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FORTIFICATION OF PASTA WITH AMARANTH LEAF POWDER AND DEFATTED SOY FLOUR: EFFECTS ON PHYSICAL, COOKING AND SENSORY CHARACTERISTICS

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ABSTRACT

Natural nutritional resources like cereals, legume, fruits and vegetables contains plenty of nutrients as antioxidants, vitamins, dietary fibres, minerals, proteins and phenolic compounds. Incorporation of these nutritional resources in staple foods like pasta increases nutritional as well as functional value for health improvement or disease prevention. Amaranthus and Soy has been traditionally considered as an important functional component in ancient meals, and are also popular crops due to its high nutritional value and easy availability which suggests their incorporation in main stream meals and snacks to fight malnutrition. In the current study, an attempt has been made to fortify the pasta with varying proportion of Amaranth Leaf Powder (ALP) and Defatted Soy Flour (DSF) alone and in combination with Control pasta to improve the nutritional components. Since, the fortification may affect the different properties of pasta, therefore the sensory, cooking and physical properties (flours) of the Control and fortified pasta were studied. Results of this study indicated that the Control pasta fortified with DSF (16%) and ALP (6%) alone and in-combination {Control: DSF (16%): ALP (6%)} scored highest sensory acceptability in comparison to other combinations. Control pasta with DSF (16%) shown the maximum bulk density and swelling capacity. The maximum gluten content was found in Control pasta as compared to other groups. There was minimum gruel loss observed in case of Control: DSF in comparison to other fortified groups. Taken together, the current study suggested that the fortification of pasta with DSF and ALP could be one of the potential approaches for enhancing the nutritional value with the highest acceptability of staple food like pasta particularly in respect of ease of preparation, sensory appeal, long storage capability and cost effectiveness.

Keywords: Amaranth Leaves Powder (ALP), Defatted Soy Flour (DSF), Durum Wheat Semolina, Fortification, Natural Ingredients, Pasta.

1. INTRODUCTION

Most of the world population likes to eat pasta especially women and childrens. Pasta is a staple food of traditional Italian cuisine. Staple foods are required to be fortified with nutritional ingredients to enhance its nutritional value, and since they are more popular among every age groups it may lead to a good health status as well. Pasta preparation includes some unit operations like making of dough by mixing, kneading, extruding and drying procedure. Extruder; an equipment used for the pasta production, is based on auger extrusion principle in which kneading and extrusion are performed in a single operation [1]. Traditionally, it is manufactured from durum wheat semolina as a main component. Earlier studies suggested that durum wheat is a best suitable raw material for pasta production [2]. Pasta is known as a good source of starch and carbohydrates, thiamine, iron, riboflavin and niacin and it is also cholesterol free but it is not accepted as a healthy food because it is deficient in protein (in lysine), fat, dietary fibre and some other nutrients [2, 3]. This gives an opportunity for the use of non-traditional raw materials to increase the nutritional value of pasta [4]. So there is a need to fortified staple foods with other nutrients like fibre and protein etc. by using natural ingredients.

Leafy vegetables are very good source of dietary fibre, minerals, vitamins and bioactive components. They can substantially improve nutrients level of the various popular staple foods. Some green leafy vegetable also have nutraceutical properties. Hence, their use in the staple foods is an optimistic approach to combat micronutrient deficiencies [5]. Amaranth is a fibre rich, diverse short lived veggie plant. It is widely used in foods in various forms like vegetable, leaf powder (Dry) and seed flour in meals, dessert and in snacks. Amaranth is a third-millennium tropical food plant known as pseudo-cereal, it is considered as super food because it is a leading resource of fibre, minerals, vitamin, bioactive compounds, though it is an ignored and underutilised crop. It belongs from genus *Amaranthus* (L.) family Amaranthaceae (around 70 species found) and cultured for grain and vegetable which have therapeutic potential and some time used as ornamental plant also [4, 6, 7].

Soy is known for highly rich plant protein source. It has been consumed in various forms in meals or snacks like tofu, soy milk, soy sauce, soy flour etc. Soy provides all 9 essential amino acids (such as lysine, threonine etc.), functional ingredients, plentiful of antioxidants, vitamins, minerals to human body. Use of soy in the form of Defatted soy started in 1930. Defatted soy (Fat-free) is a significant and low cost source of protein. In previous research studies, it is reported that soya flour was used in baked products, extruded products and deep fat- fried snacks which were made from cereal and legume flours. Various snacks, fortified with different flour like sesame, soy, defatted soy flour blend etc. in different proportion were sensorial evaluated and found widely accepted. Different plant proteins like mushroom and defatted soy flour were incorporated for the fortification of pasta [8, 9]. In literature earlier studies reported that consumption of soybean products reduces various serious diseases like cancer, blood serum cholesterol, and heart disease. Soy bean is beneficial for health prospective as it contains proteins (40%), minerals (5%), and B vitamins for human nutrition which makes it a demanding bean [10]. Soybean; also known as miracle bean is widely being used against protein malnutrition scenario.

Present study was conducted with an aim to develop fortified pasta with fibre and protein rich materials by using a green leafy vegetable Amaranth and Soy Flour (defatted) and further evaluated their physical, cooking and sensory parameters. Incorporation of such ingredients in pasta may increase its nutritional as well as functional properties.

2. MATERIAL AND METHODS

The details of materials and methodologies is described under following sections to evaluate the physical properties (flours), cooking quality parameters and sensory analysis of pasta fortified with defatted soy flour (DSF) and amaranth leaf powder (ALP).

2.1. Raw materials

Raw materials used in current study were, Durum Wheat Semolina (DWS), Refined Wheat Flour (RWF), Defatted Soy Flour (DSF), Amaranth leaves powder (ALP) and water. Good quality commercially available refined wheat flour, durum wheat semolina, defatted soy flour (DSF) and the fresh and healthy leaves of amaranth were purchased from market.

2.2. Preparation of Amaranth Leaf Powder(ALP)

Amaranth leaf powder was prepared by using the vegetable from local market. Fresh and healthy leaves were selected manually to be used for further process at the same time damaged leaves were discarded. Selected fresh leaves were washed and rinsed gently in the tap water for the removal of all kind of dirt and dust. Removal of excess water was carried out by spreading the leaves on a perforated tray for 10-15min. Leaves were dried in a cabinet drier at 25-30°C for 5-6 hrs followed by cooling at room temperature for around 30 min. [11]. After drying, leaves were ground into a fine powder and screened using fine pore size stainless steel sieve. The powder was then quickly stored in airtight polythene packaging bags (Fig. 1).

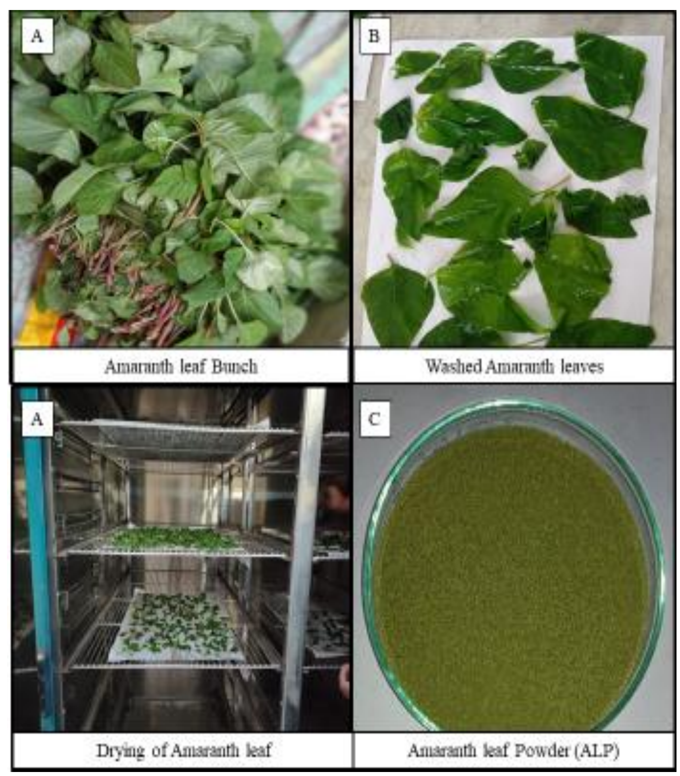


Fig. 1: (A)Bunch of Fresh leaves, (B) Washed Amaranth Leaves, (C) Drying of Amaranth Leaves, (D) Amaranth Leaves Powder (ALP)

2.3. Experimental design

The Control and fortified pasta samples were made by using different concentrations of Durum Wheat Semolina, Refined Wheat Flour (RWF), Defatted Soy Flour (DSF), and Amaranth Leaf Powder (ALP) with the help of water (32 to 34%). The selection of raw materials for pasta preparation is a very critical part out of the entire process as their composition as well as physical properties can directly affect the physiochemical properties of end product [12]. In the current study, an attempt was made to fortify the control pasta (contains durum wheat semolina, refined wheat flour and water) with varying proportion of ALP and DSF each separately and in combination. Initially, the Control pasta was fortified with different proportions of ALP (3, 6, 9 and 12%) and DSF (4, 8, 12, 16 and 20%) independently while maintaining the weight proportion of control pasta. Control pasta fortified with best proportion of DSF as evaluated by sensory acceptability, was further incorporated with different proportions of ALP (3, 6, 9 and 12%). Based on sensory acceptability, the best combination of control pasta with DSF and ALP alone as well as in-combination was further evaluated for its physical characteristics and cooking quality parameters.

2.4. Preparation of Control pasta (Control) and Fortified Pasta

Preparation of Control and fortified pasta was started with mixing of different raw materials, flours and water in pasta mixer-extruder machine (Model: Dolly La Monferrina, Italy) followed by kneading in to a dough. Required amount of water was added to keep the moisture content around 32-34% in mixture. Mixing and kneading was done for an optimum time of 20-30 min till it produced homogeneous dough.

Fig. 2: (A) Control, (B) Control + ALP, (C) Control + DSF, (D) Control + DSF + ALP

A sharp blade cutter was fixed in front of the die in extrusion machine and the speed of the sharp blade cutter was adjusted as per requirement which cut the dough in the desired shape of pasta. The Control and fortified pasta samples were dried in cabinet drier at around 55°C for 90-120min. followed by cooling at ambient room temperature for around 20-30min (Fig. 2) and then packed in commercially available zip poly bags pouches [13].

2.5. Quality characteristics

The prepared Pasta was tested for various quality parameters.

2.5.1. Sensory evaluation of developed Pasta

Sensory analysis of cooked Pasta was carried out by using nine point hedonic scales [14] by semi- trained panel of 10 members. Various parameters like colour, flavour, texture, taste and overall acceptability were taken for analysis and average of these parameters was recorded.

2.5.2. Physical parameters

The Physical properties of developed Pasta blend flours were conducted as bulk density, swelling capacity and gluten content.

2.5.2.1. Bulk Density

Bulk Density of the Pasta blends flour samples was determined. A sample (10 g) was put in a calibrated 25 ml measuring cylinder and the initial volume was recorded. The bottom of the cylinder was tapped repeatedly on a firm pad on a laboratory bench until a constant volume was observed. The volume in measuring cylinder was recorded as final volume. The bulk density was calculated as the ratio of the sample weight to the volume occupied by the sample after tapping [15].

2.5.2.2. Gluten content

For the evaluation of the Gluten content in pasta blend flour, 50 gram of flour was taken from each sample and dough was prepared by adding sufficient amount of water. Prepared dough was dipped in the water for an hour. Each dough was then washed in the running water to squeeze off the starch and fibre part. Washing was done until squeezed water runs clear. After washing, excessive water was squeezed and dried in hot air oven at 100°C for 1 h. Weight of dried gluten was taken and gluten content was calculated by the following equation [16, 17].

Gluten content %= [Weight of dry gluten (g)/Weight of flour (g)] ×100

2.5.2.3. Swelling capacity (ml/g)

The swelling capacity was determined by the method described earlier [15, 18]. A graduated cylinder (100 ml) was filled with the sample up to 10 ml mark and quantity of sample was weighed. The distilled water was added to give a total volume of 50 ml. The top of the graduated cylinder was tightly covered and mixed the flour and distilled water by inverting the cylinder. The suspension was inverted again after 2 min and left to stand for a further 8 min. After 8th min the volume occupied by the sample was recorded.

2.5.3. Cooking parameters of developed Pasta

Cooking properties is considered as the most important quality characteristics of pasta. Optimum Cooking time (OCT), cooked weight, water absorption, swelling index and cooking loss/Gruel loss are the parameters conducted as they express the cooking quality of Pasta.

2.5.4. Optimum Cooking Time (OCT)

Optimum cooking time (minutes) for each sample was determined according to the AACC [16]. Pasta (10 g) was cooked in 100 ml of boiling distilled water and analysed every minute until it reached the optimum cooking time, considered as the time necessary to obtain complete gelatinisation of starch and it is shown by the disappearance of the white central core, after having pressed the pasta strand between two transparent glass plates [19-22].

2.5.5. Weight of cooked Pasta

Sample of pasta (10g) was placed into 100 ml of boiling distilled water in a 500 ml beaker. The samples were analysed for their cooked weight ascertained by the following equations [23]:

Cooked weight = [weight of cooked pasta (g)/weight of uncooked pasta (g)]×100

2.5.6. Water Absorption

Water absorption of cooked pasta was determined after draining [20, 24, 25].

Water Absorption = [(Weight of cooked pasta - weight of raw pasta)/ weight of raw pasta] × 100

2.5.7. Swelling Index

Swelling index of cooked pasta was measured by using the method described by Tudorica [21]. Swelling Index of cooked pasta (SI; grams of water per gram of dry pasta) was evaluated by drying pasta samples to constant weight
at 105°C, expressed as:

[Weight of cooked product (W1)-Weight after drying (W2)]/Weight after drying (W2)

2.5.8. Cooking Loss

Cooking loss/Solid Gruel in the cooking water collected from each sample was determined by evaporation to constant weight in a hot air oven at 103°C. The dried residue was weighed and calculated according to the following expression [20, 22, 24].

Cooking Loss = [Weight of cooking water dried residue/Weight of raw pasta] × 100

2.6. 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 t-test and analysis of variance (ANOVA).

3. RESULTS AND DISCUSSION

3.1. Sensory Analysis

The sensory evaluation of pasta is one of the most important factors in determining the acceptance of pasta products on the basis of sensorial performance for its promotion and future commercialization. It is one of the utmost significant parameters for assessing the quality of pasta products, which allows evaluating the overall attributes of cooked pasta. In this study, the sensory analysis of freshly cooked pasta in various combinations with control pasta was carried out using 9 point hedonic scale with the help of a panel of 10 semi-trained evaluators from the Institute. The Control and fortified pasta samples were evaluated separately for the sensory parameters like colour, flavour, texture, taste and overall acceptability by the each panellist. The effect of the fortification of control pasta with ALP and DSF on sensory parameters is presented in table 1. The observations indicates the sensory parameters for all best scored combination in their treatment groups i.e. Control pasta with ALP and DSF alone and in combination (Control: DSF: ALP). The Control: ALP, Control: DSF and Control: DSF: ALP, scored positively and ranges between 8.6 to 9 score in total average of all attributes, suggesting a good acceptance of fortification with DSF & ALP by the panellists (Fig. 3). The Control pasta fortified with combination of DSF and ALP found to relatively have lesser score as compared to Control with other groups. Taken together these observations show that the Control pasta fortified with DSF resulted in the most acceptable combination.

Table 1: Sensory analysis of prepared pasta

Sensory	Colour	Flavour	Texture	Taste	Overall Acceptability	Average of all Parameters
Control	8	8	8.5	8	8	8.1
Control: ALP (6%)	8	9	9	9	9	8.8
Control: DSF (16%)	9	9	9	9	9	9
Control : DSF (16%) :ALP (6%)	9	9	8	8	9	8.6

Sensory analysis of cooked Pasta was done by semi- trained panel of 10 members.

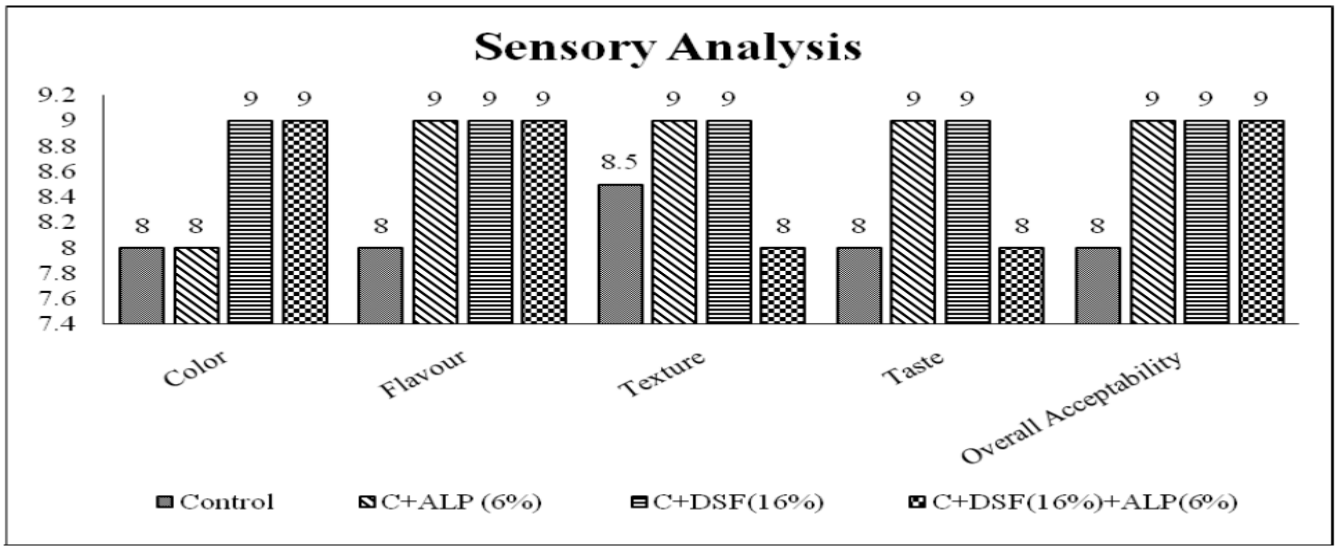
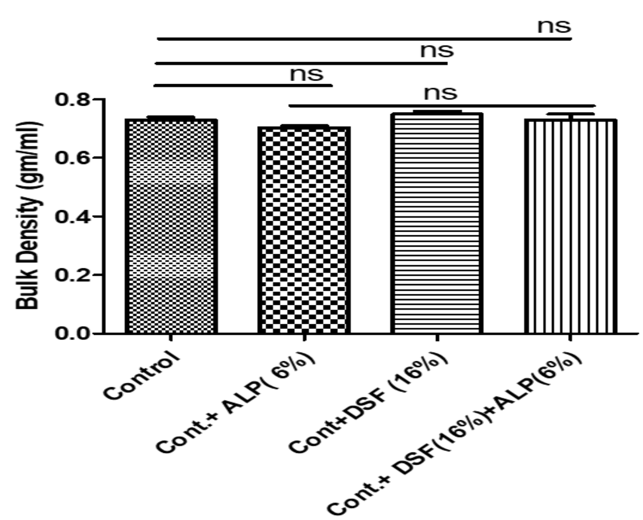


Fig. 3: Graphical representation of Sensory analysis of prepared pasta

3.2. Physical properties

3.2.1. Bulk Density

Bulk density is one of the most important characteristics of the pasta which significantly impacts on its commercialization. Bulk density is expected to significantly alter by the starch, fibre, protein and gluten content of the raw pasta flour. The higher bulk density may be due to the presence of high fibre content in the pasta blends and crude fibre in the composite blend samples [26, 27]. In the current study, observations indicated that the bulk density was slightly different among the treatment groups i.e. Control, ALP, DSF and the combination of it. The bulk density ranges from 0.71 to 0.75gm/ml (Fig. 4). The observed bulk densities among these groups clearly suggest that the size as well as the nature of the ingredient e.g. starch, fibre and protein, present in different treatment groups, possibly affects their mutual interactions during pasta making process and leading to the differential bulk density of Control, ALP, DSF and combinations groups.

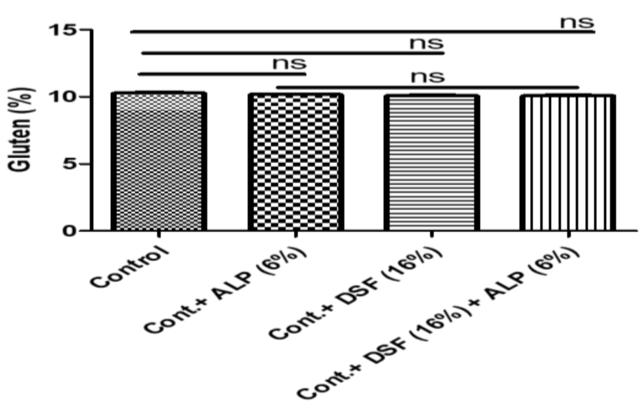


*Values are Mean (±1 SD) of three observations from independent experiments. Significance of difference is calculated among Control Vs. Treatments Groups and between the treatments (ns= non-significant, *p<0.05 , **p< 0.01, ***p<0.001)*

Fig. 4: Bulk Density

3.2.2. Gluten content

In pasta products, the starch network and the gluten protein considerably defines the quality of pasta and these are directly correlated with the starch composition and protein content of the pasta ingredients e.g. glutenin and gliadin are the two main components of gluten. In water, glutenin and gliadin form a strong gluten network which is typical for wheat flour. This gluten network forms uniform and compact system with swelled starch granules during the cooking process. The competitive behaviour between protein coagulation and starch swelling, determines the cooking quality and textural characteristics of pasta [12]. It has been reported earlier that the gluten content is decreased with the increased level of fortification. This may be due to the replacement of wheat flour with blend material, leading to the dilution of gluten in fortified pasta sample. Also, glutenin and prolamin are the main components of gluten which provide viscosity, extensibility, elasticity and cohesive properties of dough [28]. In the present study, the observations indicated that the gluten content among the different groups ranges from 10.0% to 10.2% (Fig. 5). The differences in gluten percent were not significant among these groups but might be contributing towards the gelatinization, swelling capacity and water absorption of the pasta blends.



*Values are Mean (±1 SD) of three observations from independent experiments. Significance of difference is calculated among Control Vs. Treatments Groups and between the treatments (ns= non-significant, *p<0.05 , **p< 0.01, ***p<0.001)*

Fig. 5: Gluten Content (%)

3.2.3. Swelling Capacity

The swelling capacity of raw flours depends on the size of the flour particles, flour types and processing methods as well as instrument/unit operations e.g. the flour of parboiled rice has more swelling capacity as compared to raw rice [29]. There are various methods available to assess the flour or starch swelling properties. The observations indicated that the swelling capacity among different treatment groups ranges from 3.0 to 3.3ml/gm (Fig. 6). Importantly, the size and nature of the flour particles may significantly contribute in cooking properties like cooking time, cooking loss, cooking weight, water absorption and swelling index etc., by influencing the mutual interaction among the ingredients during the pasta making and cooking process.

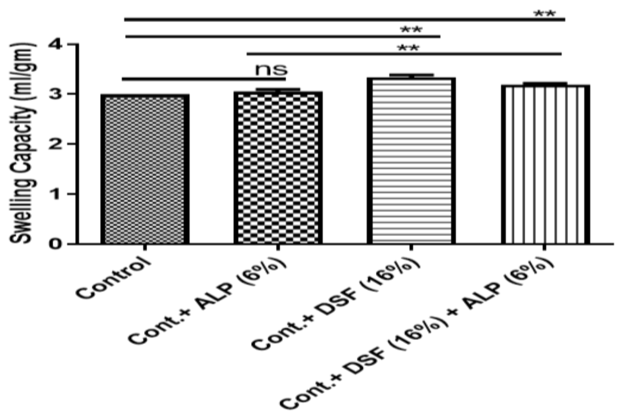


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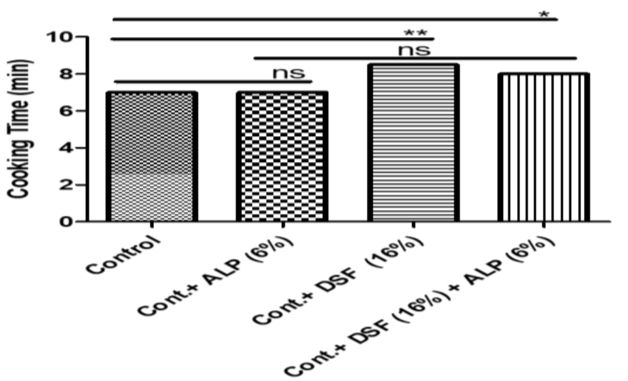
Fig. 6: Swelling Capacity

3.3. Cooking parameters of developed pasta

3.3.1. Optimum Cooking Time (OCT)

The cooking time of pasta plays a very important role in its consumer acceptance as well as in preserving the nutritional properties of raw pasta. The optimum cooking time of Control pasta fortified with ALP, DSF and combination were observed and found to be between 7.0 to 8.5min (Fig. 7). The maximum cooking time was observed in case of Control: DSF i.e. 8.5min., while the minimum cooking time observed was 7min in case of Control and Control: ALP. The varying time taken for cooking among these groups is indicating that the blending of durum wheat semolina and refined wheat flour (Control) with Amaranthus leaf powder (ALP) and Defatted soya flour (DSF) might have differentially influence the interaction between the gradients which resulted in altered cooking properties of pasta. The cooking time increased from 7.0min to 8.5min in case of Control:DSF whereas the cooking time was reduced slightly from 8.5min to 8min in Control: DSF: ALP. Interestingly, the reduced cooking time in case of Control: ALP might be due to fibre content in ALP which is known to reduce the cooking time. Hence, the cooking properties of the pasta are appearing to be dependent on the composite ingredients in the form of protein, fibre, carbohydrate and starch present in the blend. Hence, the observed altered cooking time could be attributed to their differential interacting with raw flour.

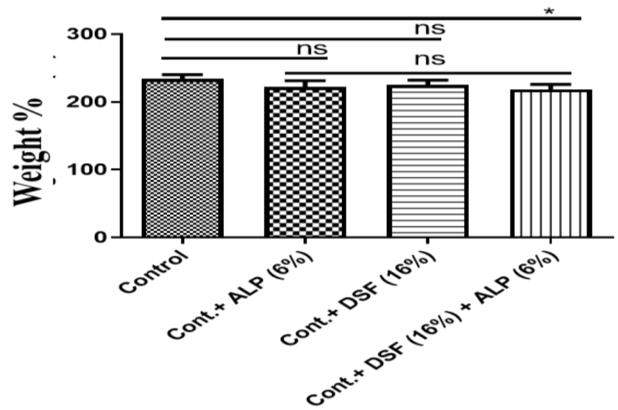


*Values are Mean (±1 SD) of three observations from independent experiments. Significance of difference is calculated among Control Vs. Treatments Groups and between treatment (ns=non-significant, *p<0.05, **p< 0.01, ***p<0.001)*

Fig. 7: Optimum Cooking Time (OCT)

3.3.2. Weight of Cooked Pasta

The weight of cooked pasta is largely dependent on the swelling capacity, water absorption, and the solid gruel loss during the pasta cooking process. These parameters are dependent on the ingredients present in the raw flour and pasta blend. Therefore, weight of cooked pasta fortified with ALP, DSF and in combination was determined using methodology described in earlier section and the detail results are presented in (Fig. 8). The weight of Control and fortified cooked pasta varied from 218% to 234%. The maximum weight was observed in case of Control while, the minimum weight was observed in Control: DSF: ALP i.e. 218.30%. The relative differences in percent cooked weight is dependent the composition of the raw flour and pasta blend material used which might affects the cooking properties e.g. the water absorption, bulk density, gruel loss etc. The minimum cooked weight % of Control: DSF: ALP could be attributed to the possible gruel loss, water absorption/swelling index and fibre content.

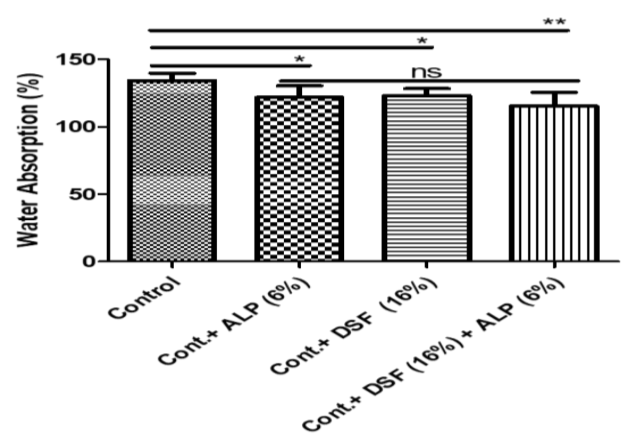


*Values are Mean (±1 SD) of three observations from independent experiments. Significance of difference is calculated among Control Vs. Treatments Groups and between treatments (ns= non-significant, *p<0.05, **p< 0.01, ***p<0.001)*

Fig. 8: Cooked Weight (%)

3.3.3. Water Absorption

The raw flour material and the process of making the pasta blend may significantly alter the swelling properties and therefore the water absorption of cooked pasta. The dietary fibre and protein content enrichment into pasta may also alter the water absorption quality of the pasta blend as compared to Control pasta [30] Therefore, the % water absorption of cooked pasta was determined among different treatment groups Control, DSF, ALP and in combination using a well-established method described in earlier section. The detail results are presented in Fig. 9, the observations indicated that water absorption ranges from 118% to 134%.



*Values are Mean (±1 SD) of three observations from independent experiments. Significance of difference is calculated among Control Vs. Treatments Groups and between treatment (ns = non-significant, *p<0.05, **p< 0.01, ***p<0.001)*

Fig. 9: Water Absorption (%)

The maximum water absorption was observed in case of Control i.e. 134.37% while the minimum water absorption was observed in Control: DSF: ALP i.e. 118.30%. Although, the relative differences in % water absorption were not relatively significant among all treatment groups. However, the observed difference can be attributed to the alteration in the water absorption related properties e.g. swelling capacity of Control: ALP and Control: DSF in alone as well as in combinations i. e., Control: DSF: ALP during the pasta cooking process.

3.3.4. Swelling index

Swelling index of a food material is an indicator of water absorbed by the starch and protein during its cooking process which is utilized for the starch gelatinization and protein hydration. The swelling index depends on the compositional structure of the sample and the sample with the minimum swelling index is expected to have more nutrient density [31], it is also reported in literature that the low amylase content produces high swelling power [32]. The swelling index of the pasta with different treatments as shown in the fig.10 indicated that there were no relative significant differences observed among the groups. The maximum swelling index was observed in Control pasta (1.57) and the minimum in Control: DSF: ALP (1.47). The swelling index can be correlated with the association binding within the starch granules and apparently the strength and character of the starch network which may be correlated with the amylase content of the flour.

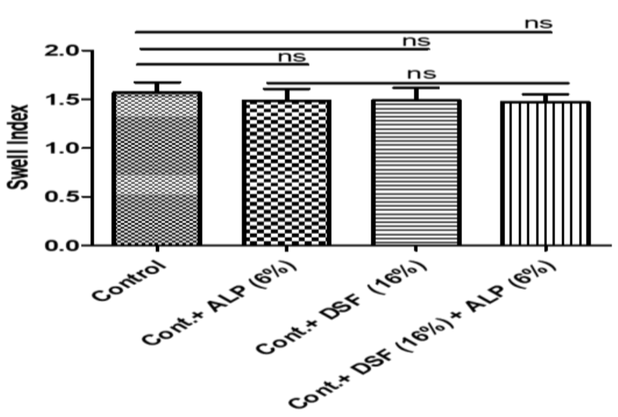


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Fig. 10: Swelling Index

3.3.5. Cooking loss

Solid Gruel or Cooking loss is one of the most important factors in determining the cooking quality of pasta products. The total content of solids gruel which is leached out in the cooking water during the cooking process of the pasta is considered as the gruel loss and is also known as the cooking loss (CL). Therefore, the gruel in the cooking water is commonly used as an indicator of pasta quality. Gruel loss represent the resistance of pasta to disintegrate during boiling, thus low amount of solids gruel into the cooking water indicates good cooking quality [33]. In literature, it has been reported that the incorporation of legume flours for spaghetti, the cooking loss and firmness increased with an increase in legume flour addition [34]. The addition of vegetable raw materials increases the sensory quality and nutritional value of pasta, but may reduce the cooking quality of products [35]. The observations largely indicated that the solid gruel loss was increased with the fortification of pasta. The minimum gruel loss was observed in Control i.e. 2.7% whereas, the maximum gruel loss was observed in case of Control: DSF: ALP i.e. 4.8% (Fig. 11).

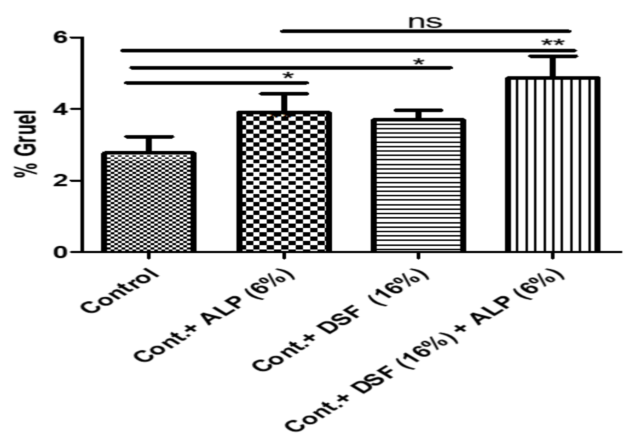

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Fig. 11: Cooking Loss (%)

The gruel loss between the Control: ALP and Control: DSF was 3.9% and 3.7% respectively. The observed differences in solid gruel loss among these groups may possibly due to the nature of ingredients, the solubility in water, interferences in gelatinization process, cooking temperature and time. The mutual interaction of ingredient present in Control: ALP, Control: DSF and Control: DSF: ALP might also be altering the binding, releasing/leaching out the starch and fibre in to the water in the form of solid gruel during the cooking process of pasta.

4. CONCLUSION

The fortification of pasta may significantly affect the cooking properties like cooking time, cooking loss, water absorption, bulk density, swelling capacity, gluten content etc. Durum wheat semolina (DWS) with refined wheat flour (RWF) pasta were used as Control and were incorporated with DSF and ALP alone as well as in combination for the fortification. Though, the pasta fortified with DSF and ALP were found more acceptable than control. The hedonic scale score appears to increased in a positive manner in all the treatment while non-significant differences observed in cooking properties. Taken together, the current study suggested that the fortification of pasta with DSF and ALP could be a one of the potential approaches for enhancing the nutritional value with the highest acceptability of staple food like pasta. However, there is much need to optimize the fortification process to enhance the cooking properties so as to preserve the nutritional value and maintain its sensorial acceptability as well.

5. ACKNOWLEDGEMENT

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