World Applied Sciences Journal 39 (1): 44-55, 2021
ISSN 1818-4952

DOI: 10.5829/idosi.wasj.2021.44.55

Using Vegetable Powders as Natural Colorants to Produce Functional Macaroni

[1]Marwa Fawzi Ahmed El-Farsy, [1]Samia El-Safy F. and [2]Abo El-Naga, M.M.

[1]Food Science and Technology Department,
Faculty of Home Economic, Al-Azhar University, Tanta, Egypt
[2]Food Technology Research Institute, Agricultural Research Center, Giza, Egypt

Abstract: Currently, the demand for healthy foods has increased to prevent disease and improvements include ingredients that have health effects, such as dried vegetable powders. The study was carried out to produce health and functional macaroni by substituted wheat flour with vegetable powders as natural colorants components. Macaroni from blend of wheat flour (72%) supplemented with tomato powder (Tp), red pepper powder (Pp), carrot powder (Cp), turmeric powder (Tup), roselle powder (Rp) and spinach leaves powder (Sp) (at 5 and 10%) was prepared as natural source of color for producing healthy and functional macaroni. The macaroni samples were stored at ambient temperature for 6 months. The prepared macaroni was evaluated for its chemical composition, cooking quality, textural, color, microbiological aspects and sensory attributes. The results of chemical and nutritional quality characteristics of macaroni showed that fiber and ash were higher in macaroni supplemented with vegetable powder compared to control sample. Cooking time increased from 4.46 (in control) to 9.82 min (in macaroni supplemented with 10%Tup) and cooking loss (CL) increased from 3.58 to 7.53%. Macaroni with 10% Sp recorded the highest values of volume, weight increase and water absorption (160.48, 138.09 and 180%, respectively). The lightness (L*) value of supplemented macaroni decreased with the incorporation of vegetable powders, from 64.65 (control sample) to 34.70 (in formula contain 10% Rp) and from 73.05 (control) to 30.41 (10% Rp) for uncooked and cooked samples, respectively, whereas the color parameters changed during storage at ambient temperature. The addition of vegetable powders influenced the macaroni color, decreasing the L* and a* and increasing b*. The sensory evaluation showed that the macaroni substitute with vegetable powders had higher score than the control sample ($p \leq 0.05$); color, flavor, taste, texture and overall acceptance. All macaroni samples had a high overall acceptability, particularly at 5 and 10% red pepper and 10% tomatoes powder. Utilization of vegetable powders enhanced the color of macaroni samples compared with control. Incorporation of such ingredients in macaroni increases the nutritional as well as functional properties.

Key words: Natural colorants · Macaroni · Vegetable powders · Nutritional composition · Color parameter · Texture analysis · Sensory quality

INTRODUCTION

In recent years, consumers are averting foods containing artificial colorants by reason of associations with possible harmful effects to human health. As a result, food industries have been substituting them by natural pigments and there is a risen world-wide trend towards usage of natural colors in food industries [1]. Natural colored pigments from plant products have drawn a great attention in all worldwide because of its benefits in the food colorant processing manufacture. These pigments display various colors and are made up of different phytochemicals commonly found in the food matrix such as orange (β-carotene), yellowish - green (lutein), green (chlorophyll) and blue-purple (anthocyanin) [2, 3].

Consumer perception has been that natural food colorant ingredients would be safer, healthful and considered as potential food colorants for preparing hard candy and Jellies [4]. Most often, the colorants are extracted from plant material, but other sources such as insects, algae and fungi are used as well [5].

Corresponding Author: Samia El-Safy F., Food Science and Technology Department,
Faculty of Home Economic, Al-Azhar University, Tanta, Egypt.

The advantages of using natural colorants are many as they are eco-friendly, safe for body contact, unsophisticated and harmonized with nature, obtained from renewable sources and also their preparation involves a minimum possibility of chemical reactions. Generally natural dyes do not cause health hazards; on the contrary, they sometimes act as health cures like turmeric and annatto etc. Furthermore, the use of natural dyes offers no disposal problems [6].

Tomato (*Lycopersicon esculentum*) is an important agricultural commodity containing high concentration of lycopene. It is regarded as an important contributor of carotenoids to human diet [7].

Red pepper (*Capsicum annuum* L.) is widely used as a savory food additive and food ingredient to provide spicy flavor and attractive color to food preparations and products [8]. Red color is one of the most important quality parameters of red pepper which is due to the high content of carotenoids, i.e., capsanthin and capsorubin, which provide the red color, violaxanthin; capsanthin-5, 6-epoxide, zeaxanthin, lutein, β-cryptoxanthin and β-carotene providing the yellow orange color [9]. Red pepper is also an excellent source of vitamin C and polyphenols [10], it is now considered a functional food and an important source of natural pigments to replace artificial colorants in foodstuffs [11].

Turmeric, the rhizome of the herb *Curcuma longa* L., with strong flavor and yellow color, contains turmerin, essential oils and curcuminoids (phenolic compounds) (strong antioxidants) [12]. Curcumin, the major coloring principal present in turmeric, can be extracted and used as a natural food color [13].

Carrot (*Daucus carota* L.) is one of the most valuable vegetables and it is an important source of nutritional compounds, such as carotenoids, vitamins [14]. The color of carrot roots gradates among white, yellow, orange, purple and red. Carotenoids content varies highly among carrot genotypes [15].

Pasta is one of the most popular cereal products in the world. Its main advantages are versatility, ease of preparation, low price and long shelf life [16]. In recent years, consumption of pasta has been steadily increasing. This creates a possibility to produce new types of pasta, for example enriched with unconventional raw materials. Pasta is a one among the ready to cook cereal food that comprises spaghetti, noodles, vermicelli, etc., due to easy convenience and palatability. The long shelf life and the short time of preparing meals as well as the variety of forms and shapes are the main advantages of this product. Pasta is usually made from durum semolina or/and common wheat flour [17]. The competitiveness of pasta can be increased by using various vegetable additives as fresh or partially dried pulp, dry powder or dry concentrate [18].

In addition to natural dyes, vegetable raw materials are rich sources of dietary fiber, mineral compounds and biologically active sub-stances (phenolic compounds, glucosinolates, vitamin C and tocopherols) that play an important role in pre-venting oxidative stress and chronic diseases [19, 20]. The pasta fortified with edible vegetable flour can greatly enhance the nutritional value of the food [21]. The competitiveness of pasta can be increased by using various vegetable additives as fresh or partially dried pulp, dry powder or dry concentrate [22, 23]. These types of raw materials are used in the production of various food products as natural colouring, flavouring and fragrance components.

Addition of vegetables and fruits to pasta can contribute to a natural attractive look, new tastes and a sense of a complete meal with all the goodness of the vegetables and fruits that have been incorporated. Conventional vegetable pastas, such as spinach and tomato-containing pastas, consist mainly of wheat flour with about 3 to 3.5 percent by weight or less vegetable solids and tend to change in color and flavor during processing, storage and upon cooking [24].

Thus, the objective of this study was the development of functional macaroni with partial substitution of the wheat flour for different vegetable powders as natural colorant and evaluates the influence of this substitution on macaroni quality.

MATERIALS AND METHODS

Materials:

- Strong wheat flour (72% extraction) was obtained from Ibn El-Khatab Comp., Gharbia Governorate, Egypt.
- Tomato fruits, red sweet pepper fruits, carrot root and spinach leaves were obtained from local market and dried in oven at 50°C for 4 hours. Turmeric rhizomes and roselle calyces were obtained from El-Mostafa Comp., Tanta city, Egypt.

Methods

Preparation of Raw Materials: Vegetable materials (tomatoes fruits, sweet red pepper fruits, carrot root and spinach) were cleaned for removing impurities, washed with tap water and cut into slices (1/2cm) 5 mm thickness

using fruit slicer for uniform sizes and dried in oven (UNOX (XBC60S, Italy) at 60°C for 24 hrs while spinach leaves after cleaned and washed with tap water were cut into small spices then dried in shadow in good air condition. The dried vegetables, rosella and turmeric rhizomes were ground to a powder using blender (Moulinex, France) and then sieved through, standard sieve mesh size 60. The powders were kept in tight polyethylene bags and stored at (-18°C)

Processing Macaroni Supplemented with Vegetable Powders: Macaroni was processed by using a Demaco (DE Francis machine corporation, Germany) semi commercial scale laboratory extruder according to the method described by Dexter *et al.* [25].

Initially 1000 grams of wheat flour (72 % extraction) as well as the different blends containing different levels of vegetable powders (0, 5 and 10%) were premixed at low speed in a Hobart Model G100 mixer, with gradual addition of distilled water. Mixing had been continued at moderate speed for eight minutes then the addition of water was completed. The premixed dough was then placed in the vacuum mixer of the Demco extruder to complete mixing of the blend, after which the dough was kneaded through two kneading plates to obtain homogeneous dough. The homogenous dough was then extruded through the dies under pressure and finally passed through the cutting machine.

Cooking Quality

Cooking Time: Optimum cooking time of macaroni was evaluated according to method of Singh *et al.* [26]. Five gram of macaroni sample was inserted in a beaker containing 75 ml distilled water and one strip was crushed between two glasses in every 30s. The cooking sample was continued until white fraction in control core of crushed macaroni was disappeared and time that was recorded as optimum cooking time.

Cooking Loss: Cooking loss was evaluated according to method of Ozkaya and Kahveci [27]. Ten gram macaroni sample was cooked for 4 min in 300 ml boiling water then drained. The drained liquor was evaporated to dryness and weight the cooking loss was calculated as:

$$Cooking\ loss\ \% = \frac{Weight\ of\ residues\ in\ cooking\ water}{Weight\ of\ uncooked\ sample} \times 100$$

Volume Increase: Volume increase was evaluated according to method of Ozkaya and Kahveci [27]. Twenty five gram sample was cooked in 500 ml beaker containing 250 ml boiling water on the basis of their optimum cooking time, rested for 5 min and transferred to a beaker fulfilled with 250 ml water. The same producer was repeated for uncooked macaroni as well. The percent volume increase was calculated on the basis of difference between the volume of over flowed water for cooked and uncooked macaroni.

$$\text{Volume increase } \% = \frac{Volume\ of\ cooked\ sample - Volume\ of\ uncooked\ sample}{Volume\ of\ uncooked\ sample} \times 100$$

Weight Increase: Weight increase was evaluated according to method of Ozkaya and Kahveci [27]. Ten gram sample was cooked in 300 ml boiling water for 4 minutes. After cooking the samples were drained, rinsed and weighted the weight increased percentage was calculated as the following equation:

$$\text{Weight increase } \% = \frac{Weight\ of\ cooked\ sample - Weight\ of\ uncooked\ sample}{Weight\ of\ uncooked\ sample} \times 100$$

Water Absorption: The water absorption of cooked macaroni was determined by AACC [28].

$$\text{Water absorption } \% = \frac{Weight\ of\ cooked\ macaroni - Weight\ of\ raw\ macaroni}{Weight\ of\ raw\ macaroni} \times 100$$

Chemical Analysis: The proximate composition (moisture, ash, ether extract, crude protein and crude fiber were determined according to the methods of AOAC [29]. The total carbohydrates were determined by difference method using given formula:

Total carbohydrates (%) = 100 - moisture (%) – protein content (%) - crude fat (%) - ash (%) [30].

Texture Profile Analysis: Texture profile Analysis (TPA) was determined according to the method of Bourne [31] as described follow: samples were formed to 50mm diameter cylinder with 40mm height and texture was determined by a universal testing machine (Cometech, B type, Taiwan) provided with software. An aluminum 25 mm diameter cylindrical probe was used in a TPA double compression test to penetrate to 50% depth at 1mm/S speed test. Hardness (N), Gumminess (N), Chewiness (N), Cohesiveness, Springiness (N) and resilience were calculated from the TPA graphic. Both springiness and resilience give information about the after stress recovery capacity. But, while the former refers to retarded recovery, the lather concerns instant anew recovery (immediately after the first compression, while the probe goes up).

Color Measurement: Objective evaluation color of macaroni samples were measured by Hunter L*, a* and b* parameters were measured with a color difference meter using a spectrocolorimeter with the CIE lab color scale (Hunter, Lab Scan XE - Reston VA, USA) in the reflection mode [32]. Microbiological attributes of macaroni

Total bacteria count (TBC) and yeast and molds (Y and M) were evaluated periodically in different substituted macaroni during different storage periods for three weeks. All plates were incubated at 37°C for 48 h for TBC while at 28°C for 3-5 days for Y and M. All microbiological examinations were performed in triplicates and determined at zero time, 7, 15 and 21 days, respectively according to the procedures described by Difco Manual [33].

Sensory Evaluation: Sensory evaluation of cooked macaroni samples were carried out by 10 person of the department's staff, Faculty of Home Economic, Al-Azhar University, the person were asked to evaluate color, taste, odor, texture and overall acceptability for macaroni using 10 hedonic scale as described by Pinarli *et al.* [34].

Statistical Analysis: Statistical analysis for data obtained was subjected to analysis of variance according to SPSS [35]. Significant differences among individual means analyzed by Duncans multiple range tests [36].

RESULS AND DISCUSSION

Chemical Composition (%) of Raw Materials: Chemical compositions of wheat flour (72%) and different plant powders are presented in Table (1). The obtained results revealed that spinach leaves powder (Sp) and wheat flour recorded the highest crude protein content being 19.66 and 11.98%, respectively, while tomato powder had lower crude protein content being 4.10 %. On the other hand, the highest value of ether extract was recorded for tomato powder, followed by spinach powder and turmeric powder being 6.25, 6.11 and 3.80 %, respectively. Meanwhile, roselle powder (Rp) had the lowest ether extract value being 0.29%. Spinach powder (Sp) contained the highest ash content 19.86 % followed by tomato powder 13.10% and roselle powder 11.02 %. While the wheat flour (72 % ext.) had the lowest ash content being 0.80 %.

Turmeric powder contained the highest crude fiber content 18.00 % followed by spinach powder 14.80 % and roselle powder 12.29 %. Meanwhile, wheat flour (72 % ext.) had the lowest crude fiber content being 0.83 %.

Proximate Composition of Macaroni Supplemented with Vegetable Powders: Data in Table (2) shows the effect of incorporation of plant powders at different ratios (0, 5 and 10%) on proximate chemical composition of macaroni. The obtained results indicated that moisture content of macaroni increased from 12.16% in control sample to 12.47% and 12.29% in macaroni contained 5 and 10% Pp. The moisture content increased in all blends except for macaroni prepared with Cp and Sp which slightly decreased from 12.16% in control sample to 12.09 and 11.94% in macaroni with 10% Cp and 10% Sp, respectively.

The highest value of protein content was observed in macaroni with Sp (12.40% and 12.74% with 5 and 10% Sp, respectively), followed by control sample (12.00%) and Cp which recorded 11.81 and 11.89% for 5 and 10% Cp, respectively. Incorporation spinach powder not only as natural colorant in macaroni but also enhanced or improved the protein content and nutritive value of prepared macaroni. The results are agreement with Galla *et al.* [37] who reported that increasing addition of spinach (5 – 15%) shown good enhancement in protein, minerals and fiber in biscuits compared to control.

The total ash content was increased from 0.49% in control sample to 2.39% with incorporation of 10% Sp, which might be increasing the mineral contents of the macaroni, resulted from relatively higher mineral contents of spinach leaves. Also, fiber contents significantly ($p<0.05$) increased in macaroni dependent manner with vegetable powders incorporation from 0.49 to 2.39%, 1.85 to 2.27% in 10% Sp and 10% Tp, respectively. Therefore, different vegetable powders can be used not only to enhance the nutritional value of macaroni, but also as natural coloring ingredients define attractive color.

Effect of Supplementation with Vegetable Powders on the Cooking Quality of Macaroni: Quality of macaroni could be estimated from cooking attributes such as cooking loss, weight increase and volume increase. The cooking quality of macaroni prepared from the different ratios of vegetable powders was determined. Data in Table (3) showed that cooking time increased as incorporated plant powders. The highest cooking time was found in macaroni incorporated with 10% Tup (9.82 min) and 5% Tup (8.50 min) followed by macaroni with 10% Sp (7.34 min) compared with the control sample (4.46 min). Similar results observed by Chhikara *et al*., [38] who reported that addition of beetroot pulp in noodles progressively increased cooking time due to lower rate of water absorption as there is a competition between protein (gluten), starch granules and fibers for absorption of water.

Table 1: Proximate chemical composition of wheat flour and different vegetable powders (% on dry weight basis)

Constituents (%)	WF (72%)	Tp	Pp	Tup	Cp	Rp	Sp
Moisture	11.00±0.04^{f}	12.19±0.01^{d}	15.66±0.03^{a}	12.39±0.07^{c}	11.62±0.06^{e}	12.93±0.02^{b}	7.17±0.09^{g}
Crude protein	11.98±0.02^{b}	4.10±0.05^{a}	8.0±0.04^{d}	7.31±0.03^{e}	10.64±0.07^{c}	6.65±0.06^{f}	19.66±0.01^{a}
Ether extract	1.89±0.06^{d}	6.25±0.07^{a}	0.47±0.09^{e}	1.98±0.02^{d}	3.80±0.01^{c}	0.29±0.04^{f}	6.11±0.08^{b}
Ash	0.80±0.05^{g}	13.10±0.08^{b}	6.00±0.01^{f}	8.27±0.09^{d}	6.70±0.04^{e}	11.02±0.07^{c}	19.86±0.02^{a}
Crude fiber	0.83±0.01^{g}	10.07±0.02^{d}	8.33±0.05^{e}	18.00±0.04^{a}	8.15±0.03^{f}	12.29±0.08^{c}	14.80±0.06^{b}
Carbohydrates	73.50±0.07^{a}	54.29±0.03^{e}	61.54±0.06^{b}	52.05±0.05^{f}	59.09±0.02^{c}	56.82±0.01^{d}	32.40±0.04^{g}
Energy	358.93±0.03^{a}	289.81±0.04^{c}	282.39±0.02^{d}	225.26±0.01^{g}	313.12±0.05^{b}	256.49±0.09^{f}	263.23±0.07^{e}

where: Tp = tomato powder Pp = pepper powder Tup = turmeric powder
Cp = carrot powder Rp = rosella powder Sp = spinach powder
Values are means ± Standard deviation of triplicate trials
In a row, means ± having the same superscript letters are not significantly different at 5% level. DWB = Dry weight basis

Table 2: Chemical composition (%) of macaroni supplemented with vegetable powders

Treatments	Moisture	Crude protein	Ether extract	Ash	Crude fiber	Available Carbohydrates	Energy
Control	12.16 ± 0.1^{cd}	12.00 ± 0.4^{c}	1.85± 0.6^{cd}	0.49± 0.3	0.85± 0.5^{i}	72.65± 0.1^{a}	348.58± 0.2^{abcd}
5 % Tp	12.16 ± 0.3^{cd}	11.59 ± 0.1^{g}	2.03± 0.4^{b}	1.09± 0.6	1.31± 0.7^{g}	71.82± 0.3^{e}	351.91± 0.6^{ab}
10 % Tp	12.16 ± 0.2^{cd}	11.18 ± 0.5^{h}	2.27± 0.3^{a}	1.70± 0.4	1.77± 0.8^{de}	70.92± 0.1^{j}	348.83± 0.3^{abcd}
5 % Pp	12.29 ± 0.5^{b}	11.82 ± 0.3^{de}	1.76± 0.7^{def}	0.74± 0.1	0.92± 0.3^{i}	72.47± 0.8^{b}	353.00± 0.5^{a}
10 % Pp	12.47 ± 0.7^{a}	11.64 ± 0.2^{f}	1.70± 0.5^{fg}	1.01± 0.8	1.84± 0.4^{d}	71.34± 0.4^{h}	347.22± 0.6^{abcd}
5 % Tup	12.20 ± 0.6^{c}	11.74 ± 0.9^{e}	1.83± 0.3^{cde}	0.85± 0.2	1.69± 0.1^{e}	71.69± 0.9^{f}	350.19± 0.2^{abcd}
10 % Tup	12.22 ± 0.4^{bc}	11.55 ± 0.7^{g}	1.85± 0.1^{cd}	1.24± 0.3	2.54± 0.5^{a}	70.60± 0.4^{l}	345.25± 0.7^{d}
5 % Cp	12.09 ± 0.9^{d}	11.89 ± 0.2^{d}	1.91± 0.8^{c}	0.84± 0.4	1.19± 0.7^{h}	72.08± 0.6^{c}	353.07± 0.9^{a}
10 % Cp	11.99 ± 0.4^{e}	11.81 ± 0.6^{de}	2.01± 0.2^{b}	1.09± 0.5	1.55± 0.3^{f}	71.55± 0.7^{g}	351.53± 0.2^{abc}
5 % Rp	12.18 ± 0.8^{cd}	11.76 ± 0.5^{e}	1.75± 0.7^{ef}	0.98± 0.3	1.39± 0.2^{g}	71.94± 0.5^{d}	350.55± 0.3^{abcd}
10 % Rp	12.21 ± 0.1^{bc}	11.51 ± 0.3^{g}	1.64± 0.5^{g}	1.49± 0.7	1.96± 0.9^{c}	71.19± 0.2^{i}	345.56± 0.5^{cd}
5 % Sp	11.94 ± 0.3^{e}	12.40 ± 0.6^{b}	2.02± 0.2^{b}	1.41± 0.4	1.51± 0.7^{f}	70.72± 0.3^{k}	350.66± 0.1^{abcd}
10 % Sp	11.71 ± 0.1^{f}	12.74 ± 0.2^{a}	2.25± 0.6^{a}	2.39± 0.8	2.22± 0.3^{b}	68.69± 0.1^{m}	345.97± 0.4^{bcd}

where: Tp = tomato powder Pp = pepper powder Cp = carrot powder
Tup = Turmeric powder Rp = rosella powder Sp = spinach powder
Values are means ± Standard deviation of triplicate trials
In a row, means ± having the same superscript letters are not significantly different at 5% level. DWB = Dry weight basis

Table 3: Cooking quality of macaroni prepared with vegetable powders

Treatments		Cooking time (min)	Cooking loss (%)	Volume Increase (%)	Weigh Increase (%)	Water absorption (%)
Control		4.46± 0.03^{k}	3.58± 0.08^{l}	125.39± 0.01^{m}	79.96± 0.05^{m}	125± 0.07^{k}
Tp	5%	5.43± 0.05^{gh}	5.39± 0.02^{h}	132.95± 0.06^{j}	114.29± 0.03^{g}	135± 0.04^{i}
	10%	6.02± 0.02^{f}	5.86± 0.07^{g}	141.67± 0.04^{g}	130.23± 0.01^{b}	142± 0.06^{g}
Pp	5%	5.30± 0.04^{i}	4.29± 0.01^{k}	138.04± 0.07^{i}	108.33± 0.06^{i}	140± 0.08^{h}
	10%	5.50± 0.06^{g}	4.92± 0.03^{i}	149.05± 0.02^{d}	125.00± 0.09^{c}	150± 0.05^{f}
Tup	5%	8.50± 0.01^{b}	6.88± 0.05^{d}	138.51± 0.03^{h}	104.40± 0.07^{j}	152± 0.03^{d}
	10%	9.82± 0.08^{a}	7.53± 0.02^{a}	157.80± 0.06^{b}	114.68± 0.03^{f}	163± 0.02^{b}
Cp	5%	5.12± 0.03^{j}	4.45± 0.07^{j}	132.61± 0.01^{k}	119.62± 0.05^{e}	140± 0.06^{h}
	10%	5.38± 0.07^{h}	4.97± 0.03^{i}	149.61± 0.05^{c}	123.81± 0.04^{d}	151± 0.09^{e}
Rp	5	6.47± 0.02^{e}	6.22± 0.05^{f}	128.82± 0.08^{l}	99.72± 0.02^{k}	134± 0.01^{j}
	10	7.00± 0.06^{d}	7.19± 0.01^{c}	143.80± 0.03^{f}	111.12± 0.09^{h}	142± 0.07^{g}
Sp	5	7.05± 0.01^{d}	6.39± 0.04^{e}	146.61± 0.02^{e}	95.24± 0.07l	160± 0.05^{c}
	10	7.34± 0.05^{c}	7.35± 0.07^{b}	160.48± 0.01^{a}	138.09± 0.04^{a}	180± 0.02^{a}

where: Tp = tomato powder Pp = pepper powder Tup = Turmeric powder
Cp = carrot powder Rp = rosella powder Sp = spinach powder
Values are means ± Standard deviation of triplicate trials
In a row, means ± having the same superscript letters are not significantly different at 5% level

From the same table, the highest cooking loss was observed in macaroni contain 10% Cup and 10% Sp which recorded 7.53 and 7.35%, respectively. Also, macaroni prepared with 10% Rp had a higher increased in cooking loss (7.19%) compared with control sample (3.58%). Similar results were observed by Getachew and Admassu [39] who reported that cooking loss was increased as incorporation level of dried moringa leaves and oat flour is increasing. This could be due to weak bonding network formation occurred in chemical composition which

encapsulate them during cooking as oat and moringa leaves flour have lower gluten content. Cooking loss is related to the leakage of amylose from the starch granules, during cooking, which results in an unpleasant sticky texture [40].

Volume increase % and weight increase % of macaroni prepared from vegetable powders were higher than control. The volume and weight increase of supplemented macaroni ranged from 125.39 to 160.48% and from 79.96 to 138.09%, respectively.

Carrot Powder incorporated pasta showed highest increase in the cooking loss which might be due to the presence of sugars and fiber which have high affinity for water resulting in the partial development of gluten network [41].

Vegetable macaroni samples had more water absorption with maximum for spinach powder (180) and minimum for control sample (125). This substantial increase in water absorption is due to an increase in fiber content of resultant pasta and strong water binding ability of fiber [16].

Effect of Supplementation with Vegetable Powders on the Color of Macaroni

Color of Macaroni: The color parameters of uncooked and cooked supplemented macaroni with different vegetable powders, given as L* value (lighthness or brightness), a* value (greenness to redness) and b * value (blueness to yellowness) were measured in uncooked and cooked macaroni samples (Table 4). From the data, it could be noticed that uncooked and cooked macaroni enriched with vegetable powders showed lower lightness (L*) value than control macaroni which implies their darker appearance as compared to control. The highest L* value was found in 10% Cp (57.16) and lowest in 10% Rp macaroni (34.70).

After cooking the coloring of the macaroni became darker. The increase of redness parameter (a*) in uncooked and cook macaroni supplemented with vegetable powders showed increase compared to control samples (Table 4). Uncooked pasta with spinach showed intensive green color as seen by negative a* value that indicates green shade opposite to carrot, beetroot and tomato supplemented pasta [22].

However, the values of redness and yellowness were found higher in macaroni containing tomato powder (Tp) and turmeric powder Cup) when compared to control. The most of studies of the color measurements on enriched pasta were performed on uncooked pasta, but it remains unclear whether the color of the pasta before or after cooking has the most significant impact on consumer perception of the pasta [40].

Difference in the color characteristics of macaroni could be attributed due to presence of different colored pigments in respective flour/powder. Also, non-enzymatic browning and pigment destruction induced the color change during extrusion cooking [42].

Uncooked and cooked spinach macaroni had green color as seen from negative a* that indicates green shade. These values indicated that the supplemented macaroni had green natural colour of spinach used. The color of cooked sample was slightly less green than corresponding uncooked sample. Leaching of color during cooking was almost negligible and all noodles had attractive green color after cooking also. The results of present investigation were in accordance with the finding of Rekha *et al*. [22].

Regarding b* values, it could be noticed that b* values of macaroni formulations with vegetable powders, increased compared with control except for macaroni supplemented with Rp and Sp. In this respect, Svec *et al*. [43] reported that color changes in pasta formulations depend on intrinsic characteristics of the original food matrix utilized for the wheat flour replacement. Similary to our results, a* and b* values were increased, while L* values were decreased in dry pasta added with lentil and yellow pea flour [44].

Color values of instant noodles substituted with pumpkin powder at 0, 5, 10, 15 and 20% were significantly different ($p \leq 0.05$). Wheat flour noodle was light-yellow, whereas, PP noodles were dark-yellow to brown. The addition of PP at higher levels resulted in decreasing L* values and increasing a* and b* values (Table 4).

Storage period of 0 – 6 months resulted in decrease in L* value while, a decrease in a* and b* values was observed in all the macaroni samples.

Texture Profile Analysis of Macaroni Prepared from Vegetable Powders as Natural Colorant: Textural properties are the most critical characteristic when assessing quality and consumers' acceptance of cooked noodles [45]. The texture profile of the vegetable powders supplemented macaroni is presented in Table 4. From the obtained data, the highest and lowest values for hardness were observed in 10% Tup (21.68 N) and 5% Cp (11.27 N), respectively. The increase in the hardness of macaroni supplemented with turmeric and carrot powders may be due the increase in the amount of fiber compared to control.

Table 4: Color measurements of macaroni supplemented with vegetable powders

Treatments		Storage period (month)											
		0	2	4	6	0	2	4	6	0	2	4	6
		Before Cooking											
		L*				a*				b*			
Control		64.65	64.38	58.44	58.42	3.94	3.88	3.71	3.69	22.23	22.10	20.29	203.20
Tp	5	55.13	55.15	55.15	55.17	12.73	12.66	11.58	11.56	27.81	27.56	27.31	27.27
	10	53.81	53.77	55.09	55.11	13.82	13.69	12.21	12.0	29.92	29.57	29.26	29.26
Pp	5	46.82	47.65	49.67	49.69	25.31	25.19	23.82	23.77	33.11	32.94	30.37	30.32
	10	48.11	48.25	48.31	48.81	26.00	25.16	23.87	23.82	34.07	33.96	31.56	31.49
Tup	5	54.93	55.09	55.70	55.73	9.32	9.40	9.45	9.46	48.91	49.09	49.82	49.77
	10	55.24	55.44	55.45	55.83	10.17	10.37	11.08	11.11	50.23	50.43	50.81	50.99
Cp	5	56.05	56.23	57.54	57.55	11.23	10.98	9.65	9.56	28.84	28.58	28.52	28.26
	10	57.16	57.34	58.67	58.68	11.49	11.19	9.10	9.02	29.03	28.87	27.38	27.17
Rp	5	44.97	45.18	46.86	46.88	17.02	17.12	15.50	15.48	5.10	5.05	4.82	4.76
	10	34.70	34.96	37.13	37.16	22.30	21.87	19.76	19.68	3.75	3.59	3.58	3.26
Sp	5	37.31	37.58	39.89	39.91	-0.30	-0.33	0.03	0.01	15.53	15.20	13.71	13.64
	10	38.23	38.41	38.54	38.51	-0.81	-0.88	-0.45	-0.47	14.73	14.50	13.07	13.01
		After Cooking											
		0	2	4	6	0	2	4	6	0	2	4	6
Control		73.05	72.61	67.23	66.38	0.75	0.77	0.90	1.57	15.71	15.44	14.56	13.48
Tp	5	46.22	46.52	53.19	54.41	13.99	13.91	12.27	7.55	25.30	25.61	26.12	30.52
	10	41.84	42.02	45.41	53.66	16.89	16.58	14.06	9.90	26.05	26.25	28.73	29.65
Pp	5	41.25	41.43	44.20	46.52	21.90	22.05	23.58	24.33	30.51	30.84	32.93	34.09
	10	39.20	39.51	41.06	43.74	23.74	23.83	23.84	23.89	32.20	32.34	33.76	36.14
Tup	5	49.14	48.78	48.51	44.34	14.34	14.14	10.70	10.28	39.21	39.42	41.71	42.37
	10	53.00	52.49	51.58	48.86	15.77	15.32	14.99	13.50	44.91	45.15	53.10	55.87
Cp	5	56.03	56.45	59.26	65.10	6.83	6.53	5.45	5.17	22.15	22.15	22.79	24.32
	10	52.83	53.25	57.61	63.72	9.63	9.24	7.71	6.98	22.97	23.35	25.31	29.92
Rp	5	43.99	42.40	33.95	28.66	16.51	16.17	15.24	13.14	5.26	5.41	6.15	6.20
	10	30.41	30.66	28.73	23.74	20.19	20.64	19.29	18.44	6.03	6.29	7.69	9.45
Sp	5	35.89	36.58	38.68	48.20	-1.30	-1.41	-1.01	0.05	15.80	15.49	15.22	14.58
	10	31.54	31.84	34.07	37.09	-2.02	-2.0	-1.08	-0.96	20.71	20.31	14.53	13.70

where: Tp = tomato powder Pp = pepper powder Tup = Turmeric powder
Cp = carrot powder Rp = rosella powder Sp = spinach powder

Table 5: Texture profile analysis (TPA) of macaroni incorporated with different ratios of vegetable powders

Treatments	%	Hardness (N)	Adhesiveness (mj)	Springiness (mm)	Gumminess (N)	Chewiness (mj)	Resilience	Cohesiveness
Control		11.83	0.63	0.58	5.74	3.30	0.14	0.49
TP	5	12.70	0.50	0.30	0.55	3.820	0.41	0.28
	10	15.19	0.60	0.49	6.53	4.20	0.17	0.43
PP	5	11.94	0.56	0.48	6.23	3.60	0.19	0.36
	10	12.33	0.60	0.55	8.05	5.20	0.19	0.37
Tup	5	17.13	0.20	0.35	3.91	3.40	0.12	0.34
	10	21.68	0.50	0.39	1.14	4.88	0.52	0.11
CP	5	11.27	0.40	0.25	3.88	3.20	0.49	0.43
	10	12.86	0.50	0.33	3.49	4.50	0.53	0.48
Rp	5	12.91	0.30	0.40	10.23	3.00	0.25	0.32
	10	13.65	0.40	0.43	7.01	8.20	0.21	0.41
SP	5	14.64	0.30	0.39	5.79	2.30	0.11	0.35
	10	16.64	0.50	0.50	11.87	10.70	0.14	0.41

Table 6: Microorganisms count of macaroni incorporated with vegetable powders during storage period at room temperature for 6 months (CFU/g × 10^2)

	Storage periods (month)				
Treatments	0	2	4	6	Mean
			Total plat count		
Control	15.0± 0.06	16.7± 0.02	18.3± 0.04	20.0± 0.07	17.5000[a]
5% Tp	10.0± 0.04	11.33± 0.01	12.67± 0.05	14.7± 0.02	12.1750[e]
10% Tp	8.3± 0.03	9.7± 0.05	11.6± 0.01	13.33± 0.04	10.7325[g]
5% Pp	12.3± 0.01	13.6± 0.02	15.3± 0.06	17.0± 0.07	14.5500[b]
10% Pp	11.7± 0.08	13.0± 0.04	14.6± 0.02	17.3± 0.08	14.1500[c]
5% Tup	6.7± 0.06	7.7± 0.03	9.3± 0.07	10.3± 0.01	8.5000[i]
10% Tup	2.3± 0.04	3.6± 0.05	5.7± 0.03	6.7± 0.06	4.5750[j]
5% Cp	9.3± 0.07	11.0± 0.01	12.6± 0.05	14.3± 0.03	11.8000[e]
10% Cp	8.0± 0.04	9.7± 0.02	11.3± 0.07	13.0± 0.01	10.5000[g]
5% Rp	7.3± 0.02	8.7± 0.04	10.6± 0.06	12.0± 0.07	9.6500[h]
10% Rp	5.7± 0.06	7.0± 0.03	9.3± 0.01	10.7± 0.05	8.1750[i]
5% Sp	11.0± 0.03	12.3± 0.06	15.0± 0.09	16.7± 0.01	13.7500[d]
10% Sp	8.6± 0.01	10.0± 0.05	12.33± 0.07	14.33± 0.03	11.3150[f]
			Moulds and yeasts		
Control	2.7± 0.02	5.0± 0.05	5.33± 0.07	8.66± 0.03	5.4225[a]
5% Tp	2.3± 0.04	3.0± 0.01	3.67± 0.03	4.33± 0.06	3.3250[d]
10% Tp	1.67± 0.05	2.33± 0.03	2.33± 0.01	3.0± 0.07	2.3325[fg]
5% Pp	2.0± 0.01	2.0± 0.06	3.33± 0.04	4.0± 0.05	2.8325[e]
10% pp	1.0± 0.09	1.67± 0.07	2.67± 0.03	4.0± 0.08	2.3350[fg]
5% Tup	0.67± 0.01	1.0± 0.04	1.67± 0.05	2.3± 0.01	1.4100[h]
10% Tup	0.33± 0.02	1.0± 0.02	1.33± 0.07	2.0± 0.04	1.1650[h]
5% Cp	2.3± 0.03	3.0± 0.01	4.33± 0.06	6.67± 0.05	4.0750[c]
10% Cp	2.0± 0.05	2.67± 0.03	4.0± 0.01	5.33± 0.07	3.5000[d]
5% Rp	1.0± 0.08	1.67± 0.05	3.0± 0.07	4.66± 0.06	2.5825[ef]
10% Rp	0.67± 0.02	0.67± 0.02	2.33± 0.04	4.0± 0.08	1.9175[g]
5% Sp	2.3± 0.07	3.67± 0.03	5.33± 0.01	6.67± 0.04	4.4925[b]
10% Sp	1.67± 0.03	2.33± 0.06	3.00± 0.08	4.0± 0.05	2.7500[ef]

where: Tp = tomato powder Pp = pepper powder Tup = Turmeric powder
Cp = carrot powder Rp = rosella powder Sp = spinach powder

Values are means ± Standard deviation of triplicate trials

In a row, means ± having the same superscript letters are not significantly different at 5% level

Macaroni with 5 and 10% of vegetable powders were less adhesiveness than the control macaroni, indicating that the stickiness of the macaroni decreased by 5-10% following vegetable powders incorporation. Springiness was defined as the distance to which the sample recovered in height during the time that elapsed between the end of the first compression cycle and the start of the second compression cycle [46]. The springiness of supplemented macaroni decreased with increased vegetable powders substitution. Springiness values were the highest in control sample (0.58 mm) followed by macaroni supplemented with 10% Pp (0.55 mm) and 10% Sp (0.50 mm).

Gumminess was calculated by the product of (that is, by multiplying) firmness and cohesiveness, whereas chewiness, defined as the energy required to masticate solid food to a state of readiness for swallowing [47].

Microbiological Aspects of Supplemented Macaroni with Vegetable Powders: Pasta products have relatively low water activity; therefore, they are generally regarded as a microbiologically safe food [48].

Data in Table (6) showed that total bacterial count all macaroni samples supplemented with vegetable powders. The lowest value of total bacterial count was observed in macaroni contained 10% Tup (2.3 × 10^2 CFU/g) followed by 10% Rp (5.7 ×10^2 CFU/g) and 5% Tup (6.7 × 10^2 CFU/g). This may be due the presence of phytochemicals which had antimicrobial activities such as phenolic compounds.

Table 7: Sensory evaluation of macaroni incorporated with vegetable powders during storage period at room temperature for 6 months

Treatments	Storage period (month) 0	2	4	6	Mean
			Color		
Control	8.0± 0.03	7.8± 0.04	7.6± 0.05	7.5± 0.02	7.725^{c}
5 % Tp	9.3± 0.05	9.4± 0.01	9.3± 0.06	9.1± 0.03	9.275^{ab}
10 % Tp	9.6±0.02	9.1± 0.03	9.0± 0.04	8.9± 0.01	9.150^{ab}
5 % Pp	9.4± 0.01	9.4± 0.05	9.3± 0.07	9.2± 0.06	9.325^{a}
10 % Pp	9.5± 0.04	9.4± 0.02	9.2± 0.03	9.0± 0.07	9.275^{ab}
5% Tup	9.3± 0.06	9.2± 0.03	9.2± 0.05	9.0± 0.09	9.175^{ab}
10% Tup	9.0± 0.02	9.0± 0.04	8.9± 0.08	8.9± 0.01	8.95^{ab}
5% Cp	9.2± 0.08	9.1± 0.05	8.9± 0.01	8.8± 0.02	9.00^{ab}
10% Cp	9.5± 0.05	9.3± 0.01	9.2± 0.03	9.2± 0.04	9.30^{a}
5% Rp	9.2± 0.01	9.1± 0.02	8.9± 0.05	8.7± 0.07	8.975^{ab}
10% Rp	9.1± 0.04	9.0± 0.08	8.8± 0.02	8.5± 0.03	8.85^{b}
5% Sp	9.1± 0.07	9.1± 0.03	8.9± 0.05	8.7± 0.01	8.95^{ab}
10% Sp	9.2± 0.03	9.0± 0.01	8.8± 0.07	8.6± 0.06	8.90^{ab}
			Odour		
Control	8.5± 0.03	8.3± 0.04	8.2± 0.01	8± 0.05	8.25^{f}
5 % Tp	9.2± 0.06	9.1± 0.02	9.1± 0.03	9.0± 0.01	9.10^{abcd}
10 % Tp	9.3± 0.01	9.2± 0.03	9.2± 0.05	9.1± 0.02	9.20^{abc}
5 % Pp	9.6± 0.02	9.5± 0.04	9.5± 0.03	9.4± 0.01	9.50^{a}
10 % Pp	9.5± 0.04	9.4± 0.02	9.4± 0.01	9.2± 0.05	9.38^{ab}
5% Tup	9.0± 0.07	9.0± 0.04	8.9± 0.02	8.9± 0.03	8.95^{bcd}
10% Tup	8.9± 0.03	8.8± 0.01	8.6± 0.06	8.5± 0.07	8.70^{de}
5% Cp	9.1± 0.05	9.0± 0.03	8.9± 0.08	8.7± 0.04	8.93^{cd}
10% Cp	8.9± 0.02	8.7± 0.05	8.6± 0.04	8.5± 0.06	8.68^{ef}
5% Rp	9.3± 0.01	9.1± 0.03	9.0± 0.05	8.8± 0.07	9.05^{bcd}
10% Rp	8.7± 0.04	8.5± 0.06	8.3± 0.07	8.1± 0.09	8.40^{ef}
5% Sp	9.2± 0.03	9.1± 0.05	8.9± 0.06	8.9± 0.08	9.03^{bcd}
10% Sp	8.9± 0.05	8.8± 0.06	8.7± 0.09	8.5± 0.07	8.73^{de}
			Taste		
Control	8.1± 0.09	8.0± 0.05	7.9± 0.06	7.8± 0.07	7.95^{f}
5 % Tp	9.1± 0.08	9.0± 0.04	8.9± 0.07	8.8± 0.05	8.95^{abc}
10 % Tp	9.2± 0.05	9.1± 0.06	9.0± 0.08	8.9± 0.04	9.05^{abc}
5 % Pp	9.2± 0.01	9.2± 0.02	9.1± 0.04	9.0± 0.08	9.13^{ab}
10 % Pp	9.3± 0.03	9.3± 0.04	9.2± 0.06	9.1± 0.01	9.23^{a}
5% Tup	8.7± 0.06	8.6± 0.01	8.5± 0.03	8.5± 0.05	8.58^{cde}
10%Tup	8.9± 0.07	8.8± 0.05	8.6± 0.02	8.6± 0.03	8.73^{bcd}
5% Cp	8.8± 0.02	8.7± 0.06	8.7± 0.04	8.6± 0.07	8.70^{bcd}
10% Cp	8.9± 0.04	8.9± 0.03	8.8± 0.01	8.7± 0.05	8.83^{abc}
5% Rp	8.5± 0.08	8.4± 0.04	8.2± 0.07	8.0± 0.06	8.28^{ef}
10% Rp	8.4± 0.05	8.3± 0.06	8.1± 0.01	7.9± 0.04	8.18^{def}
5% Sp	9.1± 0.03	9.1± 0.01	8.9± 0.08	8.7± 0.07	8.95^{abc}
10% Sp	8.9± 0.07	8.7± 0.02	8.6± 0.04	8.5± 0.09	8.68^{bcd}
			Texture		
Control	8.0± 0.09	8.0± 0.08	7.9± 0.05	7.8± 0.03	7.93^{d}
5 % Tp	9.3± 0.06	9.2± 0.03	9.1± 0.04	9.0± 0.07	9.15^{a}
10 % Tp	9.5± 0.04	9.4± 0.01	9.2± 0.02	9.1± 0.05	9.30^{a}
5 % Pp	9.4± 0.02	9.2± 0.05	9.1± 0.06	9.0± 0.08	9.18^{a}
10 % Pp	9.5± 0.01	9.5± 0.02	9.3± 0.03	9.2± 0.06	9.38^{a}
5% Tup	9.3± 0.03	9.2± 0.05	9.2± 0.01	9.0± 0.04	9.18^{a}
10% Tup	9.1± 0.05	9.1± 0.06	9.0± 0.08	8.9± 0.09	9.03^{ab}
5% Cp	9.2± 0.06	9.2± 0.04	9.1± 0.03	9.0± 0.07	9.13^{a}
10% Cp	9.3± 0.01	9.1± 0.03	8.9± 0.09	8.8± 0.08	9.03^{ab}
5% Rp	8.6± 0.05	8.4± 0.01	8.2± 0.07	8.0± 0.03	8.30^{cd}
10% Rp	8.5± 0.07	8.3± 0.02	8.1± 0.05	8.1± 0.06	8.25^{cd}
5% Sp	9.1± 0.04	9.1± 0.06	8.9± 0.03	8.8± 0.02	8.98^{ab}
10% Sp	8.8± 0.02	8.7± 0.09	8.5± 0.06	8.4± 0.04	8.60^{bc}

Table 7: Continued

Treatments	Storage period (month) 0	2	4	6	Mean
	Overall acceptability				
Control	8.2± 0.07	8.0± 0.09	7.9± 0.05	7.8± 0.08	7.98[d]
5 % Tp	9.2± 0.01	9.2± 0.03	9.1± 0.06	9± 0.02	9.13[ab]
10 % Tp	9.4± 0.03	9.2± 0.04	9.1± 0.07	9.0± 0.09	9.18[ab]
5 % Pp	9.4± 0.04	9.3± 0.02	9.3± 0.05	9.2± 0.06	9.30[a]
10 % Pp	9. 5± 0.02	9.4± 0.01	9.3± 0.03	9.1± 0.07	9.33[a]
5% Cup	9.1± 0.08	9.0 ± 0.06	8.9± 0.09	8.8± 0.08	8.95[abc]
10% Cup	9.0± 0.07	8.9± 0.09	8.8± 0.08	8.7± 0.05	8.85[abc]
5% Cp	9.1± 0.06	9.0 ± 0.8	8.9± 0.09	8.7± 0.04	8.925[abc]
10% Cp	9.2± 0.05	9.0 ± 0.07	8.8± 0.06	8.8± 0.09	8.950[abc]
5% Rp	8.9± 0.09	8.8± 0.06	8.6± 0.05	8.4± 0.05	8.68[bc]
10% Rp	8.7± 0.08	8.5± 0.05	8.3± 0.03	8.2± 0.06	8.43[cd]
5% Sp	9.1± 0.04	9.1± 0.03	8.9± 0.09	8.8± 0.02	8.99[abc]
10% Sp	9.0± 0.07	8.8± 0.05	8.7± 0.08	8.5± 0.04	8.75[abc]

where: Tp = tomato powder Pp = Red pepper powder Tup = Turmeric powder
Cp = carrot powder Rp = Roselle powder Sp = Spinach leaf powder
Values are means ± Standard deviation of triplicate trials
In a row, means ± having the same superscript letters are not significantly different at 5% level

The maximum permissible level of total aerobic colony of ready-to-eat foods as given by Fylde Borough Council extracted from manual of PHLSG [49] is 10^4-10^6 CFU/g of ready-to-eat food products.

The same trend was observed for moulds & yeasts. The decrement in moulds and yeasts in macaroni supplemented with vegetable powders may be the antimicrobial compounds. Microbial loads was increased during storage period.

Effect of Supplementation with Vegetable Powders as Natural Colorant on the Sensory Evaluation of Prepared Macaroni: Sensory evaluation of pasta samples can be an important step to consider the possibility towards an industrial and commercial approach [50]. From data in Table (7), it could be observed that substitution with vegetable powders as natural colorant enhanced the color compared with control sample (8.00) particularly those with 10% Tp (9.60). Macaroni with 10% Pp and 10% Cp had the higher color score (9.50) for each one of them followed by 5% Pp (9.40).

Taste of vegetable powders incorporated macaroni (from 8.40 to 9.30) was found superior to control sample (8.10). Macaroni with 10% Pp was adjudged superior in terms of taste. Incorporation of sweet red pepper powder recorded highest scores for all quality attributes of substitution 5% and 10% higher among other macaroni formula or control sample.

The data showed that, macaroni fortified with vegetable powders showed higher values of exterior color, odor, taste and general acceptability in comparing with macaroni control. The sensory analysis clearly pointed out that the incorporation of vegetable paste improved the color, mouth feel, taste, texture and overall quality of pasta [51].

CONCLUSIONS

Incorporation of different vegetable powders as natural colorant was found suitable for making healthy and functional macaroni with acceptable quality parameters (cooking quality, color, sensory quality) and enhance the nutritive value of macaroni.

REFERENCES

1. Le, Q.U., H.L. Lay, M.C. Wu and T.H. Nguyen, 2018. Natural plant colorants widely used in Vietnam traditional food culture. J. Food Nutr. Agric., 1(1): 40-46.
2. Aggarwal, B.B., A. Kumar and A.C. Bharti, 2003. Anticancer potential of curcumin: Preclinical and clinical studies. Anticancer Research, 23: 363-398.
3. Mortensen, A., 2006. Carotenoids and other pigments as natural colorants. Pure Appl. Chem., 78: 1477-1491.
4. El-Gharably, A.M.A., 2005. Characterization of anthocyanin pigments extracted from grape skins and its potential uses as antioxidant and natural food colorants. J. Home Econ., Minufiya Univ., 15: 51-70.
5. Aberoumand, A., 2011. A Review Article on Edible Pigments Properties and Sources as Natural Biocolorants in Foodstuff and Food Industry. World J. Dairy & Food Sci., 6(1): 71-78.

6. Kumar, J.K. and A.K. Sinha, 2004. Resurgence of natural colourants: A holistic view. Natural Product Letters, 18: 59-84.
7. Bhat, N.A., I.A. Wani and A.M. Hamdani, 2020. Tomato powder and crude lycopene as a source of natural antioxidant in whole wheat flour cookies. Heliyon, 6: e03042.
8. Gutiérrez, C.L.M., D.I.T. Medina, M.E. Jaramillo-Flores, 2016. Chapter 24: Pepper and Spice Capsicum. In Handbook of Vegetable Preservation and Processing, 2nd ed.; Eds., Hui, Y. H. and E.-Özgül Evranuz, CRC Press: Boca Raton, FL, pp: 559-588.
9. Scala, K.D. and G. Crapiste, 2008. Drying Kinetics and Quality Changes During Drying of Red Pepper. LWT-Food Sci. Technol., 41: 789-795.
10. Fudholi, A., M.Y. Othman, M.H. Ruslan and K. Sopian, 2013. Drying of Malaysian *Capsicum annuum* L. (Red Chili) Dried by Open and Solar Drying. Int. J. Photoenergy, 1: 4589-4594.
11. Gomes, L.M.M., N. Petito, V.G. Costa, D.Q. Falcão, D.Q. and K.G. De Lima Araújo, 2014. Inclusion Complexes of Red Bell Pepper Pigments with β-Cyclodextrin: Preparation, Characterization and Application as Natural Colorant in Yogurt. Food Chem., 148: 428-436.
12. Sharma R.A., A.J. Gescher and W.P. Steward, 2005. Curcumin: the story so far. European Journal of Cancer, 41: 1955-68. doi: 10.1016/j. ejca.2005.05.009.
13. Abdeldaiem, M.H., 2014. Use of yellow pigment extracted from turmeric (*Curcuma longa*) rhizomes powder as natural food preservative. American Journal of Food Science and Technology, 2(1): 36-47.
14. Riganakos, K.A., L.K. Karabagias, L. Gertzou and M. Stahla, 2017. Comparison of UV-C and thermal treatments for the preservation of carrot juice. Innovative Food Science and Emerging Technologies, 42: 165-172.
15. Baranski, R., C. Allender and M. Klimek-Chodacka, 2012. Towards better tasting and more nutritious carrots: carotenoid and sugar content variation in carrot genetic resources. Food Res. Int., 47: 182-187.
16. Kaur, G., S. Sharma, H.P.S. Nagi and B.N. Dar, 2012. Functional properties of pasta enriched with variable cereal brans. Journal of Food Science and Technology, 49(4): 467-474.
17. Sobota, A., Z. Rzedzicki, P. Zarzycki and E. Kuzawinska, 2015. Application of common wheat bran for the industrial production of high fiber pasta. International Journal of Food Science and Technology, 50: 111-119.
18. Oliviero, T. and V. Fogliano, 2016. Food design strategies to increase vegetable intake: the case of vegetable enriched pasta. Trends in Food Science and Technology, 51: 58-64.
19. Shashirekha, M.N., S.E. Mallikarjuna and S. Rajarathnam, 2015. Status of bioactive compounds in foods, with focus on fruits and vegetables. Critical Reviews in Food Science and Nutrition, 55: 1324-1339.
20. Aguilera, Y., M.A. Martin-Cabrejas and E. Gonzalez de Mejia, 2016. Phenolic compounds in fruits and beverages consumed as part of the mediterranean diet: their role in prevention of chronic diseases. Phytochemistry Reviews, 15: 405-423.
21. Vital, A.C.P., C. Itoda, Y.S. Crepaldi, B.R. Saraiva and P.T. Matumoto-Pintro, 2020. Use of asparagus flour from non-commercial plants (residue) for functional pasta production. J. Food Sci. Tech., 57(8): 2926-2933.
22. Rekha, M.N., A.S. Chauhan, P. Prabhasankar, R.S. Ramteke and G. Venkateswara Rao, 2013. Influence of vegetable purees on quality attributes of pastas made from bread wheat (*T. aestivum*). Cyta J. Food, 11(2): 142-149.
23. Oliviero T. and V. Fogliano, 2016. Food design strategies to increase vegetable intake: The case of vegetable enriched pasta. Trends in Food Science & Technology, 51: 58-64.
24. Villota, R. and R.C. Maksimoski, 1996. Method for producing vegetable pasta, Alexandria, VA: USPTO. United States Patent Number, US 005508053A.
25. Dexter, J., J. Mastuo and J. Kruger, 1990. The spaghetti making quality of commercial durum wheat samples with variable amylose activity, Cereal Chem., 76: 405-412.
26. Singh, N., G.S. Chauhan and G.S. Bains, 1989. Effect of soy flour supplementation on the quality of cooked noodles. Inter. J. Food Sci. and Tech., 24: 111-114.
27. Ozkaya, H. and B. Kahveei, 1990. Tahilve Urnleri Analize Yontemleri. Gida Teknol. Dernegi Yayinlari No: 14, ANKARA, pp: 146-148.
28. A.A.C.C., 2005. Approved methods of the American Association of cereal chemists. St paul Minnesota.
29. AOAC, 2010. Official Methods of Analysis. Association of Official Analytical Chemistis 19th ed. Washington, D.C., USA.
30. Yadav, S. and R.K. Gupta, 2015. Formulation of noodles using apple pomace and evaluation of its phytochemicals and antioxidant activity. Journal of Pharmacognosy and Phytochemistry, 4(1): 99-106.

31. Bourne, M., 2002. Food texture and viscosity Concept and measurement, Academic Press, An Elsevier Science Imprint, New York, pp: 175, pp: 253.
32. Mohamed, Z.E., G.H.H. Ismaiel and A.E. Rizk, 2016. Quality characterizations of pasta fortified with red beet root and red radish. Inter. J. Food Sci. and Tech., 1(1): 1 -7.
33. Difco-manual, 1984. Dehydrated Culture Media and Reagents Microbiological and Clinical Laboratory Procedures. Difco-Detroits. Michigan, USA.
34. Pinarli, I., M.D. Oner and S. Ibanoglu, 2004. Effect of wheat germ addition on the microbiological quality, *in vitro* protein digestibility and gelatinization behavior of macaroni. Europian Food Research and Technology, 219: 52-59.
35. SPSS, 1997. Spss users Gide statistics version 8 Copy right Spss Inc., USA, Washington , D. C. USA.
36. Duncan, D., 1955. Multiple range and multiple F test. Biometric, 11: 1-42. Edition ASSOC. Office. Anal. Chem., Arlington.
37. Galla, N.R., P.R. Pamidighantam, B. Karakala, M.R. Gurusiddaiah and S. Akula, 2017. Nutritional, textural and sensory quality of biscuits supplemented with spinach (*Spinacia oleracea* L.). Inter. J. Gastronomy and Food Sci., 7: 20-26.
38. Chhikara, N., K. Kushwaha, S. Jaglan, P. Sharma and A. Panghal, 2018. Nutritional, physicochemical and functional quality of beetroot (*Beta vulgaris* L.) incorporated Asian Noodles. Cereal Chem., 96: 154-161.
39. Getachew, M. and H. Admassu, 2020. Production of pasta from Moringa leaves - oat - wheat composite flour. Getachew & Admassu, Cogent Food & Agriculture 6: 1724062, pp: 1-11.
40. Mercier, S., C. Moresoli, M. Mondor, S. Villeneuve and B. Marcos, 2016. A meta-analysis of enriched pasta: what are the effects of enrichment and process specifications on the quality attributes of pasta? Comprehensive Reviews in Food Science and Food Safety, 15(4): 685-704.
41. Wang, J., C.M. Rosell and D.B.C. Benedito, 2002. Effect of the addition of different fibers on wheat dough performance and bread quality. Food Chem., 79: 221-226.
42. Jalgaonkar, K., S.K. Jha and M.K. Mahawar, 2018. Influence of incorporating defatted soy flour, carrot powder, mango peel powder and moringa leaves powder on quality characteristics of wheat semolina-pearl millet pasta. J. Food Processing and Preservation e13575.
43. Svec, I., M. Hruskova, M. Nitova and H. Sekerova, 2008. Colour evaluation of different pasta samples. Czech J. Food Sci., 26(6): 421-427.
44. Wojtowicz, A. and L. Moscicki, 2014. Influence of legume type and addition level on quality characteristics, texture and microstructure of enriched precooked pasta. LWT-Food Sci. Technol., 59(2): 1175-1185.
45. Bhattacharya, M., S.Y. Zee and H. Corke, 1999. Physicochemical properties related to quality of rice noodles. Cereal Chemistry, 76: 861-867.
46. Zienab, A.A., I.A. Hassan and E.R. Ibrahim, 2015. Utilization of barley flour, turmeric and mushroom to produce nutritional high cake value. Middle East J. Appl. Szi., 5(4): 1257-1266.
47. Karaoglu, M.M. and H.G. Kotancilar, 2009. Quality and textural behaviour of par-baked and rebuked cake during prolonged storage. Int. J. Food Sci. Technol., 44: 93-99.
48. Ozyurt, G., L. Uslu, I. Yuvka, S. Gokdogan, G. Atci, B. Ak and O. Isik, 2015. Evaluation of the cooking quality characteristics of pasta enriched with *Spirulina platensis*. J. Food Quality, 38: 268-272.
49. PHLSG , 2008. The microbiological quality of ready-to-eat foods sampled at the point of sale. In: Public health laboratory service guidelines, Brough Council.
50. Fradique, M., B. Ana Paula, N.M. Cristiana, L. Gouveia and N.M. Bandarra, 2013. Anabela Raymundo Isochrysis gal- bana and Diacronema vlkianum biomass incorporation in pasta products as PUFA's source. LWT - Food Science and Technology, 50: 312-319.
51. Yadav, D.N., M. Sharma, N. Chikara, T. Anand and S. Bansal, 2014. Quality characteristics of vegetable - blended - pearl millet composite pasta. Agric. Res., 7: 1-8.