EFFECT OF SPINACH AND CHICKPEA FLOUR FORTIFICATION ON COOKING, FUNCTIONAL AND TEXTURAL PROPERTIES OF WHEAT PASTA

INTRODUCTION

Pasta is an extruded product, commonly prepared from hard durum wheat and is devoured everywhere throughout the world. Its creation and utilization is expanding because of its simplicity of transportation, handling, cooking and readiness (Tudorica et al., 1993). Various alterations with respect to size, shape and stronghold have been carried out time to time to make pasta nutritious and charming. Pasta is generally considered healthy as it is a rich source of complex carbohydrates and additionally to make it more fibrous and easily digestible.

MATERIAL AND METHOD

Preparation of fortified pasta
Wheat flour pasta (W Pasta) was prepared as per the standard procedure. The distinctive strides took after were mixing, kneading and after that extrusion. Prepared pasta was dried under room temperature to underneath 12 % moisture content. Spinach fortified wheat pasta (SW Pasta) was prepared by fortification of wheat flour with spinach leaf powder (10 %). Spinach powder was prepared by blanching of spinach leaves followed by drying and grinding in powder form. Fine chickpea flour was mixed with equal measure of wheat flour which likewise fortified with spinach powder (10 %) for making chickpea flour and spinach fortified wheat flour pasta (CSW Pasta).

Cooking quality
Cooking loss (%), weight and volume increase (%) were determined according to the method described by Olfa et al. (1993). A 10 g sample of pasta was placed into 300 ml of boiling distilled water in a 500 ml beaker. After simmering for 10, 20 and 30 min., samples were washed with distilled water and allowed to drain for 2 min. Then drained samples were analyzed for their cooking loss, weight and volume increment ascertained by the following equations:

Cooking loss = 100 - (weight of pasta after cooking / weight of pasta before cooking) x 100

Weight increase = (weight of pasta after cooking - weight of pasta before cooking) / weight of pasta before cooking x 100

Volume increase = (volume of pasta after cooking - volume of pasta before cooking) / volume of pasta before cooking x 100
Weight increased (%) = [(weight increased of pasta - weight of uncooked pasta) / weight of uncooked pasta] * 100

Cooking loss (%) = [(weight of drained residue in cooking water) / weight of uncooked pasta weight] * 100

Volume increased (%) = [(volume of cooked macaroni - volume of uncooked macaroni) / Volume of uncooked macaroni] * 100

Optimum cooking time was established according to Pinarli et al. (2004).

**Physico-chemical analysis**

Moisture content (%), ash content (%), crude fat (%), total carbohydrates (%) and dietary fiber content (%) were determined according to AOAC method (AOAC, 2004). Crude protein content was determined by using Kjeldhal Method and protein content in samples was obtained by using the conversion factor of 6.25. Titratable acidity (per cent citric acid) was estimated by titrating a known volume of the sample against standard 0.1 N NaOH solution by using phenolphthalein as an indicator up to the pink colour as end point (Rangananna, 2009).

**Quantitative analysis of antioxidant compounds**

**Ascorbic acid**

Ascorbic acid content was determined as per standard AOAC method using 2, 6-dichlorophenol indophenol dye (AOAC, 2000). The sample extracted in 3 % m-phosphoric acid was titrated with the dye to an end point of pink colour. Results were expressed as mg per 100 g of sample.

**Total phenolics**

The amounts of total phenolics in the fruits were determined with the Folin-Ciocalteu reagent according to the method of Bray and Thorpe (1954) using catechol as a standard. Grounded one gram sample was centrifuged at 5000 rpm and filtered. Filtrate was evaporated in oven up to dryness and dried extract was dissolved in 5 mL distilled water. 0.2 mL aliquot was taken in separate test tubes and volume was made up to 3 mL. Then 0.5 mL Folin-Ciocalteu reagent was added. After 3 min 2 mL of Na2CO3 (20 %) was added and mixed. Test tubes were placed in boiling water bath for one min and then cooled. Optical density of the sample was recorded at 650 nm with the help of Spectronic-20. The concentration was determined as per the standard procedure from the standard curve.

**Antioxidant activity**

Antioxidant activity (Free radical scavenging activity) was measured as per the method of Brand-Williams et al. (1995). DPPH (2, 2-diphenyl-1-picrylhydrazyl) was used as a source of free radical. A quantity of 3.9 mL of 6x10^{-5} mol/L DPPH in methanol was put into a cuvette with 0.1 mL of sample extract and kept for 30 min. in dark and absorbance was measured at 515 nm against methanol as blank. The remaining DPPH concentration was calculated using the following equation:

Antioxidant activity (%) = \frac{Ab(S) - Ab(B)}{Ab(B)} \times 100

Where, 
Ab (B) = Absorbance of blank
Ab (S) = Absorbance of sample

**Texture profile analysis**

The textural properties of samples were measured using Texture Analyzer, TAXT2i (Stable 70 Microsystems, UK) using P/ 75 cylindrical probe. Force calibration of the instrument was done prior to start of the experiment to minimize measurement error. The instrument was operated at pre-test speed = 3.073 mm/s, test speed = 2 mm/s, post test speed = 10 mm/s, distance = 30 mm, strain rate = 60 %, trigger force = 5 g, and data acquisition rate of 150 pps. The textural data (force vs. time) was analysed by the instrument software (TEE 32) and parameters (rupture strength and adhesiveness) were measured.

**Statistical analysis**

Results were expressed as mean values ± standard deviations. Each analysis assay was done five times from the same sample to determine reproducibility. The samples were subjected to One-way analysis of variance and Tukey’s test to check for significant differences (p < 0.05) using S-plus for Windows (version 8.04).

**RESULTS AND DISCUSSION**

**Cooking Quality**

The cooking nature of pasta as influenced by time of cooking has been displayed in Table 1. With the increase in cooking time, the increase in weight of WP, SWP and CSWP was measured as 146.2 to 259.0, 151.1 to 243.2, 113.7 to 216.5 g, respectively. However the most elevated increment in weight was seen in SWP followed by WP and CSWP irrespective of increment in cooking time. Similarly with increase in cooking time, the losses were also increased in all the treatments. The most astounding loses were seen in SWP, while least in CSWP. Volume is another important characteristic of the cooking of pasta. In the present study volume of pasta increased with increase in cooking time. The most noteworthy volume was

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>SWP</th>
<th>CSWP</th>
<th>WP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (%)</td>
<td>8.2 ± 0.03(^a)</td>
<td>8.1 ± 0.04(^a)</td>
<td>8.5 ± 0.05(^c)</td>
</tr>
<tr>
<td>Ash (%)</td>
<td>0.85 ± 0.02(^a)</td>
<td>1.80 ± 0.01(^a)</td>
<td>0.82 ± 0.00(^c)</td>
</tr>
<tr>
<td>Acidity (%)</td>
<td>0.32 ± 0.01(^b)</td>
<td>0.59 ± 0.03(^b)</td>
<td>0.23 ± 0.02(^b)</td>
</tr>
<tr>
<td>Crude fiber (%)</td>
<td>4.19 ± 0.03(^b)</td>
<td>3.82 ± 0.02(^b)</td>
<td>2.48 ± 0.01(^b)</td>
</tr>
<tr>
<td>Crude protein (%)</td>
<td>10.5 ± 0.04(^b)</td>
<td>18.55 ± 0.03(^b)</td>
<td>10.8 ± 0.02(^b)</td>
</tr>
<tr>
<td>Crude fat (%)</td>
<td>0.98 ± 0.03(^b)</td>
<td>1.55 ± 0.02(^b)</td>
<td>1.03 ± 0.03(^b)</td>
</tr>
<tr>
<td>Total carbohydrates(%)</td>
<td>79.48 ± 0.23(^b)</td>
<td>70.47 ± 0.12(^b)</td>
<td>84.21 ± 0.14(^b)</td>
</tr>
</tbody>
</table>

\(^a\) All data are the mean ± SD of five replicates. Mean followed by different letters in the same column differs significantly (p≤ 0.05).

**Table 1. Physico-chemical properties of different fortified pasta’s**

<table>
<thead>
<tr>
<th>Cooking quality of different fortified pasta’s</th>
<th>SWP</th>
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<tr>
<td>Weight increase (g)</td>
<td>151.1 ± 0.03(^a)</td>
<td>113.7 ± 0.03(^a)</td>
<td>124.5 ± 0.06(^a)</td>
</tr>
<tr>
<td>20</td>
<td>193.8 ± 0.03(^b)</td>
<td>185.8 ± 0.04(^b)</td>
<td>190.4 ± 0.02(^b)</td>
</tr>
<tr>
<td>30</td>
<td>243.2 ± 0.05(^b)</td>
<td>216.5 ± 0.02(^b)</td>
<td>229.2 ± 0.03(^b)</td>
</tr>
<tr>
<td>Cooking loss (%)</td>
<td>1.6 ± 0.04(^b)</td>
<td>0.8 ± 0.06(^b)</td>
<td>0.7 ± 0.07(^b)</td>
</tr>
<tr>
<td>20</td>
<td>1.8 ± 0.07(^b)</td>
<td>1.1 ± 0.08(^b)</td>
<td>1.0 ± 0.06(^b)</td>
</tr>
<tr>
<td>30</td>
<td>2.2 ± 0.07(^b)</td>
<td>1.6 ± 0.05(^b)</td>
<td>1.5 ± 0.05(^b)</td>
</tr>
<tr>
<td>Volume increased (%)</td>
<td>1.6 ± 0.03(^b)</td>
<td>0.8 ± 0.02(^b)</td>
<td>1.2 ± 0.04(^b)</td>
</tr>
<tr>
<td>20</td>
<td>1.8 ± 0.04(^b)</td>
<td>1.0 ± 0.04(^b)</td>
<td>1.4 ± 0.05(^b)</td>
</tr>
<tr>
<td>30</td>
<td>2.2 ± 0.05(^b)</td>
<td>1.4 ± 0.03(^b)</td>
<td>2.0 ± 0.02(^b)</td>
</tr>
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**Table 2. Cooking quality of different fortified pasta’s**

82 Journal on Processing and Energy in Agriculture 21 (2017) 2
seen at 30 min cooking irrespective of different sample. However, maximum increase in volume was recorded in SWP whereas lowest in CSWP.

Increase in the cooking loss with the increase in wheat flour content in pasta may be related to gluten dilution and the protein solubility during cooking in water. It has been seen that a direct relationship exists between pasta cooking quality and protein content. Increase in gluten in pasta results in reduced amount of solid residue in the cooking water (Pinarlı et al., 2004). An immediate connection has been seen between cooking time and cooking loss. Comparable outcomes were likewise revealed by Breen et al. (1977) in spaghetti made from bean fortification.

**Physico-chemical properties**

The diverse physico-chemical characteristics such as moisture, ash, acidity, crude protein and crude fat were evaluated to compare the quality of developed fortified pasta. The moisture, ash and acidity content of pasta ranged from 8.1 to 8.5, 0.82 to 1.80 and 0.23 to 0.59 %, respectively. The low moisture content in the final product is associated with the long shelf life (Prabhhasankar et al., 2009). A comparative or slightly higher ash levels have been reported in durum wheat flour enriched with chickpea flour (Sabanis et al., 2006) and lentil flour fortified spaghetti (Zhao et al., 2005) in a range of 1.7 to 3.6 per cent, respectively.

Crude protein is one of the important characteristics of any food product. Amid the study it was found that crude protein was significantly affected by fortification of pasta and it ranged from 18.55 per cent (CSWP) to 10.80 per cent (WP). The crude fat was also analysed and found in a range of 0.98 per cent to 1.55 per cent, with highest content in CSWP and minimum in SWP. Like most of the legumes, chickpeas are considered a good source of protein and have been reported to possess 20.7 % protein content (Bravo et al., 1999; Sabanis et al., 2006; Zhao et al., 2005 and Iqbal et al., 2006).

**Antioxidant properties**

Antioxidants are the important compounds which are required for the protection of our body from free radicals that causes oxidative stress. Ascorbic acid and phenols are the major intensifies that are naturally found in plant based foods. Information exhibited in Table 3 demonstrates the ascorbic acid and total phenolics content in developed pasta. Maximum total phenolics and ascorbic acid content was recorded as 20.4 and 3.03 mg/100 g, respectively in CSWP.

<table>
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<th>Characteristics</th>
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<th>CSWP</th>
<th>WP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ascorbic acid (mg/100g)</td>
<td>15.3 ± 0.03</td>
<td>20.4 ± 0.04</td>
<td>13.6 ± 0.02</td>
</tr>
<tr>
<td>Total phenols (mg/100g)</td>
<td>1.93 ± 0.02</td>
<td>3.03 ± 0.02</td>
<td>1.85 ± 0.03</td>
</tr>
</tbody>
</table>

*All data are the mean ± SD of five replicates. Mean followed by different letters in the same column differs significantly (p<0.05).

**Texture**

The fortification of wheat pasta resulted in an increase in hardness, which can be clearly observed from the Figure 2. Information demonstrating the texture profile of developed pasta has been presented in Table 4. The maximum stickiness was found in WP (-7.742 g) and minimum in SWP (-5.579 g). Hardness and stickiness are related to the amount of starch and starch gelatinization in the product. During cooking, extreme changes occur in the microstructure of pasta. The consistency of dry pasta changes by the diffusion of water from outside to the inside and closer to the surface of the pasta strand the changes are more outrageous. Starch granules are responsible for poor structure of pasta. Protein matrix also breaks down due to denaturation which occurs due to cooking of product. Elasticity in pasta is somewhat protected by protein gluten (Voisey et al., 1978). Malcolmson et al. (1993) found that protein level significantly affected the firmness, compressibility and cooking loss of optimally cooked spaghetti, whereas elasticity was found to relate to drying temperature. Lower firmness ensnares spaghetti with lower quality. Rayas et al. (1996) reported that using buckwheat and amaranth flours in pasta, there was a diminishing value in firmness but an increase with lupin flour. This could be related to the inclusion of insoluble fiber which makes the porous structure of pasta and subsequently influences firmness (Petitot et al., 2009).
CONCLUSION

Pasta is a traditional instant product and getting to be noticeably prominent in present day world. Pasta produced using wheat flour higher in fibre and nutrient content than the conventional pasta made from durum wheat. The fortification of chickpeas and spinach in wheat flour makes it more healthy and worthy by expanding the wholesome quality as well as also functional properties which are deficient in the customary pasta. Cooking quality, physico-chemical and functional properties of wheat pasta are directly related to the fortification. CSWP was found to be the best as far as nutritional, functional and cooking quality. Fortification increased the antioxidant properties along with textural properties wheat pasta and fortified wheat could be produced and used as an alternative for conventional pasta and can add variety in food products.

ACKNOWLEDGMENTS: We would like to thank the Department of Food Science and Technology, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan for their support to conduct the research and further we might want to express gratitude toward Food Security Pvt. Ltd. for providing financial assistant.

Authors’ contribution All authors contribute equally in this article.

REFERENCES


Fig. 2. Effect of fortification on textural properties of different types of pasta


Received: 15. 01. 2017. Accepted: 06. 04. 2017.