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Enhancement of Nutritional and Functional Characteristics of Noodles Formulated with Spinach Leaves and Sugar Beet

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Abstract

The current work assesses the potential of incorporating spinach leaves (SL) and sugar beet powder (SBP) as functional ingredients at 5% in preparing nutrients dense noodles. The chemical composition, antioxidant properties, cooking quality and acceptability by a consumer sensory panel (n = 10) were evaluated. Results showed that noodles formulated with SL and SBP exhibited significant increase in moisture, ash crude fiber and minerals in correlation to the control. Meanwhile, minor change was observed in fat and protein content compared with control noodle. For evaluating antioxidant properties, radical scavenging activity of 2,2 -diphenyl - 1 -picrylhydrazyl (DPPH), total phenolic content (TPC) as well as total flavonoid content (TFC) were assessed. Results revealed that SL and SBP noodles were significantly superior in antioxidants quality than those of the control samples ($p < 0.05$). SL -noodles exhibited the highest total phenol content (381.66) mg GAE/100g, whereas SBP -noodles showed the highest antioxidant activity expressed as DPPH (18.20%) as well as the highest total flavonoid content (46.19) mg RE/100 g Incorporation of SL and SBP modifies functional quality of noodles i.e. cooking time, cooking loss, water absorption, swelling index and noodles' color. SBP -noodles cooking quality showed increased cooking time as well as water uptake. Greenness as well as redness increased significantly for SL and SBP noodles respectively. The sensory studies recommended the incorporation of SL and SBP to the noodles to attain desired sensory quality without affecting the overall acceptability. SL and SBP -noodles could therefore be used to produce high -quality noodles with nutritional -promoting properties.

Key words: Noodles, spinach leaves, sugar beet powder, cooking quality, antioxidant activity, total phenolic and flavonoid, sensory characteristics.

1. Introduction

Cereal products like noodle and pasta existed for thousands years and are among the foods that are widely consumed all over the world. Pasta is traditionally manufactured using durum wheat semolina, whereas noodle usually made from common wheat flour, water and some additives [1]. Noodles are very popular wheat foods products and play an important role in human nutrition and culture [2]. The importance of noodles is increasing as it is simple to prepare, low cost, and enjoy appropriate sensory properties, long shelf life and, therefore, it is suitable vehicle for enrichment [3].

Since noodles have a low content of nutrients, therefore, the use of additives has become an important in the manufacture of noodles, with the aim of increasing their nutrient content. Many additives have been developed and are used in noodles including protein [3, 4] and fiber [5]. Studies on developing foods with high antioxidant activity have also gained importance in recent years [6]. This is to some extent because of the association between different phytochemicals in vegetables with either potential or proven beneficial effects on human health, like carotenoids and phenolic acids [7].

Multiple micronutrients deficiencies are considered persistence public health problem especially in developing countries [8]. Whereas, many interventions strategies adopted and were unsatisfactory to increase micronutrient, food based strategy proved effective [9]. An approach in the

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present study was to produce noodles with high nutrient content, by incorporating spinach and sugar beet powder. spinach is one of the dark green leafy vegetables belongs to the Goosefoot family (Chenopodiaceae) rich in antioxidants, folate, iron, potassium and unsaturated fatty acids [10, 11, 12]. Meanwhile, sugar beet proved to be relatively potent antioxidants [13, 14]. The aim of the present work is to evaluate the use of dried spinach and sugar beet powder as a source of antioxidants, fiber and minerals as additives in the production of noodles. The chemical composition, antioxidant activity, cooking properties and sensory characteristics of produced noodles were evaluated.

2. Experimental:

2.1. ***Materials:*** Spinach leaves, sugar beet, wheat flour, salt and eggs were obtained from a local market in Cairo, Egypt.

2.2. Methods

2.2.1. Preparation of spinach leaves and sugar beet powder

Spinach leaves and sugar beet were washed, steam blanched and dried at 50°C. The dried samples were ground to fine powder and kept in plastic bag until further investigation.

2.2.2. Preparation of noodles

To prepare noodle samples, flour (250g), salt (4.25g), egg (1piece) and water (50ml) were used [15]. Wheat flour was replaced by spinach leaves (SL) and sugar beet powder (SBP) in the formulation at the level of 5%. All dried components of the formula (flour, SL or SBP flours, and salt) were mixed in Moulinex QA503DB1 Kitchen Machine (Moulinex, France), at low speed until a uniform mix was achieved then eggs and water were added, and the mix speed was increased until the dough is smooth and elastic. The wrapped the ball of dough in plastic and rest for 20 minutes.

The dough was divided into four pieces. The pieces were first formed into a dough sheet by a process of folding and passing the pieces through the rollers of the pasta machine (Pasta Machine With Removable Cutters and Fittings For Marcato PASTADRIVE ATLAS 150) several times. Then, this sheet was cut into strands of 2.0 mm thickness using the cutting roll attachment of the noodle machine. Another pasta shape, Past bike was used (see Figure 1) and were dried in an oven at 50°C.

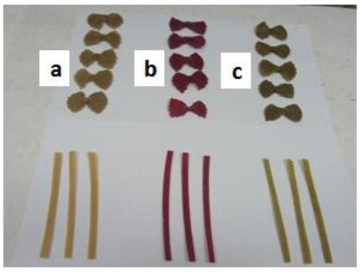

Figure1. Control-noodle (a), SBP-noodle (b) and SL-noodle (c)

2.2.3. Proximate chemical composition of noodles

The proximate composition (moisture, fat, protein, ash, fiber) of samples was determined using standard procedures [16]. Carbohydrate content was calculated by difference.

2.2.4. Antioxidant activity-evaluation

Antioxidant activity was determined using–DPPH method [17]. A radical scavenging activity was expressed by % of scavenging activity and was calculated by the following formula:

$$\text{Radical Scavenging Activity (\%)} = \frac{AB^{*} - AS^{**}}{AB} \times 100$$

*Absorbance Blank, **Absorbance Sample

2.2.5. Determination of phytochemicals

2.2.5.1. Total phenolic content

Total phenolic content (TPC) was determined using Folin-Ciocalteu reagent [18]. The reaction mixture contained 100 µL of extracts, 500 µL of the Folin-Ciocalteu reagent, and 1.5 mL of 20% sodium carbonate. The final volume was made up to 10 mL with deionized water and then the mixture was vortexed. After 2 h of reaction, the absorbance was measured at 765 nm and the results were expressed as Gallic acid equivalent.

2.2.5.2. Total falvoniod content

Total flavonoid content (TFC) was determined according. Chang et al., [19]. Briefly, aliquots of 0.5 ml of sample extract was mixed with 1.5 ml of 95% alcohol, 0.1 ml of 10% aluminum chloride , 0.1 ml of 1 M potassium acetate, and 2.8 ml of deionized water. After incubation at room temperature for 40 min, the reaction mixture absorbance was measured at 415 nm against a deionized water blank on a spectrophotometer, rutin was chosen as a standard. The data was expressed as milligram rutin equivalent (RE)/100g samples.

2.2.6. Determination of cooking quality

Cooking quality of prepared noodles i.e. cooking time, cooking loss water absorption and swelling index were determined. The optimum cooking time was determined using 10 g of sample which - placed in 200 ml of boiling water until the white core of noodles disappeared [20]. Cooking loss was measured by evaporating the cooking water to dryness in oven at 105°C as described in A.A.C.C., [16]. Cooking loss was calculated as a percentage of dry matter lost during cooking to dry weight. Water absorption was evaluated using the weighing cooked and drained cooled samples.

Water absorption (%) =

Weight of cooked noodle -Weight of uncooked noodle/ Weight of uncooked noodle X100 [21].

2.2.7. Color evaluation

The color (L*a*b*) values of the samples were determined by spectrophotometer (Hunter Lab Color Standard Quest XE, USA). The instrument was standardized each measurement with white tile and equipped with a light source illuminant D65 and 10°. L* (lightness- darkness), a* (redness-greenness) and b* (yellowness-blueness) values were measured. The values taken were an average of three readings. The Chroma represents color saturation or purity are calculated from $C=(a^2+b^2)$ ½ . The total intensity for the control and the SL and SBP noodles was calculated as follows: Total intensity $(a^2 + b^2 + L^2)^{1/2}$

2.2.8. Sensory evaluation

According to Laus et al., [22], ten sensory panel members were instructed to evaluate the prepared noodle samples. Sensory attributes i.e. taste, softness, stickiness, color, odor and overall acceptability were assessed using a 9-point Hedonic scale (1=extremely poor and 9=excellent).

2.2.9. Statistical Analysis

ANOVA and the significant differences between mean values was determined using Duncan test. The level of significance used was $p < 0.05$. Statistical analyses were conducted by using SPSS 20.0 (SPSS for Windows, 2007, SPSS Inc., Chicago, USA). All measurements were performed in triplicates, unless otherwise stated.

3. Results and Discussion:

3.1. Proximate analysis of the noodles

Chemical composition of the samples are presented in Table 1. Moisture content of SL and SBP noodles were significantly increased compared with control noodle. In general, low moisture content increases the shelf life of food products. The slight increase in moisture was coupled with significant decrease of protein content due to the replacement of flour with SL and SBP powder. Protein content is important because it influences the cooking quality of the product. Meanwhile, the inclusion of SL and SBP improved the content of all measured minerals with the only exception of manganese.

3.2. **Antioxidant activity, Total phenolic and flavonoid contents**

DPPH radical scavenging activity, total phenolic as well as total flavonoid content of the prepared noodles are shown in Table 2. Results demonstrated that SBP-noodle exhibited the highest DPPH radical scavenging activity (18.20%) followed by SL-noodle (14.69%) compared to the control noodle (10.02%). Fortification the noodles SL and SBP powder at the level of 5%, total flavonoid content increased significantly from 10.91 (mg RE/100g) in the control noodle to 40.77 and 46.19 (mg RE/100g) in SL and SBP noodle respectively. Same trend was reported for total phenolic content where SL-noodle exhibited 381.66 (mg GAE/100g) followed by SBP-noodle 239.72 (mg GAE/100g) compared to the control noodle (57.74 GAE/100g).

These results reflected clearly the significant improvement of the antioxidant capacity of the formulated noodle and showed that SL and SBP are valuable source of flavonoid and phenolic compounds. The results of this study confirmed that, SL and SBP powder is reasonable vehicle for enriching noodle with nutrient dense supplements [23].

3.3. The Cooking quality

Enrichment of foods with dietary fiber improves the functional properties of the food but might lead to problems in technical quality [24]. Accordingly, cooking performances of the investigated noodle in terms of optimum cooking time, cooking loss, water absorption, and swelling index are shown in Table 3. The data revealed that both SL and SBP powder had a noticeable impact on the cooking quality. The optimum cooking time decreased from 11.67 for the control noodle to 10.74 min for SL-noodle. Meanwhile, SBP-noodles showed prolonged cooking time i.e. 13.41 min. No significant differences of cooking loss between SL, SBP and control noodles. Cooking loss commonly used to predict the noodle cooking quality and directly reflects the material loss of the dried noodles during cooking. Table 3, showed the water absorption and swelling index which significant increased when fortified noodle with SL and SBP powder. Chen et al., [24] has been reported that wheat bran affected the transportation of water due to self-absorption. Accordingly, we conclude that self-absorption of dietary fiber impacted water diffusion during cooking.

3.4. The Color quality

Table 4 illustrates the color parameters (L*), (a*), (b*), saturation and total intensity in the fortified noodles. It is noteworthy that the inclusion of SL and SBP powder has significant impact on the color quality of the noodle. Control noodles had highest (L*) values compared to SL-noodle and SBP-noodle. Similar trend was recorded in measuring (b*) score where SL-noodle and SBP-noodle exhibited reduced in b* score. Due to the strong pigmentation of SL and SBP powder, SL-noodle showed negative value of (a*) meanwhile, SBP-noodle reflected increasing in (a*) value compared to the control-noodle. These results agreed with the study of Debbarma et al., [25], who observed that the noodles prepared with seaweed puree become green with negative a* value.

3.5. Sensory evaluation

The effect of incorporation of SL and SBP on the sensory profile of noodles is depicted in Table 5. There was no significant difference in mean values of taste, softness, stickiness, color, odor and overall acceptability for the fortified noodles with SL and SBP. The softness score decreased significantly for SBP-noodle. This was coincided with the high water absorption as well as swelling index. In addition this sensory defect was not associated with overall acceptability score. A possible explanation of the low softness might be related to the incorporation of dietary fiber that, due to its high hydrophilicity, preferentially absorbs water and competing with starch granules [26]. These results had highlighted on the incorporation of SL and SBP in noodles which showed no significant differences compared to the control noodle.

Table 1. Proximate composition of formulated noodles

Chemical composition	Control	SL-noodles*	SBP-noodles**
Moisture	7.48±.013^{b}	7.79±0.22^{a}	7.84±0.04^{a}
Ash	3.19±0.44^{c}	4.08±0.02^{b}	4.79±0.05^{a}
Fat	2.37±0.18^{a}	2.30±0.14^{a}	2.27±0.22^{a}
Protein	14.05±0.60^{a}	13.08±0.65^{c}	13.58±0.03^{b}
Fiber	2.31±0.08^{b}	2.37±0.04^{b}	3.68±0.31^{a}
Total Carbohydrates***	70.60±0.60^{a}	70.38±0.57^{b}	67.84±0.75^{c}
Zn (mg/kg)	7.87±0.12^{c}	11.38±0.34^{a}	10.42±0.38^{b}
Mg (mg/kg)	90.33±0.58^{c}	120.67±1.15^{a}	104.67±0.58^{b}
Fe (mg/kg)	24.33±1.15^{b}	35.33±0.58^{a}	36.67±0.58^{a}
Mn (mg/kg)	4.37±0.16^{b}	4.07±0.12^{c}	4.73±0.03^{a}

*SL: Spinach leaves; **SBP: Sugar beet powder; ***Calculated by difference
Values are expressed as mean ± SD (n=3). Letters followed by the same letter in the same row are not significantly different from each other at p>0.05.

Table 2. Effect of incorporating of SL and SBP on the antioxidant properties of the noodles

Antioxidant properties	Control noodles	SL-noodles*	SBP-noodles**
Scavenging activity (%)	10.02±0.24^{c}	14.69±0.22^{b}	18.20±0.16^{a}
Total flavonoid content (mg RE/100g)***	10.91±0.60^{c}	40.77±0.52^{b}	46.19±0.99^{a}
Total phenolic content (mg GAE/100g)****	57.74±1.80^{c}	381.66±4.45^{a}	239.72±0.43^{b}

Values are expressed as mean ± SD (n=3). Letters followed by the same letter in the same row are not significantly different from each other at p>0.05. *SL: Spinach leaves; **SBP: Sugar beet powder; ***Rutin equivalent,**** Gallic Acid equivalent.

Table 3. Cooking properties of the formulated noodles

Cooking properties	Control noodles	SL- noodles*	SBP- noodles**
Cooking time (min)	11.67±0.45[ab]	10.74±0.36[b]	13.41±1.24[a]
Cooking loss (%)	12.49±0.75[a]	12.62 ±0.32[a]	12.37 ±0.99[a]
Water absorption (%)	125.55±0.60[c]	147.07±0.08[b]	166.95±0.12[a]
Swelling index (g $_{water}$/g $_{dry\ noodles}$)	1.67±0.03[c]	1.83±0.00[b]	2.10 ±0.02[a]

Values are expressed as mean ± SD (n=3). Letters followed by the same letter in the same row are not significantly different from each other at p>0.05. *SL: Spinach leaves; **SBP: Sugar beet powder

Table 4. Effect of SL and SBP incorporation on the color quality of the noodles

Color parameters	Control noodles	SL-noodles	SBP-noodles
L* Lightness(+)/darkness (-)	51.16±0.81[a]	43.63±1.13[b]	34.98±0.35[c]
a* Redness(+)/greenness(-)	2.41±0.00[b]	-0.96±.028[c]	16.65±0.19[a]
b* Yellowness (+)/Blueness(-)	13.26±1.58[a]	9.03±0.97[b]	2.59±0.19[c]
Color saturation (C)	13.48±1.54 [b]	9.08±0.96 [c]	16.84±0.21 [a]
Total intensity	52.94±0.14 [a]	44.57±1.30 [b]	38.82±0.41 [c]

Values are expressed as mean ± SD (n=3). Letters followed by the same letter in the same row are not significantly different from each other at p>0.05.

Color saturation $C = (a^2 + b^2)^{1/2}$

Total intensity $(a^2 + b^2 + L^2)^{1/2}$

Table 5. Effect of the incorporation of SL and SBP on the sensory characteristics of noodles

Sensory attributes	Control noodles	SL-noodles*	SBP-noodles**
Taste	8.38±0.74[a]	8.50±0.53[a]	8.34±0.92[a]
Softness	8.75±0.38[a]	8.75±0.46[a]	6.75±0.46[b]
Stickiness	7.88±0.83[a]	8.13±0.83[a]	8.00±0.93[a]
Color	8.38±0.74[a]	8.75±0.46[a]	8.63±0.52[a]
Odor	8.75±0.46[a]	8.38±0.52[a]	8.63±0.52[a]
Overall acceptability	8.75±0.46[a]	8.63±0.52[a]	8.50±0.53[a]

Values are expressed as mean ± SD (n=10). Letters followed by the same letter in the same row are not significantly different from each other at p>0.05. *SL: Spinach leaves; **SBP: Sugar beet powder

4. Conclusion

To meet the ever growing nutritional demand of modern consumers, nutrient dense ingredients i.e. SL and SBP was incorporated into different noodle formulas. Proximate composition of the SL and SBP noodles reflected the enrichment with fiber as well as selected minerals. Indeed, antioxidant activity and phenolic and flavonoids compounds of SL and SBP were markedly enhanced. The results of cooking properties revealed the obvious impact of incorporating SL and SBP into the noodles. Additionally, water absorption increased significantly by the incorporation of SL and SBP compared to the control noodle. SBP-noodle presented lower sensory scores according to softness and no significant difference was found for other sensory indicators among noodle samples. This study has shown that

5. Conflicts of interest

The authors declare no conflict of interest

6. Formatting of funding sources

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