Soest, Netherlands) bath for 1 h. The extracts were then filtered through Whatman No. 1 filter paper and concentrated in vacuo, using a rotary evaporator (Büchi, Germany) at 30°C. The concentrates were transferred to pre-weighed glass vials and completely dried under a stream of cold air at room temperature. Once a constant weight of each extract was obtained, the extracts were stored in the dark at 10°C until used for analysis. The 1,1-Diphenyl-2-picrylhydrazyl (DPPH) radical-scavenging capacity of the noodle sample extracts was evaluated using a DPPH assay described by Moyo et al. (2010) with modifications. In triplicate, 15 µL of methanolic extracts at different concentrations (10, 25 and 50 mg/mL) were diluted with 80% methanol to a final volume of 750 µL. The diluted extracts were then added to an equal volume of DPPH (100 µM in methanol). The mixtures were incubated at room temperature in the dark for 30 min. A solution consisting of methanol in place of the extract was used as a negative control, while ascorbic acid was used as a positive control. Absorbance was read at 517 nm using a UV-visible spectrophotometer. Background correction of the extract absorbance was done by adding methanol in place of the DPPH solution, this was done for each extract to correct any absorbance due to extract color. The radical scavenging activity (RSA) was calculated using the following equation:

$$\% \text{ RSA} = [1- (\text{Aextract} - \text{Abackground} / \text{Acontrol})] \times 100$$

where Aextract, is the absorbance of the reaction mixture containing the sample extract or standard antioxidant, Abackground is the absorbance of the background solution and Acontrol is the negative control. The EC50, which is the concentration of the extract required to scavenge 50% of DPPH radical, was determined for each extract using Graph Pad Prism software.

2.6 *Sensory evaluation*

Samples of cooked noodles were used for sensory evaluation. Noodle samples weighing 200 g were cooked by adding 500 mL of boiling water for 5 min before draining. Drained noodles were served using small plastic dishes to a panel. Untrained panelists (60 students recruited at the University of Zululand) were used to test if there were any differences between the samples, evaluate the acceptance and preference for samples in this study (Curtis, 2013). The panelists were regular consumers of noodles and had at least tasted *Amaranthus* before. Ethical clearance was obtained from the Biomedical Research Ethics Committee (BREC), University of KwaZulu-Natal (BREC REF NO: BE453/19.) and consent was obtained from participants before they evaluated the samples. A nine-point hedonic scale score card, where 9 = extremely like and 1= extremely disliked, was used to assess the products. Panelists were briefed on how to fill the score card. The cooked noodles were evaluated for sensory attributes: color, texture, aroma, taste and overall acceptability and each panelist evaluated four samples. In order to prevent bias, each panelist received samples in a randomized order, which was done using a Table of Permutations of Nine. Water was used to rinse the mouth before and in-between t testing of samples in order to prevent the carry over effect.

2.7 *Data analysis*

The results represent the average of replicate determinations, expressed as mean ± standard deviation (S.D). The data obtained were analyzed by analysis of variance (ANOVA) using SPSS version 25. Significant F tests at levels of probability ($p<0.05$) are reported.

3. Results

3.1 *Noodle samples*

Figures 1(a-d) shows the noodle samples fortified with ALP. The 1% ALP noodle sample (b) looked much like the control (a) and increases in the concentration of ALP resulted in more noticeable color changes - the noodle samples containing 2% and 3% ALP (samples c and d, respectively) looked different from the control.

(a) (b) (c) (d)

Figure 1: Instant noodle prototypes: (a) Control, (b) prototype with 1% ALP, (c) prototype with 2% ALP and (d) prototype with 3% ALP

3.2 *Nutritional composition*

Table 2 shows the proximate composition of the noodle samples. The protein content of all the ALP-fortified noodles was similar to that of the control and remained above the recommended percentage content (8%) (Ginting and Yulifianti, 2015) of conventional noodles. The fiber (8.08-13.8%) and ash (2.73-3.82%) contents of the noodle samples fortified with ALP were not significantly higher than those of the control. The fat content in the fortified noodle samples increased from 1.55% to 5.00%, which led to a higher energy value albeit a significant decrease in total glycemic carbohydrate content when ALP was increased to 2%.

Table 2: Proximate composition of noodle samples (g/100 g, dry matter basis)

	Gross energy (kcal)	Total glycemic carbohydrates	Fat	Protein	Fiber (NDF)	Ash (%)
C	396.05 ± 0.66^{c}	83.38 ± 0.44^{a}	1.55 ± 0.13^{c}	12.15 ± 0.52^{a}	11.77 ± 3.11^{a}	2.92 ± 0^{a}
V1	409.51 ± 1.23^{ab}	81.20 ± 0.42^{a}	4.09 ± 0.25^{b}	11.98 ± 0.53^{a}	8.08 ± 3.14^{a}	2.73 ± 0^{a}
V2	411.00 ± 0.87^{ab}	79.54 ± 0.69^{b}	5.00 ± 0.17^{a}	11.96 ± 0.53^{a}	13.85 ± 1.53^{a}	3.50 ± 0^{a}
V3	407.55 ± 1.32^{b}	79.23 ± 0.70^{b}	4.57 ± 0.26^{ab}	12.38 ± 0.55^{a}	12.36 ± 0.72^{a}	3.82 ± 0^{a}

C=Control, ALP= *Amaranthus* leaf powder, V1=1%ALP, V2=2% ALP, V3=3% ALP, NDF= neutral detergent fibre. Data reported as mean ± standard deviation. Values with the same letter in a column are not statistically different

3.3 *Mineral composition*

Table 3 shows the mineral composition (individual mineral elements) of the noodle samples containing ALP compared with the control. Except for copper, which decreased when ALP was included in the noodles, ALP addition had no significant effect on the concentrations of individual mineral elements in the noodles. These results agree with the results of total mineral content (ash) of noodle samples shown in Table 1, where addition of AL up to 3% had no significant effect on the ash content of the noodle samples compared to the control.

Table 3: Mineral composition of developed instant noodles

	Zn (mg/kg)	Fe (mg/kg)	Mn (mg/kg)	Ca (mg/kg)	Mg (%)	K (%)	Na (%)	P (%)	Cu (mg/kg)
C	10.3±0.6[a]	43.7±2.5[a]	9.0±0.0[a]	0.05±0.01[b]	0.04±0.01[a]	0.26±0.04[a]	0.82±0.05[a]	0.10±0.00[a]	4.33±1.53[a]
V1	12.0±1.0[a]	39.7±5.5[a]	11.0±2.7[a]	0.08±0.03[ab]	0.05±0.02[a]	0.26±0.04[a]	0.82±0.04[a]	0.11±0.01[a]	2.67±0.60[ab]
V2	11.0±0.0[a]	40.3±4.5[a]	9.3±2.3[a]	0.06±0.02[ab]	0.04±0.01[a]	0.27±0.01[a]	0.82±0.02[a]	0.11±0.01[a]	2.00±1.00[b]
V3	12.0±2.0[a]	36.3±3.1[a]	12.0±0.0[a]	0.10±0.02[a]	0.06±0.02[a]	0.28±0.06[a]	0.80±0.03[a]	0.12±0.01[a]	2.33±0.58[b]

C=Control, V1=1%ALP, V2=2% ALP, V3=3% ALP. Data reported as mean ± standard deviation. Values with the same letter in a column are not statistically different

3.4 Physical quality

3.4.1 Texture

With regard to texture, the results revealed that instant noodles fortified with *Amaranthus* leaf powder (ALP) were softer than the control. The force required to break the noodles significantly decreased upon ALP addition from 609.08 (g) for the control to 271.39 (g) for the 3% ALP s ample. However, the differences in the force required to break noodles with ALP (1-3%) were not significant as it remained on the same level (Table 4).

Table 4: Texture of developed prototypes

Sample	Firmness (g)
C	609.08±8.71[a]
V1	285.99±3.14[b]
V2	306.42±49.84[b]
V3	271.39±64.11[b]

C-Control, V1-1%ALP, V2- 2% ALP, V3- 3% ALP *data reported as mean ± standard deviation * values with the same letter in a column are not statistically different, letter was assigned in a descending order in reference to the mean

3.4.2 Color

The CIELAB color space readings (Table 5) indicated that as more ALP is added, the noodles became greener, decreasing the lightness of the instant noodles from 71.77 (control) to 45.39 (3% ALP). Similarly, all the samples for the raw and dried noodle sheets, cooked noodles as well as the broth (with ALP addition) were greener compared to the control.

Table 5: Color readings for ALP noodles

	L*	a*	b*
Cooked strands			
C	71.77±0.04[a]	1.74±0.04[d]	28.67±0.07[c]
V1	52.22±0.02[b]	1.85±0.01[c]	30.52±0.02[a]
V2	48.56±0.04[c]	2.93±0.04[a]	29.49±0.05[b]
V3	45.39±0.02[d]	2.41±0.03[b]	29.45±0.10[b]
Broth			
C	27.83±0.10[a]	-3.15±0.08[c]	7.91±0.09[b]
V1	17.64±0.16[b]	-2.19±0.19[b]	12.47±0.93[a]
V2	15.29±0.05[c]	-2.42±0.17[b]	8.02±0.06[b]
V3	13.23±0.01[d]	-1.55±0.19[a]	12.91±0.54[a]

Wet sheets			
C	54.54±0.08^{a}	4.30±0,00^{a}	25.49±0.09^{a}
V1	44.74±0.01^{b}	3.26±0,03^{b}	25.08±0.01^{b}
V2	43.18±0.02^{c}	2.03±0,05^{c}	25.04±0.12^{b}
V3	38.26±0.03^{d}	3.26±0,04^{b}	20.83±0.07^{c}
Dry Sheets			
C	52.45±0.01^{a}	2.84±0.03^{b}	22.46±0.02^{b}
V1	49.66±0.02^{b}	2.21±0.01^{c}	24.69±0.03^{a}
V2	38.67±0.02^{d}	2.17±0.02^{c}	21.71±0.09^{c}
V3	45.45±0.01^{c}	3.08±0.03^{a}	24.67±0.08^{a}

C-Control, V1-1%ALP, V2- 2% ALP, V3- 3% ALP *data reported as mean ± standard deviation * values with the same letter in a column are not statistically different, letter was assigned in a descending order in reference to the mean

3.5 Antioxidant activity

Table 6 shows that the antioxidant activity in samples increased with the increase in the content of *Amaranthus* leaf powder in the noodles. Noodle samples without ALP as well as those with 1 and 2% ALP substitution exhibited the lowest antioxidant activity, while noodles with a 3% content of ALP exhibited the highest antioxidant activity. The differences in the DPPH radical-scavenging activity among the samples tested were not significant ($p>0.05$). The similarities in the DPPH radical-scavenging activity among these samples is attributed to the narrow range of ALP contents tested.

Table 6: 1, 1-Diphenyl-2-picrylhydrazyl (DPPH) radical-scavenging activity (EC50) evaluated in noodles with different contents of *Amaranthus* leaf powder (ALP)

Sample	RSA % (50 mg/mL)	EC_{50} (mg/mL)
C	53±0.24^{b}	22.66 ± 0.20^{b}
V1	53±0.31^{b}	25.00 ± 0.54^{bc}
V2	52±0.45^{b}	13.85 ± 0.72^{a}
V3	57±0.41^{a}	12.57 ± 0.25^{a}

C-Control, V1-1%ALP, V2- 2% ALP, V3- 3% ALP *Values indicate mean ± STD (n = 3). Different letters associated with EC50 indicate significant differences at the 5% level of significance

3.6 Consumer Acceptability

Consumer acceptability tests were used in this study to check for the degree of liking/dislike of the three sample products developed. Sensory results are represented in Table 7. Results indicates that all the sensory properties tested for samples with 1, 2 and 3% ALP were accepted in a similar way as the control except for color. The addition of ALP significantly affected the color of the fortified noodles which also lead to a decrease in acceptability to 5.47 on the hedonic scale (Neither like/dislike).

Table 7: Sensory evaluation results

Sample	Color	Aroma	Texture	Taste	Overall
C	6.67±2.12[a]	5.60±2.29[a]	6.40±2.03[a]	5.33±2.34[a]	5.68±2.27[a]
V1	6.38±1.91[ab]	5.10±2.27[a]	6.73±2.02[a]	5.55±2.90[a]	5.63±1.97[a]
V2	6.32±2.21[ab]	5.63±2.15[a]	7.00±1.87[a]	5.15±2.46[a]	5.37±2.07[a]
V3	5.47±2.22[b]	5.20±2.45[a]	6.88±1.78[a]	4.93±2.61[a]	6.67±2.14[a]

C-Control, V1-1%ALP, V2- 2% ALP, V3- 3% ALP *data reported as mean ± standard deviation * values with the same letter in a column are not statistically different, letter was assigned in a descending order in reference to the mean

4. Discussion

Although the addition of ALP slightly increased the protein content in terms of the percentage change, these changes were not significant. This may be linked to the smaller substitution ratios of *Amaranthus* leaf powder. The results indicate that, although, it was expected that increasing ALP would result in an increase in the fiber and protein content of the noodles, the ALP concentrations (up to 3%) used in this study are not adequate for improving the nutritional value of instant noodles, in terms of their protein and fibre contents. Therefore, higher concentrations of ALP are required. Similarly, although *Amaranthus* leaves are often reported high in minerals (Alegbejo, 2013, Mampholo et al., 2015, Beswa et al., 2016, Soriano-Garcia et al., 2018), the results indicate that ALP concentrations (up to 3%) used in the current study would not improve the mineral composition of instant noodles- this suggests that a higher concentration of the ALP should be added. However, due to the bitter tastes of ALP, it may be necessary to explore other options to mask the bitterness if higher concentrations of the ALP were incorporated in instant noodles. Additionally, the nutritional value of noodles is dependent on the type of ingredients used (Duda et al., 2019) and Olusanya et al. noted that increased cooking of Moringa *Olefeira* leaf powder, which is derived from a green leafy vegetable, might lead to loss of some nutrients (Olusanya et al., 2019). An assessment of the nutritional composition of leaves used is then recommended in order to fully establish the factor behind not having an improved protein content against the control as expected. Instant noodles with ALP had an improved protein fibre ash as well as fat content (Table 2) against wheat noodles tested by Sikander et al. suggesting that *Amaranthus* can potentially be used to produce nutritious instant noodles especially since protein content remained above the recommended 8% (Ginting and Yulifianti, 2015).

The increase in oil content resulted in high energy- this can be attributed to addition of ALP, which is reported to contain an average of 1.63% fat (He and Corke, 2004). The oil content of the noodles of the current study is, however, lower than that of fried noodles as reported by Qi et al. where about 15.47% oil uptake occurred when an emulsifier was added (Qi et al., 2019). In addition, when compared with the noodles investigated by Marciniak-Lukasiak et al. (2019), which had about 20.5- 30.5% fat, the fortified noodles developed in this study were lower in fat. This suggest that steaming followed by drying before cooking in broth (opposed to frying) may be recommended for preparation of noodles.

Alemayehu et al. (2016) linked a decrease in noodle texture (softening) to addition of nettle leaves powder to wheat flour, which is gluten free. However, in this study. ALP addition did not result in a significant increase in the fiber content of the noodles. Therefore, the decrease in the texture of the noodles upon addition of ALP may be linked to other factors, such as the increased fat content in the samples. Dried *Amaranthus* leaves contain fat ranging from 1.08-2.18% (He and Corke, 2004). Although this may be below the fat content of *Amaranthus* grains, it can be noted that, in this study, ALP addition corresponded with an increase in the fat content and a decrease in the texture (softening) of the noodles. In addition, Gulia and Khatkar (2013) reported that a higher mixing time was an undesirable in the preparation of noodles as it resulted in a crumblier dough with higher oil uptake and increased cooking loss which was also observed in the present study. However, softer instant noodles may be desirable to some consumers and not desirable to other consumers, because there are variations in texture preference among consumers (Gulia et al., 2014). In addition, softer noodles may serve as a specialty product for a defined group of consumers, for example individuals with swallowing difficulties and the elderly as well as toddlers.

A light and yellow color is desirable for instant noodles, however an addition of a different colored ingredient to the noodles may alter this color (Kim, 1996). The addition of green ALP significantly lead to the change in color from cream white to dark green, which can also be directly observed during production. Similar results were attained where addition of green pea flour produced pale green colored noodles and addition of Suma wheat flour also produced green colors (Adebayo et al., 2018). The green colors are attributed to the green chlorophyll pigments present in *Amaranthus* leaves. The broth color values indicated that during the cooking process there may be some attributes of the noodle strands that are lost into the broth as suggested by Gulia et al. (2014). Differences in the processing method of instant noodles may result in different effects on the color of the final product. A study on the effect of different processing methods on the color of noodles is recommended.

Antioxidants scavenge free radicals and thereby provide cellular protection and mitigate the risk of degenerative health conditions, such as cardio-vascular diseases and cancer. *Amaranthus* leaves have been suggested to possess medicinal and functional properties- they are potentially health-promoting (Ganjare and Raut, 2019, Oomen and Grubbens, 1978, Grubbens and Denton, 2004). The presence of antioxidants in the instant noodles developed in this study therefore suggests that this product has a potential to contribute to the improvement of consumer health. Fortification with *Amaranthus* was found to contribute to an increased antioxidant activity and positively contribute to reduction of stress and other postmenopausal women (Kushwaha et al., 2014). An investigation of the possible effect of

Amaranthus-fortified noodles on the overall health status is proposed and larger substitution increments are suggested.

Sensory evaluation is one of the important steps to take note of when developing a new product. The high acceptance of the samples containing up to 3% ALP suggests that the addition of ALP to the instant noodles did not compromise the overall acceptability of noodles among students although the color acceptability of this sample (noodles containing 3% ALP) was lower than the other samples. This observation is noteworthy as the color of starchy foods is known to play a significant role in their acceptability (Beswa et al., 2016). Acceptance in this case may be attributed to the familiarity of green foods arising from spinach consumption, which some consumers indicated that they were already consuming. Acceptability of texture may be linked to a lower cutting force required to break the strands that was observed during textural analysis (Table 2) as the ALP content increased. Taste and flavor need to be further developed as the addition of *Amaranthus* powder contribute a bitter taste towards the final product. This observation is contrary to sentiments expressed by the panelists in trial stages as some reported a leafy “Imifino” flavor bursting out from the samples, which was quite acceptable to them during testing.

5. Conclusions

The aim of the study was to determine the effect of adding ALP on the nutritional composition, antioxidant activity and physical quality of instant noodles. The nutritional content of all the samples had fairly acceptable levels of proteins which was good as it remained above the recommended 8%. However, noodles that were fortified with *Amaranthus* showed an increase in the energy and fat content. The texture of the instant noodles showed that with an addition of ALP the noodle strands become softer. Similarly, in terms of color the addition of ALP led to the darkening of the noodles as they become greener. This, however, did not compromise the overall acceptability of the instant noodles as the sample with 3% ALP was liked the most by panelists. The product however still requires improvement in terms of taste and flavors and greater nutritional benefits might be derived from higher ALP increments. This study suggests that *Amaranthus* leaf powder-fortified noodles could be as acceptable as the control. The innovation could be complemented with product promotional campaigns on new food consumption and further product development is recommended to improve the overall quality of the ALP-fortified noodles. The study also proposes that an instant noodle sachet made from *Amaranthus* leaves is developed to complement the ALP-fortified noodles and improve color, flavor and aroma. This will be in line with the Philippines who have opted to fortify the noodle seasoning rather than the flour to get a more packed flavor of the seasoning (Gulia et al., 2014). In addition, ALP, if added in high amounts leads to bitterness. However, a sachet made from cooked leaves (in the traditional method that also involves addition of peanuts) in a form of a relish to form a sauce or dried into a powder has potential to bring in the more flavorful element of *Amaranthus* which could improve the taste and aroma with potential nutritional benefits.

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