ORIGINAL ARTICLE

Development and Characterization of Vegetable Waste Powder-Based Pasta

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A B S T R A C T

The current study is planned to evaluate nutritional characteristics, mineral composition, and sensory attributes of pasta incorporated with vegetable wastes *i.e.*, potato and pea peel. Anti-oxidant potential, total phenolic, and flavonoid contents were examined. Vegetables and their wastes are good sources of vital nutrients such as vitamins, dietary fibers, antioxidants, and phytochemicals. The utilization of these agro-wastes for the development of cost-effective food products is mainly focused on in this article. At first, different concentrations (5, 15, and 25%) of potato and pea peel powders were added to the pasta recipe. Dough rheology was determined. The nutritional analysis illustrated that the maximum values of DPPH contents were obtained for 25% potato peel-incorporated pasta showing significant results. Total phenolic contents also depicted highly significant values, which ranged from 132.15 to 221.70 mg GAE/100g upon the addition of a maximum percentage of peel powders. Total flavonoid contents were also observed highest at 25% vegetable waste incorporation *i.e.*, up to 30.00 mg Quercetin/100g. The nutritional composition of pasta illustrated that vegetable wastes are the treasure of macro as well as trace minerals. The sensory evaluation demonstrated that supplementation of 15% potato and pea peels resulted in improved color and textural attributes of pasta. Considering the challenges of food waste and their management strategies, this study depicted that these vegetable wastes may be used significantly for the development of value-added food products with enhanced nutritional profiles and sensory properties.

Keywords: Agro-waste Utilization, Vegetable Peels, Anti-Oxidants, TPC, TFC.

1. INTRODUCTION

Pasta is an ancient food product that is abundantly consumed almost all over the world. It is also a staple food of the Mediterranean people. Pasta appeared in different shapes and sizes and was given different names accordingly (Noodles, macaroni, spaghetti, lasagna, *etc.*) (Giacco *et al*., 2016). Durum wheat semolina is the best choice for pasta because it gives better color, cooking properties, and customer satisfaction. Pasta is a good source of carbohydrates, proteins, vitamins, and minerals. In recent years, pasta is being fortified with various essential nutrients *i.e.*, proteins, vitamins, and fiber contents (Zarzycki *et al*., 2020; Majewska *et al*., 2020).

Vegetables are among the most utilized food commodities. These are sources of vital nutrients that are required for the body to grow, develop, and be healthy and active. Their demand is increasing day by day because of the increasing trend toward healthier nutrients profile, improving people's dietary patterns, and growing population (Coman *et al*., 2020). Vegetables are good sources of many phytochemicals, vitamins, minerals, and dietary fibers. Diets rich in vegetables contribute toward lowering the risk of many diseases. Daily intake of vegetables provides the body with good health and strong vision. Studies depicted those unhealthy diets having reduced portions of vegetables are evaluated to cause 2.7 million deaths every year (Ramya and Patel, 2019).

Worldwide food losses and waste (FLW) were estimated to reach 1.6 billion tons annually. It is estimated that globally one-third of food produced is lost every year. This accounts for major food and nutrient losses as well (Kalpna and Mital, 2011; Ishangulyyev *et al*., 2019). Globally the economic loss of $750 billion dollars was reported annually at all stages of the food supply chain (FSC) (Girotto *et al*., 2015). Waste is primarily generated during the activities such as harvesting, transporting, handling, storage, production, and processing (Ishangulyyev *et al*., 2019). Pakistan Environmental Protection Agency found that 40% of cooked food goes wasted annually (Aamir *et al*., 2018). Among these food losses, horticultural commodities rank highest of all, generating up to 60% of waste. It is estimated that the frozen and canning industries of fruit and vegetables annually generate 6 million metric tons of waste. This waste mainly comprises stems, leaves, and stalks reaching up to 20-30% (Sagar *et al*., 2018).

Potato and pea are among the most important agricultural commodities that are largely produced and consumed worldwide. Potatoes are abundantly utilized in food industries thus generating huge waste in form of peels. Singh *et al*. (2020) examined that potato peels are remarkable sources of various health-improving compounds including antioxidants and phenolic compounds. These are low-cost valuable compounds that can be used as nutraceuticals also. Pea peels are also reported to be excellent sources of important nutrients. Hulls of peas are good sources of dietary fibers and polyphenols, thus proving to be effective for the prevention of various diseases such as cardiovascular and diabetes (Martens *et al*., 2017).

The current study aims to highlight the alarming situation of vegetable waste produced each year in the world as well as in Pakistan. These are not only quantitative losses but also account for major qualitative losses as well including essential nutrients and many bioactive compounds. This causes the depletion of natural resources, loss of vital nutrients, and increased environmental pollution. Considering these issues, the pasta was developed by incorporating different vegetable powders (potato and pea peel). The objectives of the present study include the development and rheological measurements of wheat flour-vegetable waste powder blend-based dough and assessing the mineral profile and antioxidant potential of vegetable waste powder-based pasta.

2. MATERIALS AND METHODS

2.1. Procurement of Raw Materials

Vegetable wastes and durum wheat semolina were collected from the local market of Faisalabad. Required chemicals *i.e*., digestion mixture (K_2SO_4, $CuSO_4$, $FeSO_4$), H_2SO_4, NaOH, n-hexane, HNO_3, quercetin solution, methanol, DPPH extract, ethanol, ascorbic acid, Folin-Ciocalteau's reagent, $AlCl_3$, and glass wares were be purchased from scientific stores in Faisalabad.

2.2. Sample Preparation

Peas and potatoes were first washed with distilled water to remove any dust or foreign material. Pea pods were separated and peeling of potatoes was done by hand peeler and the peels of both were stored in polythene bags. Potato peels were dried in a dehydrator at 55 °C for about 27 hours. Pea peels were dried at 60 °C for 35 hours in a dehydrator until complete removal of moisture. These dehydrated peels were turned into powder form by using a grinding machine and the fine powder of both vegetables was collected and stored in polythene bags. After the incorporation of vegetable waste powder in a ratio according to the treatment Table **1**, the dough was developed to check dough rheology by using a rapid visco-analyzer according to the protocol followed by Martinez (2015).

2.3. Product Development

The pasta was prepared by firstly mixing semolina (along with little salt and oil also) with water. The incorporation of vegetable wastes in the flour was made according to the treatment plan and mixed thoroughly. Proper kneading was practiced in preparing dough for pasta. After some time, it was forced above the extruder to pass through it. Long strips of pasta were developed according to die (Haraldsson, 2010) (Fig **1** & Fig **2**).

2.4. Proximate Analysis of Pasta

Proximate analysis of pasta was done for moisture, crude protein, fat, ash, fiber, and NFE contents according to AOAC (2016).

2.5. Moisture Analysis

Firstly, the china dish was weighed with and without a sample (2 g) and then the sample in the pre-weighed china dish was placed in a hot air oven at 105±5 °C for 24 hours. It was weighed again until a constant weight was obtained and after removing it from the oven, cooled in a desiccator, and weighed again. Moisture contents were evaluated by using the formula given below:

$$\text{Moisture (\%)} = \frac{\text{Initial weight of sample (g) - Final weight of sample}}{\text{The initial weight of the sample (g)}} \times 100$$

2.6. Crude Protein

Sample (1g) was firstly digested by using a 5 g digestion mixture (K_2SO_4, $CuSO_4$, $FeSO_4$ in a ratio of 90:9:1) and 30 mL H_2SO_4. The mixture was added to a volumetric flask of 250 mL and distilled water was added to make the volume up to the mark. 10 mL of this diluted mixture was mixed with 10 mL of 40% NaOH for distillation. Ammonia was released and collected in a solution of 4% boric acid with methyl red as an indicator. Titration was done by using 0.1 N H_2SO_4. A blank reading was obtained and crude protein was determined by using (Kjeldahl apparatus):

$$\text{Nitrogen (\%)} = \frac{\text{Vol. of } H_2SO_4 \text{ usedx0.0014 x Dilution vol. (250 mL)}}{\text{The initial weight of sample (g) x Vol. of diluted sample taken}} \times 100$$

Protein% was evaluated by multiplying nitrogen% contents with the conversion factor *i.e*., 6.25.

2.7. Crude Fat

Moisture-free (2 g) sample was placed in a thimble in the apparatus. 50 mL n-hexane solvent was used and after 6-7 cycles of siphoning, the thimble was removed and the sample was subjected to an oven for removal of any residual solvent in the sample at 105±5 °C. Crude fat was calculated by using the following formula (for soxhlet apparatus):

$$\text{Crude fat (\%)} = \frac{\text{Initial weight of sample (g) - Final weight of sample (g)}}{\text{The initial weight of the sample (g)}} \times 100$$

2.8. Crude Fiber

The sample (2g) was digested by using 200 mL 1.25% H_2SO_4 (boiling) for half an hour in a beaker that was attached to the fiber tech apparatus. Sample was taken and purified water was used to wash the sample after acid digestion, the sample was digested by using alkali 1.25% NaOH. The sample was removed and washed to make it alkali-free, then oven-dried for 24 hours at 105±5 °C and weighed. The residual sample was then placed at 600 °C in a muffle furnace to determine the ash contents.

$$\text{Crude fiber (\%)} = \frac{\text{Weight of dried sample after digestion (g) - Weight of ash}}{\text{The initial weight of the dried and defatted sample (g)}} \times 100$$

2.9. Ash Contents

Firstly, charring of the 1 g sample was done in a pre-weighed crucible on the beaker. The charred sample was then placed in a muffle furnace (600 ºC) until it turned to ash (grayish-white in color). After cooling in an incubator, the crucible was weighed. Ash contents were calculated by using the formula below:

$$\text{Ash (\%)} = \frac{\text{Weight of residues after incineration (g)}}{\text{The initial weight of the sample (g)}} \times 100$$

2.10. Nitrogen Free Extract (NFE)

The nitrogen-free extract was calculated by using the following formula:

$$\text{NFE (\%)} = 100 - (\text{moisture\% - crude protein\% - crude fat\% - crude fiber\% - ash\%})$$

2.11. Rheological Analysis

Pasting temperature, peak viscosity, final viscosity, setback, and breakdown values were evaluated using a rapid visco-analyzer following the procedure of Yang (2020).

2.12. Nutritional Analysis of Pasta

Mineral determination

Sample 0.5 g was digested with 10 mL HNO_3. The sample was then shifted to a volumetric flask of 100 mL and the volume was made by adding double-distilled water in it. Prepared samples were analyzed for mineral determination in comparison with standard curves obtained for each mineral using a flame photometer and atomic absorption spectrophotometer Sayed *et al.* (2014).

Antioxidant activity

Free radical scavenging activity was determined by using DPPH extract. With the addition of 70% ethanol, ascorbic acid volume, and sample volume were adjusted to 3 mL in test tubes. DPPH 100 µM methanol solution was prepared and 1 mL of this solution is added to each test tube. Absorbance was measured at 517 nm and radical scavenging ability was evaluated as inhibition percentage and calculated following the procedure of Czaja *et al.* (2020).

%Radical scavenging activity = (A control - A sample / A control) * 100

Where control is control absorbance and a sample is the test compound absorbance.

Total phenolic contents

Total phenolic contents were determined by following the procedure of Stojceska *et al.* (2008). Gallic acid extract (0.5 mL) mixed with 0.25 mL of Folin-Ciocalteau's reagent and 3 mL of distilled water. After that 0.75 mL of sodium carbonate (saturated) was added along with 0.95 mL of distilled water instantly. After incubation, absorbance was determined at 765 nm by using a UV-Visible spectrophotometer and compared with the standard curve.

Total phenolic contents = mg GAE/g Fresh Weight (FW)

Total flavonoid contents

Total flavonoid contents were estimated according to the method of De Caro and Haller (2015). For this purpose, a stock solution was prepared by mixing 5 mg of quercetin and 1 mL of methanol. To prepare standard solutions, 5-200 µg methanol per mL of quercetin (by serial dilutions) was used. 0.6 mL of this diluted quercetin solution was mixed with the same amount of 2% $AlCl_3$. After incubation, the absorbance of the mixture was checked at 430 nm by using a UV-visible spectrophotometer. A calibration plot was used to check the TFC concentration by following the procedures by De Caro and Haller (2015).

Total flavonoid contents = mg QE/g (Dried weight) DW

2.13. Sensory Evaluation

Sensory characteristics such as color, flavor, texture, aroma, and overall acceptability were evaluated by following the procedure of Meilgaard *et al.* (2016). A 9-point hedonic scale was used to evaluate the sensory properties of pasta. This scale includes 1 for dislike extremely to 9 for like extremely. Proper care and protocols were followed to eliminate errors.

2.14. Statistical Analysis

All the obtained data collected from different parameters were subjected to statistical analysis using the analysis of variance (ANOVA) technique and statistix software with three replicates of each treatment. One-way factorial under CRD and Tukey test was used for the comparison of means where $p<0.05$. Results were shown as Means±SD to check the level of significance according to the design as given by Montgomery (2017).

Table 1. The Treatment Plan for the Development of Pasta Incorporated with Vegetable Waste Powder

Treatments	Wheat Flour Semolina (%)	Potato Peel (%)	Pea Peel (%)
T_0	100	-	-
T_1	95	5	-
T_2	85	15	-
T_3	75	25	-
T_4	95	-	5
T_5	85	-	15
T_6	75	-	25

Similar letter on the column and row shows a significant effect ($p<0.05$)
T_0 = 100% durum wheat semolina flour,
T_1 = 95% semolina flour + 5% potato peel powder,
T_2 = 85% semolina flour + 15% potato peel powder,
T_3 = 75% semolina flour + 25% potato peel powder,
T_4 = 95% semolina flour + 5% pea peel powder,
T_5 = 85% semolina flour + 15% pea peel powder,
T_6 = 75% semolina flour + 25% pea peel powder

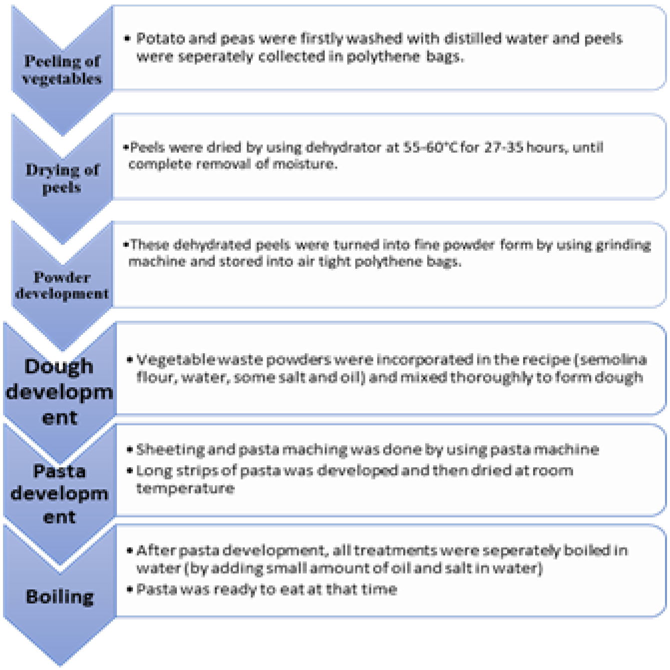

Figure 1. Development of vegetable waste powder-based pasta

3. RESULTS

3.1. Rheological Analysis

For rheological analysis, different parameters were studied using a rapid visco-analyzer such as pasting temperature, peak viscosity, final viscosity, setback, and breakdown. All these mentioned parameters are illustrated in the following (Tables **2-4**).

Rapid visco-analyzer

Statistical analysis of all the rheological properties demonstrated through mean values. Mean values illustrated that these parameters showed an increasing trend at first until the incorporation of 15% potato and 10% pea peel powder and it eventually decreased as the waste powder increased from these values.

3.2. Proximate Analysis

Mean values of proximate composition given in Table **3**. showed significant results for moisture, ash, fiber, fat, and NFE values. Results depicted that protein, fiber, and fat contents increased as potato or pea peel powder increased. This increasing trend depicted that the incorporation of these vegetable wastes resulted in the improved nutritional value of the product and these are considered among the most important factors for determining the quality and storability of the product.

The control sample (T_0) showed the highest moisture content, which gradually decreased because of increasing peel powder. The decreasing values are because of the addition of dehydrated peel powders that resulted in increased storage life of the end product. Results showed a highly significant relationship between treatments, as shown in the Table **3**. Mean values showed that the NFE contents varied as the amount of potato or pea peel increased which can be explained by varying concentrations of different peel powders.

3.3. Nutritional Analysis

Mineral

Mean values for all mineral composition are described in Table **4**, according to which an increasing trend in all the parameters is shown below. Minerals are necessary for optimal cellular functioning and to alleviate mental and physical fatigue. Mineral composition is better obtained for pea waste incorporated pasta than for potato waste samples. Minerals such as calcium, magnesium, potassium and iron exhibited increasing trend because of increasing concentration of mineral enrich vegetable waste powders in pasta.

Nutritional analysis (Antioxidant, TPC, TFC)

It was observed that the mean Table **5** depicted highly significant results in case of antioxidants. Control treatment showed lowest of all and 25% potato peel powder incorporated pasta (T_5) showed highest value for mean. Antioxidants are crucial substances for sustaining human life. Table **5** for expressing mean values of TPC is given below. Maximum and minimum values were obtained for T_5 which represents 25% incorporation of potato waste and the minimum value was obtained for T_0 which represents control treatment. Phenolic contents were evaluated to be highest among potato peel samples than in pea peel samples. Total phenolic contents showed increasing trend by incorporating more peel powders in the product. This trend is basically the result of the significant nutritional profile of these vegetable peels.

Mean value of TFC is also shown in Table **5** that illustrated that the results are highly significant between the treatments. Highest value was obtained for T_5 which contain 25% potato peel powder and minimum for control treatment *i.e.*, T_0. Flavonoids are those bioactive compounds that have shown favorable properties such as anti-viral and anti-bacterial characteristics. The Table **5** showed increasing trend from 5 to 25% incorporation

in both cases of potato and pea peel incorporation. This increasing trend is because of addition of higher amount of peel powders which are good sources of total flavonoid contents.

3.4. Sensory Evaluation

Sensory evaluation is an important part of research as it is basically depending on consumer's likeness or dis-likeness for the product. Sensory evaluation was done to determine various parameters of the product and to determine the acceptable concentration of these vegetable wastes in food product. Potato and pea peel pasta was a novel product for many consumers and the taste was not much affected in case of lower concentrations of peel powder. Texture was also not disturbed. The color of pasta was not much appreciated when the concentration of the peels rises above 15%. Mean values for all the parameters of sensory evaluation are represented in Table **6** below. Same trend was observed in case of pea peel incorporated product.

Table 2. Mean for Rheological Analysis of Vegetable Waste Powder-Based Pasta Formulations

Treatment	Peak Viscosity (Pa.s)	Final Viscosity (Pa.s)	Breakdown (Pa.s)	Setback (Pa.s)	Pasting Temperature (°C)
T_0	2263.10 ± 3.10^{i}	3305.30 ± 3.00^{h}	614.60 ± 2.70^{f}	1619.70 ± 3.20^{i}	63.75 ± 5.2^{ab}
T_1	2553.80 ± 3.10^{e}	3403.60 ± 3.20^{f}	617.60 ± 2.90^{def}	1672.30 ± 3.30^{g}	66.40 ± 5.3^{ab}
T_2	2815.60 ± 3.20^{b}	3702.00 ± 3.40^{a}	634.50 ± 3.20^{a}	1879.60 ± 3.30^{a}	72.30 ± 5.1^{a}
T_3	2196.90 ± 3.10^{j}	3291.50 ± 3.10^{i}	611.50 ± 3.00^{f}	1612.40 ± 3.20^{i}	57.80 ± 4.8^{ab}
T_4	2510.60 ± 3.00^{f}	3374.60 ± 3.30^{g}	615.40 ± 2.70^{ef}	1647.90 ± 3.00^{h}	65.50 ± 5.2^{ab}
T_5	2634.50 ± 3.30^{d}	3485.00 ± 3.00^{d}	625.60 ± 2.80^{bcd}	1783.70 ± 3.20^{d}	69.40 ± 4.7^{ab}
T_6	2103.80 ± 3.10^{k}	3219.10 ± 3.20^{j}	610.10 ± 2.80^{f}	1590.30 ± 3.00^{j}	56.00 ± 5.2^{b}

Similar letter on the column and row shows a significant effect ($p<0.05$)
T0 = 100% durum wheat semolina flour,
T1 = 95% semolina flour + 5% potato peel powder,
T2 = 85% semolina flour + 15% potato peel powder,
T3 = 75% semolina flour + 25% potato peel powder,
T4 = 95% semolina flour + 5% pea peel powder,
T5 = 85% semolina flour + 15% pea peel powder,
T6 = 75% semolina flour + 25% pea peel powder

Table 3. Mean for Proximate Contents (%) of Vegetable Waste Powder-Based Pasta Formulations

Treatment	Moisture	Crude protein	Crude fiber	Crude fat	Ash	NFE
T_0	11.50±1.50^{a}	12.00±0.50^{f}	4.50±0.03^{g}	0.50±0.05^{f}	0.75±0.05^{f}	71.25±2.63^{a}
T_1	10.50±1.00^{ab}	14.00±0.80^{e}	5.50±0.20^{f}	0.80±0.10^{cd}	0.80±0.04^{ef}	68.90±1.64^{abc}
T_2	9.60±1.00^{ab}	15.50±0.50^{bcde}	6.95±0.15^{d}	1.00±0.04^{ab}	0.89±0.03^{cde}	66.56±1.22^{bcd}
T_3	8.70±0.70^{b}	17.00±0.15^{ab}	7.40±0.05^{cd}	1.17±0.03^{a}	1.05±0.05^{ab}	65.18±0.48^{cd}
T_4	9.90±0.70^{ab}	15.00±0.50^{cde}	5.15±0.02^{f}	0.60±0.10^{ef}	0.82±0.03^{ef}	70.22±1.67^{ab}
T_5	9.55±0.80^{ab}	16.00±1.00^{bcd}	7.45±0.01^{c}	0.79±0.05^{cd}	0.96±0.02^{bc}	66.96±1.11^{bcd}
T_6	8.64±0.60^{b}	17.75±0.50^{a}	13.00±0.15^{a}	0.90±0.04^{bc}	1.10±0.02^{a}	59.74±0.76^{e}

Similar letter on the column and row shows a significant effect ($p<0.05$)
T_0 = 100% durum wheat semolina flour,
T_1 = 95% semolina flour + 5% potato peel powder,
T_2 = 85% semolina flour + 15% potato peel powder,
T_3 = 75% semolina flour + 25% potato peel powder,
T_4 = 95% semolina flour + 5% pea peel powder,
T_5 = 85% semolina flour + 15% pea peel powder,
T_6 = 75% semolina flour + 25% pea peel powder

Table 4. Mean for Mineral Contents (Mg/100g) of Vegetable Waste Powder-Based Paste Formulations

Treatment	Ca	Mg	K	Fe
T_0	8.50±0.40^{h}	30.30±0.30^{g}	336.00±1.70^{k}	3.60±2.9^{b}
T_1	11.00±0.60^{g}	41.60±0.50^{f}	361.50±1.50^{j}	5.15±2.8^{ab}
T_2	21.30±0.30^{e}	159.31±2.00^{d}	414.30±1.70^{f}	9.20±2.9^{ab}
T_3	35.00±0.50^{b}	341.50±2.50^{b}	497.65±2.20^{b}	12.50±2.9^{a}
T_4	12.20±0.30^{g}	43.00±0.40^{f}	377.50±1.50^{i}	5.45±2.9^{ab}
T_5	23.30±0.30^{d}	161.90±2.10^{d}	427.03±1.90^{e}	9.60±3.0^{ab}
T_6	37.60±1.10^{a}	354.50±2.70^{a}	509.10±2.30^{a}	13.00±3.0^{a}

Table 5. Mean for Nutritional Contents of Vegetable Waste Powder-Based Pasta Formulations

Treatment	DPPH	TPC (mg GAE/100g)	TFC (mg Quercetin/100g)
T_0	29.95±10.80^{b}	132.15±1.90^{j}	10.85±0.60^{i}
T_1	39.65±10.65^{ab}	147.20±1.80^{hi}	12.00±0.05^{hi}
T_2	49.00±11.00^{ab}	178.90±1.80^{e}	16.00±0.75^{e}
T_3	63.20±12.20^{a}	221.70±2.20^{a}	30.00±0.50^{a}
T_4	35.00±11.00^{ab}	141.60±1.60^{i}	11.25±0.20^{hi}
T_5	45.50±11.00^{ab}	171.00±2.00^{f}	14.70±0.10^{ef}
T_6	59.30±12.10^{ab}	207.60±2.50^{b}	27.70±0.60^{b}

Table 6. Mean for Sensory Evaluation of Vegetable Waste Powder-Based Pasta Formulations

Treatment	Color	Flavor	Texture	Aroma	Overall Acceptability
T_0	6.90±0.20^{cd}	6.90±0.50^{ab}	6.60±0.10^{cde}	6.50±0.10^{cde}	6.80±0.10^{cde}
T_1	7.20±0.20^{bc}	7.30±0.50^{ab}	6.90±0.20^{bc}	6.80±0.10^{bc}	7.00±0.10^{bc}
T_2	7.70±0.10^{a}	7.70±0.60^{a}	7.60±0.10^{a}	7.40±0.10^{a}	7.50±0.10^{a}
T_3	6.20±0.10^{ef}	6.00±0.50^{b}	5.80±0.10^{gh}	6.00±0.20^{f}	6.10±0.30^{fg}
T_4	7.10±0.20^{bc}	7.10±0.50^{ab}	6.80±0.10^{bcd}	6.60±0.10^{cd}	6.90±0.10^{bcd}
T_5	6.30±0.30^{ef}	6.80±0.50^{ab}	6.40±0.20^{def}	6.30±0.10^{def}	6.40±0.10^{efg}
T_6	5.50±0.10^{g}	6.10±0.60^{b}	5.70±0.10^{h}	5.90±0.10^{f}	5.60±0.10^{h}

Variation in different parameters is because of the utilization of different concentrations of potato and pea peels in product. Control treatment gave intermediate results. Smell and texture were not much affected. Taste of potato-added pasta was much liked up to 15% incorporation (T3 treatment) and in case of pasta with 10% incorporation of pea peel gave more acceptable results. Addition of maximum concentration of peel powders *i.e.*, 20 and 25% gave unsatisfactory results because of darker colors and unpleasant flavor.

Figure 2. Graphical abstract of development of pea and potato peel powder based pasta

4. DISCUSSION

The difference in the mean values of all parameters such as peak viscosity, final viscosity, breakdown, setback, and pasting temperature was observed because of the incorporation of varying concentrations of potato and pea peel powders.

Yang (2020) performed research to evaluate the effect of the incorporation of potato flour in pasta. He used different treatments and found that the results are significant among the treatments. He observed results in accordance with the values listed above. Sharma *et al*. (2021) examined the cooking quality and rheological properties of pasta fortified with potato powder and it was observed that the same trend was shown in their study results. The results were significant among all treatments and first increasing and then decreasing trend was observed in the study. (Nawaz *et al*. (2019) performed a study to evaluate the rheological properties of instant noodles prepared from potato powder and observed values in accordance with Tables **2** given below and significant results were observed between the treatments.

A similar trend of increasing dietary fibers in the case of vegetable flour incorporated spaghetti was observed in the study of Padalino *et al*. (2013) who observed a significant increase of insoluble dietary fibers in incorporated spaghetti than the control one. Sayed *et al*. (2014) studied the effect of onion skin powder on properties of dried and fried noodles. In this study, onion skin powder (OSP) at 2, 4, and 6% was added to noodles and proximate analysis was conducted. Results evaluated a similar increasing trend for fat, ash and fiber and a decreasing trend in the case of moisture contents by incorporation of OSP, as evaluated in the current study.

Fradinho *et al*. (2020) developed pasta by using potato peel extract and found that the fortified end product was rich in mineral contents especially calcium, magnesium, iron and potassium. They also observed that cooked pasta also contains a good amount of these minerals. Fen *et al*. (2017) also observed that the addition of potato powder to noodles improved the nutritional composition of the product including its mineral contents, thus giving a significant nutritional profile.

Sayed, Hassan and El (2014) investigated the impact of onion skin on the nutritional properties of noodles. They found a similar increasing trend in the case of minerals and evaluated that increase in the concentration of onion skin powder in noodles caused a significant rise in those mineral contents including calcium, iron, zinc, magnesium and potassium. The greatest concentration of these minerals is found in top-bottom wastes because these parts mainly constitute the roots of plants in which nutrient uptake mainly occurs.

Helal *et al*. (2020) performed an experiment to evaluate anti-oxidant potential of potato peel extract and they found greater oxidative stability of potato peel extract. The incorporation of peel extract in greater amounts gave more appreciable results. Sharma *et al*. (2021) also found similar results by incorporating potato flour in pasta and also found that more flour incorporation gave an increasing trend that is highly appreciable. The nutritional value of pasta by adding potato peel powder was observed by Sharma *et al*. (2021) and a similar increasing trend was shown in their study. It was just because of the incorporation of the greater amount of high-value vegetable powders.

Hernández-Ortega *et al*. (2013) conducted a study and examined a potential increase in the phenolic contents of cookies incorporated with carrot pomace. 30% carrot pomace was added in cookie dough that was dried in a conventional as well as in a microwave oven. In both cases, samples showed a significant rise in total phenolic contents. Sharma *et al*. (2021) conducted a study to determine the nutritional improvements and cooking quality of pasta made by incorporating potato flour. They examined the same increasing trends in their treatments due to increasing potato flour concentration. Values are also highly significant between all treatments.

Padalino *et al*. (2013) conducted a study to evaluate the nutritional profile and sensory attributes of spaghetti fortified with pea powder and for this purpose, they used pea powder in different concentrations. They found that highly significant results were obtained. Hanan *et al*. (2020) used pea powder for the preparation of instant soup powder and found that a significant result was obtained and the overall acceptability values enhanced up to the addition of 12.5% addition of pea powder in the product. Hernández-Ortega *et al*. (2013) utilized carrot pomace for the development of cookies. The study illustrated that the incorporation of carrot pomace influenced the cookies in such as way those sensorial characteristics tended to provide enhanced values. Color, texture, taste, as well as overall acceptability, showed improved results.

5. CONCLUSION

Vegetable waste powder-based pasta was developed to minimize nutrients-enrich vegetable wastes, the generation of which is among the utmost causes of environmental pollution. It was evaluated that nutritional analysis gave significant results by increasing waste powder in the recipe. Thus, mineral composition, antioxidant, total phenolic, and flavonoid contents were found to be highest for the 25% addition of potato and pea peel powders. But according to rheological and sensorial analysis, it was found that the best results were obtained for 15% and 5% incorporation of potato peels and pea peel powder, respectively, for the development of consumer-acceptable pasta strips. Thus, the present study concluded that the most acceptable results were obtained from 15% potato peel and 5% pea peel incorporation in a pasta recipe. It was suggested from this study that the development of different food products incorporated with a mixture of vegetable peel powders would be ideal. These food losses and waste are considered sufficient to prevent about one-eighth of the population from malnourishment.

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7. CONFLICTS OF INTERESTS

Authors declare no conflict of interest.

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