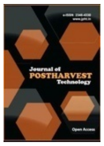

Journal of Postharvest Technology
2023, **11**(3): 75-85
www.jpht.in

RESEARCH ARTICLE

Evaluation of physico-chemical properties of developed pasta fortified with *Moringa olifera* and Amaranth leaves powder

Namrata*, Shiv Kumar

Institute of Food Technology, Bundelkhand University, Jhansi-284128, Uttar Pradesh, India

Received: 09.06.2023 Accepted: 24.07.2023

ABSTRACT

Malnutrition is turning into a serious problem in the world due to a lack of nutrient-rich diets. A staple foods like pasta, is incredibly popular but due to low in essential nutrients, it is not regarded as a healthy food. In order to increase the nutritional value of pasta, its fortification with nutrients rich sources like underutilized leafy vegetables are essential, effective and affordable approach. The current study involves the development of pasta fortified with Moringa olifera leaves powder (MLP) and Amaranth leaves powder (ALP) in different ratio which is then followed by sensory evaluation using a 9-point hedonic scale. Across all treatments groups in different ratio, C: ALP6% and C: MLP6% were scored highest sensory acceptability in comparison to other combinations. These best selected ratio were further used to evaluate their physico-chemical properties for understanding nutrients content profile. According to results, by adding these underutilized vegetables, it enhanced the nutritional value of pasta as compare to control. The current study suggested that the fortification of pasta with ALP and MLP may function as a natural health promoter and might have the potential to reduce the incidence of malnutrition in India and around the world.

Keywords: Amaranth leaf powder, fortification, moringa leaf powder, pasta, underutilized leafy vegetables

Citation: Namrata and Kumar, S. 2023. Evaluation of physico-chemical properties of developed Pasta fortified with *Moringa olifera* and Amaranth leaves powder. *Journal of Postharvest Technology,* **11**(3): 75-85.

INTRODUCTION

The development of civilization, urbanization and significant rise in population has tremendously transformed the life style and daily food habits of the people across the globe which may lead to both, the positive as well as negative consequence on their health. This has not only generated the need but also created a special place for the staple, processed ready to eat food and food products which are though rich in carbohydrates, sugar, fat, salt, and calorie but largely deficient in essential nutrients particularly in terms of macro and micronutrients like protein, fiber, vitamins and minerals etc. (Kaushik et al., 2011; Serrem et al., 2011). In view of the above, globally an urgent need is felt to develop the functional foods with sources which contains sufficient and balanced amount of essential nutrients and bioactive compounds by fortification of food, to overcome the malnutrition related problems and also to cure many comorbid conditions in low-income group population, pre-school children's and women's from rural as well as urban area (Savita et al., 2013). Fortification of food can be carried out under a well-defined

* *For correspondence*: Namrata (Email: namrata2002@gmail.com)

ISSN: 2348-4330

health policy either by the government or food manufacturers. In a similar context, the USFDA (Food and Drug Administration) has permitted the fortification of staple foods like "Pasta" which is one of the first foods, and also allowed food manufacturer to fortify their products with added nourishment like vitamins and iron (Marconi and Carcea, 2001).

Pasta is a traditional versatile dish and also well-known staple food with low glycemic index which is generally manufactured from durum wheat semolina with water however; it can also be prepared with functional as well as non-traditional ingredients as it is considered as a perfect vehicle for the addition of nutrients and make as a functional food by using nutrient rich bioactive ingredients such as phenolic compounds and dietary fibers of plants/ crops like leafy vegetables (Jenkins, 1988; Wolever et al., 1990; Bjo¨rk et al., 2000; Chillo et al., 2007; Jalgaonkar et al., 2018). Pasta and its products are made from extrusion process. They are considered as good source of energy with enough carbohydrate, starch, thiamine, iron, riboflavin, niacin and free of cholesterol and sodium but reported to be low in essential nutrients like vitamins, minerals, dietary fibers and phenolics, however, it can be fortified with essential amino acids, minerals, vitamins and phenolic compounds for increasing its nutritional value (Feillet and Dexter, 1996; Brennan et al., 2013; Ajay et al., 2018). Indeed, pasta, a staple food, is considered as an appropriate vehicle for food fortification because of worldwide consumption and acceptance, ease in preparation and transportation, sensory appeal, low costing, storage stability and properties (Marchylo and Dexter, 2001). Fortification of pasta with leafy vegetable specially underutilised vegetables is a cost effective approach.

Due to the decreased focus on their production, consumption, and utilisation, underutilised cultivars are products whose potential contribution to the national economy have not been effectively investigated. Asparagus, Amaranthus, Basella, Moringa, Ivy gourd, Globe artichoke, Kale, Broad bean, and other significant vegetable crops are underutilised. The plant species that are historically employed for their food, fibre, fodder, oil, or medicinal characteristics are the underutilised vegetable crops. However, such species have the ability to provide environmental services, revenue production, food security, nutrition, and health (nutritional/medical) services (Thakur et al., 2021).

Amaranthus plant, from family of *Amaranthaceae,* is another nutrient rich tropical plant that has been shown to have nutraceutical and bioactive potential with higher concentrations of flavonoids, poly-phenolic antioxidants, phenolic acids, proteins, soluble peptides and fibers etc. Its root, stem, leaves and seeds have been exploited tremendously to treat the multiple health related problems like pulmonary diseases, urinary disorder, gastrointestinal complications, dermatological diseases, as antihypertensive and diuretic as well (Huerta-Ocampo and Barba de la Rosa 2011; Jimoha et al., 2018). Amaranth leaves are also considered as good source of dietary fiber and minerals (manganese, iron, copper, calcium, magnesium, potassium and phosphorus) and bioactive compounds (Narwade and Pinto, 2018) indeed as per available literature, the Amaranth leaves and grains have been considered as a super food as being beneficial to almost every organ of the human body.

Moringa oleifera plant, from family of *Moringaceae,* is one of such nutrient rich natural source of essential nutrients like minerals, vitamins, dietary fibers and phenolics that can be used for the fortification of various staple and ready to eat food products as an effective remedy for fighting malnutrition. *Moringa oleifera* is universally referred to as a miracle tree or store house, the tree of life, mother's milk etc. (Wikipedia, 2020) because of excellent source of certain macro and micro nutrients, and bioactive compounds with nutraceutical or medicinal properties for human. Although every part of this plant is nutrient rich but its leaves are highly rich in minerals (calcium, potassium, zinc, magnesium, iron and copper), vitamins (A, C and E) and other essential phytochemicals such as carotenoids, toco-pherols and ascorbic acid (Gopalakrishnan et al., 2016). *Moringa oleifera* has been used even as medicine against inflammation, infections, cardiovascular, gastrointestinal, haematological, hepatic and renal disorders (Fahey, 2005; Mbikay, 2012).

It is very evident and proven that fortification of staple food like pasta using natural nutritional and bioactive ingredients sources like Moringa and Amaranth can be adopted as cost effective and a translational approach to formulate and develop the functional foods to fight nutrient deficiency based malnutrition. However, while fortifying the food for enhancing its nutritional and bioactive potential, the formulation, physical characteristics as well as functional properties of the fortified food are equally important and necessarily to be considered because of complex nature of interactions which is occurring between the food ingredients/ components (Singh et al., 2005). For example, the ratio of food fortification may vary between 1% to 50% depending on the need as well as scope of fortification and compatibility between the fortificants and the vehicle foods, therefore the physico-chemical properties of the fortificants have to be necessarily investigated and evaluated properly for formulating the functional foods for an optimized nutritional intake, and also to ensure the acceptability of food among the consumer. Similarly, the nutritional, functional and a sensory evaluation of a fortified food is also very important criteria to precisely assess the optimization and its acceptability level next to the laboratory formulation (Chadare et al., 2019).

The present study is an attempt to developed pasta fortified with these underutilized leafy vegetables such as amaranth and moringa leaves powder and evaluate on the basis of sensory evaluation. Further, the most suitable combinations of moringa and amaranth leaves powder fortified pasta were used to study their physico-chemical properties.

MATERIALS AND METHODS

Raw materials

Durum Wheat Semolina (DWS) and Refined Wheat Flour (RWF) were obtained from the local market. Amaranth Leaf Powder (ALP) and Moringa Leaf Powder (MLP) were prepared according to previous study (Namrata and Kumar, 2022; Namrata and Kumar, 2021). Fig. 1 shows the raw material used for the study.

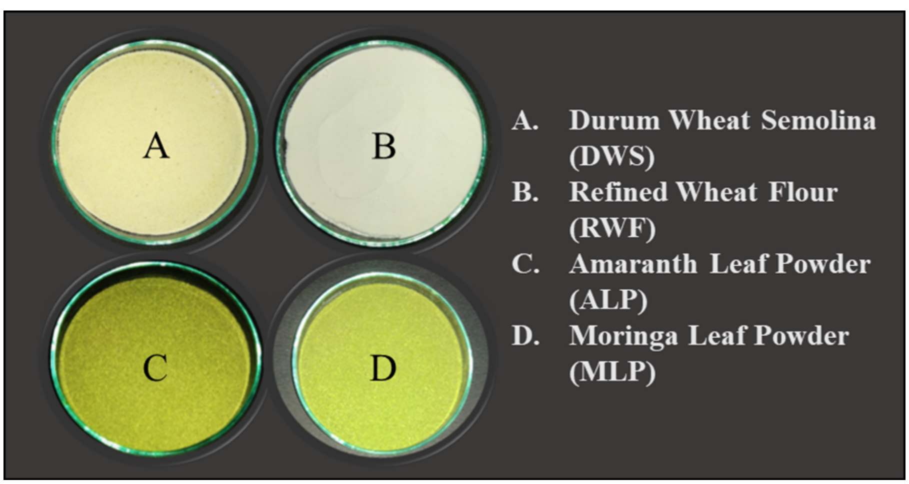

Fig. 1: Raw materials used for the study

Preparation of Pasta

Pasta samples were prepared by using serial steps including mixing, kneading, and extruding process in a pasta single unit mixer-extruder machine. The preparation of control and fortified pasta samples process starts with the mixing of different raw ingredients (flours) and water in pasta mixer-extruder machine, Model: Dolly La Monferrina, Italy, followed by kneading in to the form of dough. Subsequently, the required amount of water was added to keep the moisture content around 32-34% in the mixture. Mixing and kneading were carried out for an optimum time of around 15-30 minutes till it produces a homogeneous dough. A sharp blade cutter was then fixed in front of the die in extrusion machine and the speed of the sharp blade cutter was adjusted as per the requirement which cuts the dough in the desired size of pasta samples (Fig. 2). Finally, the control and fortified pasta samples were dried in a cabinet drier at nearly 55°C for 1.5-2 hours followed by cooling at ambient room temperature for 20-30 minutes and finally packed in commercially available air tight zip lock poly bags/ pouches (Singh et al., 2004).

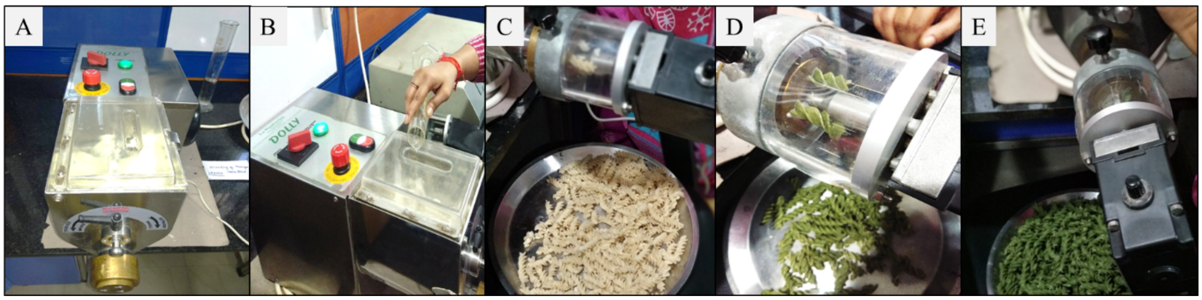

Fig. 2: Preparation of Pasta; (A) Pasta mixer-extruder machine; (B) Dough formation; (C) Control Pasta; (D) Fortified Pasta with ALP and (E) Fortified Pasta with MLP

Experimental design

In this study, the Control pasta were prepared by using Durum Wheat Semolina (70%) and Refined Wheat Flour (30%). The fortified pasta samples were prepared by using different concentration/ ratio of C: ALP and C: MLP separately while maintaining the weight proportion of control pasta (Table 1) and evaluated on the basis of sensory evaluation as per 9-point hedonic scale. Highest scoring combination of Control pasta with ALP and MLP in each group were further evaluated for their physico-chemical properties.

Table 1: Combinations/ formulations of Pasta

Treatments	Combinations	Formulations/ proportions (%)			
Fortified Pasta	C : ALP	97:03	94:06	91:09	88:12
	C : MLP	97:03	94:06	91:09	88:12

C = Control Pasta; ALP = Amaranth Leaf Powder; MLP = Moringa Leaf Powder

Sensory Analysis

Sensory attributes analysis was carried out to assess the effects of incorporation of underutilised vegetable as a source of nutrients and bioactive ingredients in pasta samples by a panel of semi-trained members. The pasta samples were cooked for the optimal cooking time for scaling these sensory attributes. This analysis was carried out by calculating 9 Point Hedonic scale Score System i.e., Colour, Texture, Taste, Flavour and Overall acceptability (OAA) of the freshly cooked pasta samples

(Ranganna, 1986). These samples were served in a random order to evaluate all the sensory attributes for each samples from 9-1 point scale, ranging from 'like extremely' to 'dislike extremely' respectively. This scale helps to find out the best pasta sample in between among the control and fortified pasta samples.

Evaluation of Physico-chemical properties

Extrusion may affect physico-chemical properties of pasta. In this study, various evaluation parameters of physico-chemical properties of developed pasta samples were shows in Table 2.

Table 2: Physico-chemical properties parameters

Parameter	Description	References
Bulk Density (BD)	Pasta samples: $BD = \frac{\text{Total weight of Pasta}}{\text{Volume occupied by Pasta}}$	(Badwaik et al., 2014)
Moisture Content (MC)	$MC\ (\%) = \frac{a - b}{c} X\ 100$ Where: a = sample weight + crucible weight (before heating) (g) b = dry sample weight + crucible weight (after heating) (g) c = weight of sample (g)	(AOAC, 2000; Sultana, 2020)
Ash (A)	$A\ (\%) = \frac{\text{Weight of ash (g)}}{\text{Weight of sample (g)}} X\ 100$	(AOAC 2000)
Crude Protein (CP)	$CP\ (\%) = \%\ \text{nitrogen}\ X\ 6.25$	(Farzana and Mohajan, 2015; AOAC, 2000)
Crude Fat (CF)	$CF\ (\%) = \frac{\text{Weight of Fat}}{\text{Weight of sample}} X\ 100$	(AOAC, 2000)
Crude Fibre (CFb)	$CFb\ (\%) = \frac{W1 - W2}{W} X\ 100$ Where: W = weight of sample W1 = sample weight + crucible weight (before heating) W2 = dry sample weight + crucible weight (after heating)	(AOAC, 2000; Farzana and Mohajan, 2015)
Carbohydrate (C)	$C\ (\%) = 100 - [\text{moisture\%} + \text{fat}\ (\%) + \text{ash\%} + \text{crude fibre\%} + \text{crude protein\%}]$	(Onwuk, 2005)
Energy Value (E)	$E\ (\%) = [(\text{Crude Protein}\ X\ 3.99) + (\text{Lipid}\ X\ 9.1) + (\text{Carbohydrate}\ X\ 3.99)]$	(Onwuk, 2005)

Statistical Analysis

Three independent observations of each sample for each test were taken and mean of these observations was used for statistical analysis i.e., the calculation of SD and p-value and the data obtained were subjected to analysis of variance (ANOVA).

RESULTS AND DISCUSSION

Sensory evaluation (as per 9 point hedonic scale)

Standardization of control and fortified pasta formulations was carried out on the basis of sensory evaluation (on a 9 point hedonic scale). All the selected best combination on the basis of sensory evolution was further used for various quality parameters. The sensory evaluation of pasta is one of the most decisive parameters in determining the quality of pasta which is carried out by analysing different sensory attributes of the cooked pasta. Sensory analysis using semi-trained panellists is considered as an important tool for assessing the quality of pasta products (Dick and Matsuo 1988). Sensory analysis of the freshly cooked control pasta as well as control pasta fortified with ALP and MLP were carried out on a 9-point hedonic scale with the help of a panel of 10 semi-trained members (Ranganna, 1986).

The sensory analysis of control pasta (T) prepared with combination of DWS (70%) and RWF (30%) and fortified pasta by maintaining weight of control pasta with different proportions of ALP and MLP i.e., T1 (3%), T2 (6%), T3 (9%) and T4 (12%) are shown in fig 3. The results shows that, the consumer acceptability were ranges from 6 to 9 in fortified pasta with ALP and 7 to 9 in fortified pasta with MLP. In the both groups of fortified pasta, the proportion of T2 were found most acceptable as per overall acceptability under 9-point hedonic scale. Hence, the proportion of T2, from both groups, were used for the detailed study on physico-chemical properties of developed fortified pasta. The high ranked prepared pasta samples were shown in fig. 4.

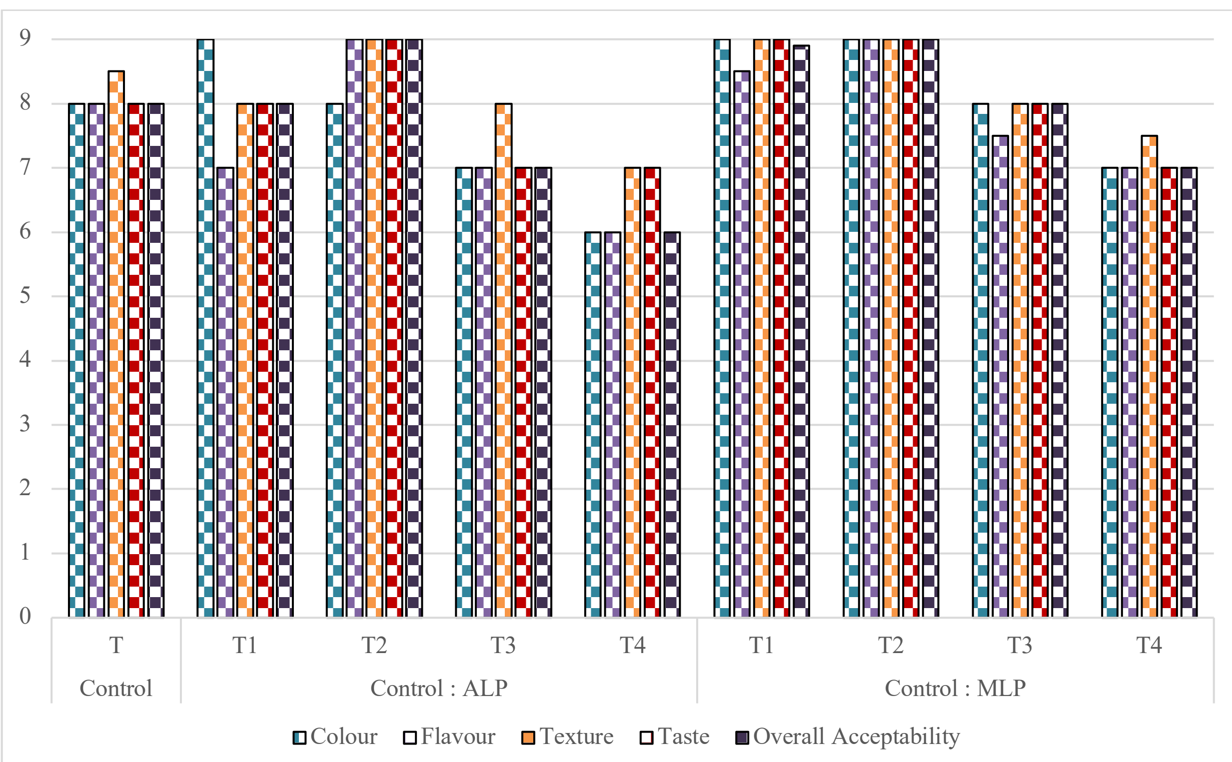

Fig. 3: Sensory analysis (as per 9 point hedonic scale) of Control and developed fortified pasta

Control (C) **C: ALP 6%** **C: MLP 6%**

Fig. 4: Consumer acceptable best formulation of developed pasta samples

Analysis of Physico-chemical properties

Raw materials

The type of raw materials used in the making of pasta affects the nutritional value and energy level of the food. To improve the value of pasta, additives, such as protein concentrates, yeast, milk and vegetable additives, are used (Jayasena and Nasar-Abbas, 2012). The proximate composition of raw ingredients has been tested accordingly (Fig. 5) and found underutilised vegetables like Amaranth and Moringa leaf powder are rich source of fibre, protein and ash etc.

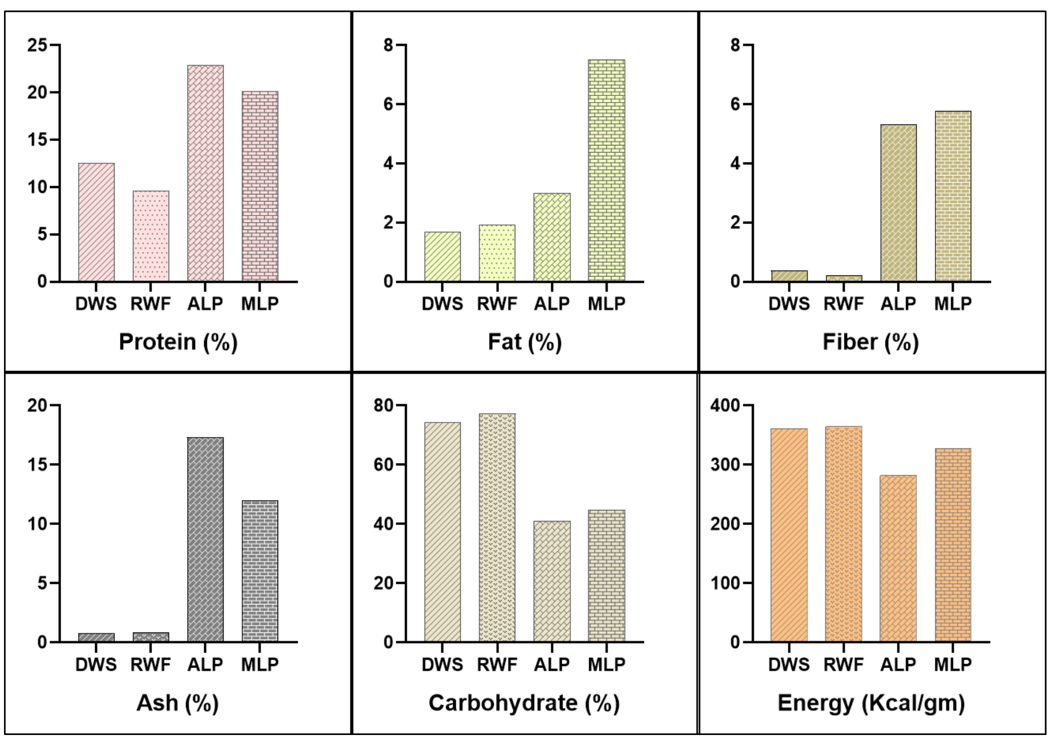

Fig. 5: Proximate compositions of raw ingredients

All the selected best combination on the basis of sensory evolution was further used for evaluation of physico-chemical properties of prepared pasta. Extrusion process may affect physico-chemical properties of pasta. Results shows that the physico-chemical properties of developed pasta fortified with ALP (94:06) and MLP (94:06) is expected to be significantly altered by the starch, fibre and protein content of the raw ingredients among the control and fortified pasta sample. The utilization of different ingredients to make pasta can produce interesting qualitative characteristics that change the dietary nature of the various formulations. The physical, chemical, and textural aspects of the pasta are directly influenced by the raw material compositions (Nilusha et al., 2019).

The physico-chemical properties of developed control and fortified pasta samples is shown in table 3. Bulk density is one of the most important characteristic of the pasta which significantly impact on its commercialization. The higher bulk density may be due to presence of high fibre content in the pasta blends and crude fibre in the composite blend samples (Sawant et al., 2013; Dayakar et al., 2015). The observations indicated that the bulk density was ranges from 0.26 to 0.28gm/ml.

The moisture content of control and pasta incorporated with underutilized vegetables were ranged from 10.4 to 11.03%. Maximum moisture content was found in pasta fortified ALP (6%) and minimum was found in control pasta. The drying procedure and time have an impact on the moisture content of pasta products.

Ash content ranged from 0.78 to 1.96%. Ash content which is an indicator of minerals was found maximum in fortified pasta (C: ALP6%) as compared to control. This may be due to the green leaves contributing to ash content. Food products like biscuit, mathi, matar and sev that were incorporated with amaranth leaf powder contained more ash content (Singh et al., 2009).

The protein content of pasta ranged from 12.37 to 12.88% .Significantly highest protein content was found in fortified pasta (C: ALP 6 %) however it is minimum in control.

The fat content of pasta samples ranged from 1.47 to 1.88%. The maximum fat content was found in fortified pasta (C: MLP6%) as compared to control. Fat content was very low in all developed Pasta samples because used raw ingredients have very less fat content and no-additional fat was used, during the preparation of pasta. Low fat content might be due to presence of powder of leafy vegetables.

Crude fiber was found between 0.38 to 0.65%. In comparison to developed fortified pasta samples, it is lowest in control. These result clearly indicates that the green leaves powder present in the fortified pasta had contributed to the crude fiber content.

Carbohydrate and energy content ranged from 71.76 to 74.59 g and 353.82 to 360.39 kcal respectively. High carbohydrate and energy content was found in control in comparison to fortified pasta samples. This might be due to application of carbohydrate rich raw ingredients in preparation of control pasta, whereas fortified pasta products exhibited lower carbohydrate and energy content as the green leave powder are deprived in carbohydrate but rich in fibre and minerals (Veena et al., 2019).

The observations from the study of physico-chemical properties of developed pasta samples clearly indicated that the level of protein, fat, fiber and ash values were increased with the incorporation of underutilised vegetables Moringa olifera and amaranth (ALP and MLP) which are rich source of protein, fiber and bioactive compounds as compared to control pasta. These observations somewhat in line with the observations reported by Jalgaonkar et al. (2018). However, there might be some losses in physico-chemical properties in developed pasta when compared to raw ingredients. This might be due to extrusion and other processing operations.

Table 3: Assessment of Physico-chemical properties of Control and developed pasta fortified with ALP (94:06) and MLP (94:06)

Parameter	Control	Control + ALP (94:06)	Control + MLP (94:06)
Bulk Density (gm/ml)	0.27±0.01	0.28±0.01	0.26±0.00
Moisture Content (%)	10.4±0.63	11.03±0.57	10.83±0.32
Ash (%)	0.78±0.03	1.96±0.06	1.53±0.17
Crude Protein (%)	12.37±0.99	12.88±0.50	12.43±1.29
Crude Fat (%)	1.47±0.11	1.77±0.04	1.88±0.06
Crude Fibre (%)	0.38±0.03	0.60±0.08	0.65±0.04
Carbohydrate (%)	74.59±1.33	71.76±1.10	72.68±1.64
Energy Value (Kcal/gm)	360.39±3.16	353.82±2.16	356.73±1.96

Values are Mean ± SD of observations from three independent experiments

CONCLUSION

Fortification is a one of the approaches to optimize the bioavailability of essential micronutrients to the consumers in the form of functional foods however; the fortification is not limited to provide only nutritional support, but also to fulfil the sensory, biological and physico-chemical requirements in staple foods. Sensory analysis indicated that the Control pasta fortified with ALP (6%) and MLP (6%) scored highest 9 points on hedonic scale and therefore considered and selected for further studies of physico-chemical properties. The result of these quality characteristics shows the slight increase in nutritive value (protein, fat, fibre and ash) in fortified pasta samples using underutilised vegetables moringa and amaranth as compare to Control pasta. Collectively, the present study suggested that the fortification of pasta with ALP and MLP can be opted as one of the cost effective approaches for enhancing the nutritional properties of pasta with natural resources which are easily available in economical manner.

ACKNOWLEDGEMENT

The authors are grateful to the Institutes of Food Technology, Bundelkhand University, Jhansi, India, for allowing to carry out the experimental work, and also all the panellists for the sensory evaluation of Pasta samples.

REFERENCES

Ajay, S., Desai, M., Brennan, A. and Charles Brennan, S. 2018. Effect of fortification with fish (pseudophycis bachus) powder on nutritional quality of durum wheat pasta. Foods, 7(4), 1–12.

AOAC. 2000. Official Methods of Analysis. 17th Edition, The Association of Official Analytical Chemists, Gaithersburg, MD, USA. Methods 925.10, 65.17, 974.24, 992.16.

Badwaik, L. S., Prasad, K. and Seth, D. 2014. Optimization of ingredient levels for the development of peanut based fiber rich pasta. Journal of Food Science and Technology, 51(10), 2713–2719.

Björck, I., Liljeberg, H. and Östman, E. 2000. Low glycaemic-index foods. British Journal of Nutrition, 83(S1), S149-S155.

Brennan, M. A., Derbyshire, E., Tiwari, B. K. and Brennan, C. S. 2013. Ready-to-eat snack products: the role of extrusion technology in developing consumer acceptable and nutritious snacks. International Journal of Food Science and Technology, 48(5), 893-902.

Chadare, F. J., Idohou, R., Nago, E., Affonfere, M., Agossadou, J., Fassinou, T.K., Kénou, C., Honfo, S., Azokpota, P., Linnemann, A. R. and Hounhouigan, D. J. 2019. Conventional and food-to-food fortification: An appraisal of past practices and lessons learned. Food Science and Nutrition, 7(9), 2781-2795.

Chillo, S., Laverse, J., Falcone, P. M. and Del Nobile, M. A. 2007. Effect of carboxymethylcellulose and pregelatinized corn starch on the quality of amaranthus spaghetti. Journal of Food Engineering, 83(4), 492-500.

Dayakar, R. B., Bhargavi, G., Kalpana, K., Vishala, A. D., Ganapathy, K. N. and Patil, J. V. 2015. Development and standardization of sorghum pasta using extrusion technology. Journal of Food Science and Technology, 52(10), 6828–6833.

Dick, J. W. and Matsuo, R. R. 1988. Durum wheat and pasta products. Wheat: Chemistry and technology, 2, 507-547.

Fahey, J. W. 2005. Moringa oleifera: A Review of the medical evidence for its nutritional, therapeutic, and prophylactic properties. Part 1. Tress for Life Journal, 1, 1–33.

Farzana, T. and Mohajan, S. 2015. Effect of incorporation of soy flour to wheat flour on nutritional and sensory quality of biscuits fortified with mushroom. Food Science and Nutrition, 3(5), 363–369.

Feillet, P. and Dexter, J. E. 1996. Quality requirements of durum wheat for semolina milling and pasta production. In: Kruger, J. E., Matsuo, R. R., and Dick, J. W. eds. Pasta and noodle technology, American Association of Cereal Chemists. St. Paul, M.N., USA, pp. 95–131.

Gopalakrishnan, L., Doriya, K. and Devaraj, S. K. 2016. Moringa oleifera: A review on nutritive importance and its medicinal application. Food Science and Human Wellness, 5, 49–56.

Huerta-Ocampo, J. A. and Barba de la Rosa, A. P. 2011. Amaranth: a pseudo-cereal with nutraceutical properties. Current Nutrition and Food Science, 7, 1–9.

Jalgaonkar, K., Jha, S. K. and Mahawar, M. K. 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. Journal of Food Processing and Preservation, 42(4), 1–11.

Jayasena, V. and Nasar-Abbas, S. M. 2012. Development and quality evaluation of high-protein and high-dietary-fiber Pasta using lupin flour. Journal of Texture Studies, 43, 153–163.

Jenkins, A. L. 1988. Starchy foods and glycemic index. Diabetes Care, 11, 149–159.

Jimoha, M. O., Afolayana, A. J. and BayoLewu, F. 2018. Suitability of Amaranthus species for alleviating human dietary deficiencies. South African Journal of Botany, 115, 65–73.

Kaushik, J. S., Narang, M. and Parakh, A. 2011. Fast food consumption in children. Indian Pediatrics, 48(2), 97–101.

Marchylo, B. A. and Dexter, J. E. 2001. Pasta production. In: Owens, G. ed. Cereals Processing Technology. Boca Raton, FL: CRC Press, pp. 109–130.

Marconi, E. and Carcea, M. 2001. Pasta from No-Traditional Raw Materials. Cereal Foods World, 46, 522–530.

Mbikay, M. 2012. Therapeutic potential of Moringa oleifera leaves in chronic hyperglycemia and dyslipidemia: a review. Frontiers in Pharmacology, 3, 1–12.

Namrata and Kumar, S. 2021. Effect of fortification of Pasta with natural immune booster Moringa Oleifera leaves powder (MLP) on Cooking Quality and Sensory analysis. Sustainability, Agri, Food and Environmental Research, 9(3), 408–424.

Namrata and Kumar, S. 2022. Organoleptic and Cooking Quality Analysis of Pasta Fortified with Dried Leaves Powder of Amaranth and Moringa. International Journal of Food and Nutritional Sciences, 11, 21–25.

Narwade, S. and Pinto, S. 2018. Amaranth—a functional food. Concepts of Dairy and Veterinary Sciences, 1(3), 1-4.

Nilusha, R. A. T., Jayasinghe, J. M. J. K., Perera, O. D. A. N. and Perera, P. I. P. 2019. Development of Pasta Products with Nonconventional Ingredients and Their Effect on Selected Quality Characteristics: A Brief Overview. International Journal of Food Science, 1–10.

Onwuk, G. I. 2005. Food analysis and instrumentation; theory and practice. Naphthali Prints, pp. 133–137.

Ranganna, S. 1986. Handbook of analysis and quality control for fruits and vegetables. Tata Mc. Graw Hill Publishing Company Limited. New Delhi-110, 7, pp. 9-10.

Savita, S., Arshwinder, K., Gurkirat, K. and Vikas, N. 2013. Influence of different protein sources on cooking and sensory quality of pasta. International Journal of Engineering Research and Applications, 3(2), 1757–1763.

Sawant, A. A., Thakor, N. J., Swami, S. B., Divate, A. D. and Vidyapeet, B. S. 2013. Physical and sensory characteristics of ready-to-eat food prepared from finger millet based composite mixer by extrusion. Agricultural Engineering International: CIGR Journal, 15(1), 100-105.

Serrem, C., Kock, H. and Taylor, J. 2011. Nutritional quality, sensory quality and consumer acceptability of sorghum and bread wheat biscuits fortified with defatted soy flour. International Journal of Food Science and Technology, 46(1), 74–83.

Singh, B., Singh, B. K., Kumar, J., Yadav, S. S. and Usha, K. 2005. Effects of salt stress on growth, nodulation, and nitrogen and carbon fixation of ten genetically diverse lines of chickpea (Cicer arietinum L.). Australian Journal of Agricultural Research, 56, 491– 495.

Singh, S., Punia, D. and Khetarpaul, N. 2009. Nutrient composition of products prepared by incorporating amaranth (Amaranthus tricolour) leaf powder. Nutrition and Food Science, 39(3), 218-226.

Singh, S., Raina, C., Bawa, A. and Saxena, D.C. 2004. Sweet potato based Pasta product: optimization of ingredient levels using RSM. International Journal of Food Science and Technology, 39, 191–200.

Sultana, S. 2020. Nutritional and functional properties of Moringa oleifera. Metabolism Open, 8, 100061.

Thakur, S., Katoch, V. and Pathania, P. 2021. Underutilized and Unexploited Vegetable Crops: Scope and Importance in Future Food Supplies. Just Agriculture, 1(11), 1–8.

Veena, B. M., Shivaleela, H. B. and Ravidra, U. 2019. Enhancement of nutritional quality of pasta by incorporating underutilized greens. Journal of Pharmacognosy and Phytochemistry, 8(4), 3118–3121.

Wikipedia 2020. Moringa oleifera. Available at: https://en.wikipedia.org/wiki/Moringa_oleifera.

Wolever, T. M., Jenkins, D. J. and Wolever, T. M. 1990. The Glycemic Index. World Review of Nutrition and Dietetics, 62, 120–185.

.