INFLUENCE OF EXTRUSION TECHNIQUE ON THE RETENTION OF 
\(\alpha\)-LINOLENIC ACID LEVEL OF WHOLE MILLED FLAXSEED

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ABSTRACT
To evaluating the \(\alpha\)-linolenic acid (ALA) before and after processing in order to meet the recommended daily allowance of ALA of 1.6 g/day for men and 1.1 g/day for women and its sensory acceptances. Vermicelli incorporated with 30% and 45% milled flaxseed was found to have a 5.95 g and 9.42 g of ALA respectively. On steaming the vermicelli, the levels declined to 5.61 g and 8.84 g indicating a very small percentage decline in the former. Similarly, pasta incorporated with 30 % and 45% milled flaxseed showed on analysis 5.9 g and 9.09g of ALA respectively and on further cooking the levels were 4.98% and 9.08 % representing a negligible change in the levels after cooking the pasta. The results indicate that the products meeting the Recommended dietary allowance (RDA) and contributing to the functional and therapeutic properties of the essential fatty acid.

KEYWORDS: Omega-3 fatty acid, lignan, alpha-linolenic acid, extrusion.

INTRODUCTION
Flaxseed, or linseed (linumusitatissimum) commonly known as alsi,jawas,aksebija in Indian languages, is a blue flowering rabi cop and a member of family linaceae. Flaxseed is grown as either oil crop or a fiber crop with fiber linen derived from stem of fiber varieties and oil from the seed of linen varieties.\[6\\]\[13\] The plant is native to west Asia and the Mediterranean. Since 500BC linen fiber has been cultivated and today it is widely grown for its oil crop ability.\[2\\]\[9\] Flaxseed is among unique oil seed crops because of its exceptionally high content of \(\alpha\)-linolenic acid (ALA), contains 35 to 45% oil, of which 45 to 52% is \(\alpha\)-linolenic acid. Beyond its oil crop ability, proximate composition of flaxseed makes it more promising for its utilization in different food products.\[3\] Flaxseed mainly comprises nutritional components such as oil, soluble fiber, protein, lignans, vitamins and minerals.\[5\]
Flaxseed is rich source of omega-3 polyunsaturated fatty acids and it is helpful in prevention of cardiovascular diseases and cancer particularly of mammary and prostate gland, anti inflammatory acticity, laxative effect and alleviation of menopausal symptoms and osteoporosis.\textsuperscript{[7,10,12]}

Nutritionists during last two decades are actually clear about selected foods that play an important role in maintaining physical and mental health status of consumers. Other than meeting nutrition needs, flaxseed generally known for its dietary factors, which are considered to modulate detrimental development of some chronic diseases. With increased consumption of highly saturated fat foods, it seems feasible that modern diets do not meet healthy eating guidelines and deficient in certain long chain omega-3 fatty acids. Flaxseed has been extensively accepted for its inadequate intake of omega-3 polyunsaturated fatty acids (PUFA), predominantly alpha-linolenic acid (ALA) and docosahexaenoic acid (DHA), which is effective in cardio vascular disease.

To improve its consumption various studies using different processing technology have been carried out to asses its stability and sensory acceptability. One such technology is extrusion. Extrusion cooking is highly adaptable and focused form of processing in which food stuff is enforced to flow under controlled conditions of heating and shearing through a terminal die. During the last two decades extrusion processing and cooking has become very popular. The foremost features of extrusion cooking comprises of flexible product characteristics, high energy efficiency, less space required for operation, new feed products formulations, automated control system with high productivity and product quality with no effluent showing environmental-friendly technology to be used\textsuperscript{[14]}. Mild extrusion conditions (high moisture content, low residence time, low temperature) improve the nutritional quality, while high extrusion temperatures (200 °C), low moisture contents (<15%) and/or improper formulation (e.g. presence of high-reactive sugars) can impair nutritional quality adversely. It is important that careful control of extrusion process parameters is essential to attain nutritionally balanced products.\textsuperscript{[11]}

**MATERIALS AND METHODS**

*Procurement of raw materials*

Raw materials included wheat flour, flaxseed (vacuum packed), purchased from local market.
Preparation of extruded products with milled flaxseed

Extrusion
Both percentages (30% and 45%) of vermicelli and pasta formulations had the ingredients: 30% and 45% of the whole milled flaxseed is replaced with the whole wheat flour (70 and 55%), 250 ml of water. Mix well the ingredients and Extrude the homogenized mixture using the single screw pasta extruder using different dyes.

Steaming
The prepared vermicelli and pasta were steamed under double boiling technique at a temperature of 80°C to stabilize the product as ready to cook and which helps to increase the nutritional profile of the product.

Drying
The vermicelli and pasta were dried at a temperature of 70°C for 4 hrs to remove the moisture content which helps to extend the shelf life of the product.

Cooking
The steamed and dried vermicelli and pasta were cooked in boiling water (100°C) 5 – 10 mins and the remaining water is drained off.

Analysis of fatty acid profile

Preparation of Fatty acid methyl esters
Acid catalyzed trans-esterification reaction was followed for preparation of fatty acid methyl esters. 20 mg of fat sample was dissolved in 1mL of hexane and 3mL of sulphuric acid in methanol (2%) was added and reflux condensation was performed for 3 hr. Extraction of cooled solution was with sodium bicarbonate and water resulted in collection of fatty acid methyl esters into hexane layer. Thin layer chromatography (TLC) technique was performed to identify the reaction completion with the solvent system hexane and diethyl ether in the proportion of 80:20.[1]

Gas Chromatography Analysis of fatty acids
The Fatty acid methyl esters were analyzed by using Shimadzu GC 2010 fitted with a split injector (250 °C) and a Flame Ionization detector (300 °C). A SP-2560, 75 m 0.18 mm I.D., 0.14 µm film thickness (Supelco) column was utilized and operated at a time-temperature program which included an 80 °C hold for 2 min to 200 °C with a 10 °C 1min raise, hold for
30 min followed by a further increase to 220 °C with a 10 °C 1 min raise and hold for 20 min. For this column, nitrogen was used as a carrier at a velocity of 13.0 cm/s. Each fatty acid methyl esters peak was identified with its standard fatty acid methyl esters (Palmitic acid, Stearic acid, Oleic acid, Linoleic acid and Linolenic acid methyl esters). The absolute amounts of fatty Acids in the oil were calculated based on the peak area percentage.\[^{[1]}\]

\(\alpha\) - linolenic acid retention

The retention of \(\alpha\) – linolenic acid in raw and after processing of extruded samples was calculated according to the expression given below.\[^{[8]}\]

\[
\alpha\) - linolenic acid retention \% = \frac{\alpha\) - linolenic acid level of processed sample}{\alpha\) - linolenic acid of Raw material (Flour mix)} \times 100
\]

RESULT AND DISCUSSION

Table 1: Fatty acid profile of flaxseed incorporated vermicelli and pasta before and after processing.

<table>
<thead>
<tr>
<th>In Grams</th>
<th>ALA level of Raw material</th>
<th>ALA level of processed products</th>
<th>ALA Retention</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Flour mix</td>
<td>Vermicelli</td>
<td>Pasta</td>
</tr>
<tr>
<td>30</td>
<td>7.43±0.13</td>
<td>5.81±0.10</td>
<td>5.84±0.04</td>
</tr>
<tr>
<td>45</td>
<td>11.14±0.09</td>
<td>9.54±0.09</td>
<td>8.93±0.10</td>
</tr>
</tbody>
</table>

From table 1 it is observed that the ALA profile of flaxseed incorporated raw and extruded pasta and vermicelli before and after processing. The extruded vermicelli contains 5.95g of ALA present in 30g milled flaxseed incorporated vermicelli and 9.42 g of ALA found in 45 g milled flaxseed incorporated vermicelli. With regard to pasta 5.9g of ALA was present in 30g and 9.09 g of ALA present in 45 g of milled flaxseed incorporated pasta. After cooking it was found to contain 5.61 g of ALA in 30 g milled flaxseed incorporated vermicelli and 8.84 g of ALA in 45 g incorporated flaxseed and in pasta 4.98 g of ALA was present in 30 g incorporated milled flaxseed and 9.23 g was present in 45 g incorporated flaxseed. The retention of alpha linolenic acid after processing has been assessed and the vermicelli incorporated 45% milled flaxseed flour showed highest retention of \(\alpha\)-linolenic acid ie., 85.63% . From table 2 it is revealed that the extrusion condition does not significantly affect the composition of fatty acid content. The results with reference to the effects of extrusion process on fatty acids retention in oil seed are limited. The linolenic acid is the most important fatty acid which is polyunsaturated has major health benefits from nutritional point.
of view.[10] From the results it is observed that the extruded product incorporated with whole milled flaxseed flours realized the retention of the highest content of alpha linolenic acid and also poly unsaturated fatty acids are present abundantly in these formulations.

Table 2: The fatty acid profiles of raw, extruded and cooked products analyzed using GC-MS method.

<table>
<thead>
<tr>
<th>S. No</th>
<th>Product</th>
<th>C16:0</th>
<th>C18:0</th>
<th>C18:1</th>
<th>C18:2</th>
<th>C18:3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Extruded pasta 30%</td>
<td>7.87%</td>
<td>5.44%</td>
<td>19.44%</td>
<td>16.12%</td>
<td>51.12%</td>
</tr>
<tr>
<td>2</td>
<td>Extruded pasta 45%</td>
<td>7.62%</td>
<td>6.11%</td>
<td>18.85%</td>
<td>14.94%</td>
<td>52.48%</td>
</tr>
<tr>
<td>3</td>
<td>Extruded vermicelli 30%</td>
<td>7.56%</td>
<td>5.48%</td>
<td>19.55%</td>
<td>15.86%</td>
<td>51.54%</td>
</tr>
<tr>
<td>4</td>
<td>Extruded vermicelli 45%</td>
<td>6.94%</td>
<td>5.09%</td>
<td>18.75%</td>
<td>14.84%</td>
<td>54.36%</td>
</tr>
<tr>
<td>7</td>
<td>Cooked pasta 30%</td>
<td>15.90%</td>
<td>4.29%</td>
<td>19.20%</td>
<td>17.51%</td>
<td>43.09%</td>
</tr>
<tr>
<td>8</td>
<td>Cooked pasta 45%</td>
<td>7.59%</td>
<td>5.33%</td>
<td>18.21%</td>
<td>15.59%</td>
<td>53.28%</td>
</tr>
<tr>
<td>9</td>
<td>Cooked vermicelli 30%</td>
<td>8.36%</td>
<td>6.14%</td>
<td>19.94%</td>
<td>16.98%</td>
<td>48.58%</td>
</tr>
<tr>
<td>10</td>
<td>Cooked vermicelli 45%</td>
<td>7.62%</td>
<td>5.93%</td>
<td>19.71%</td>
<td>15.67%</td>
<td>51.05%</td>
</tr>
<tr>
<td>11</td>
<td>Wheat flour</td>
<td>18.52%</td>
<td>1.96%</td>
<td>19.34%</td>
<td>54.89%</td>
<td>5.27%</td>
</tr>
<tr>
<td>12</td>
<td>Flax flour</td>
<td>8.93%</td>
<td>5.54%</td>
<td>23.97%</td>
<td>14.62%</td>
<td>46.94%</td>
</tr>
</tbody>
</table>

CONCLUSION

The present study has been undertaken to demonstrate the level of ALA in cold extruded products such as pasta and indigenous vermicelli in different compositions. The results showed that relatively high amount of ALA were present in vermicelli and pasta incorporated with 45 % of milled flaxseed before and after cooking in comparison to the 30% composition. With this background of study it can be concluded that flaxseed a potential functional food can be incorporated into our daily meals to meet the RDA of ALA through indigenous formulations such as vermicelli and pasta using extrusion technology thereby minimizing the antinutritional factors of flaxseed and improving its acceptance among the consumers.

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