



Development of Functional Pasta Enriched with Omega-3 Fatty Acids

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Abstract

Omega 3 fatty acid-enriched functional pasta products were developed using refined wheat flour, water, salt, fish meat and fish oil using a single screw extruder. Among the different blends studied, the most acceptable pasta was made with combination of maida (800 g), water (240 ml), fish oil (1%), fish meat (200 g). This product had a protein content of 4.84% which is higher than the regular pasta available in the market. Fatty acid profile study showed that the developed pasta had a omega-3 fatty acid levels of 974 mg. Storage study revealed that peroxide value and free fatty value are within the acceptable limit for a period of 8 weeks. Therefore the result of the present study indicate that fish meat and fish oil can be utilized for the development of well accepted functional pasta products rich in protein and omega-3 fatty acids.

Keywords: Functional pasta, single screw extruder, fish oil, peroxide value, free fatty acids

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Introduction

The demand for pasta food is increasing due to growing trends towards fast foods, particularly among younger generation, increase in the purchasing power of the people and convenience of preparation. However, nutritional specialists caution against the intake of extruded products and brand them as "junk food" due to high content of carbohydrate. Due to this, there is an ever-increasing awareness on changing the consumption pattern towards health foods. Fish is gaining more

acceptance because of its special nutritional and functional properties. Seafood is a cheap source of protein and an excellent source of lipid that contains omega-3 fatty acids especially eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). Omega-3 fatty acids are essential for normal growth and development and may prevent or moderate coronary artery disease, hypertension, diabetes, arthritis, other inflammatory and autoimmune disorders as well as cancer (Simopoulos, 2000). Interestingly, fish is also a good source of various vitamins (A, D, B6 and B12) and minerals (Iron, Zinc, Iodine, Selenium, Potassium and Sodium). Using fish meat as a raw material, many varieties of products could be made by extrusion. Fish muscle serves as a main food component for preparation of many highly acceptable ready to serve fish products like frozen surimi, frozen mince block, extruded product, imitated products etc. A few studies have reported successful incorporation of omega-3 fatty acids using flax seed meal, fish flesh (Amira et al., 2013, Shavikla et al., 2011). However, data available on pasta products with incorporation of fish oil and fish meat is limited. The first step of our research focused on enrichment of pasta with fish and fish oil containing essential fatty acids such as omega-3 fatty acids. The application in products such as pasta, bakery products, dairy products such as milk, yogurt and juice shows the conformity of the nutritional benefits of n-3 fatty acid (Iafelice et al., 2008). The fortification of spaghetti with EPA+DHA was found to increase the consumption of long chain omega-3 (LC n-3) polyunsaturated fatty acids and to decrease dietary n-6/n-3 ratio (Iafelice et al., 2008). The significant increase in plasma omega-3 fatty acids and in HDL-cholesterol observed in volunteers fed with bread and other foods containing fish oil was reported (Liu et al., 2001). Due to their oxidative nature, the addition in foods in the form of novel microencapsulated oil, known as MEG 3 (Ocean nutrition, Canada) was found to be protected until

it reached the gastrointestinal tract (Young & Conquer, 2007). Enrichment of pasta products with fish such as *Catla catla* was reported (Devi et al., 2013). Hence, the present study has been designed to incorporate fish oil and fish meat with the aim of developing functional pasta with higher levels of protein and with omega-3 fatty acids.

Materials and methods

Four different kinds of pasta were developed namely, fish oil enriched pasta (FOP), fish meat enriched pasta (FP), fish oil and fish meat enriched pasta (FFOP) and normal pasta (NP) that served as the control. Raw materials used for preparation of pasta are refined wheat flour (*Triticum aestivum*), water, salt, fish oil and fish meat. The composition of each formulation is described in Table 1.

Oil sardine (*Sardinella longiceps*) was selected for this work. Fish mince was prepared using fresh fish by discarding the head, fins, tail, viscera and washing with clean water. The flesh was separated and cooked over low flame till the temperature reached 55°C and easily separated into flakes to obtain cooked meat. The fish meat was added along with other ingredients as mentioned and also stored in refrigerator until further use. Pasta was produced at Department of Food Science and Technology, College of Food and Dairy Technology (CFDT), Chennai using a lab model mini pasta extruder (Dolly mini, Italy) which has a hopper capacity of 2 kg and production rate of approximately 6 kg^h⁻¹ with a power specification of 110 v / 220 v. The pasta products were prepared under cold extrusion condition at 70°C and initial feed moisture content of 32%. The developed pasta was dried at a temperature of about 70-80°C for 2-4 h to ensure the quality of the product. The dried pasta products were packed in polyethylene sachets, which provided moisture proof protection for the product.

Moisture, protein, fat and ash content of pasta products were determined by AOAC (2000) method.

Mineral content was estimated using the method by Gopalan et al., 2004. The prepared pasta were packed in metalized polyester terphalalene sachets and subjected to shelf life evaluation by storing them at room temperature. Sampling was done at regular intervals at 0, 4 and 8 weeks. The free fatty acid and peroxide value were analyzed using the method followed by Kolanowski et al., 2007. Fatty acid content was analysed initially for the functional pasta according to the method of AOAC (1975). Methyl esters of fatty acids (FAME) from omega-3-enriched pasta were prepared and analyzed by gas chromatography. The results were subjected to statistical analysis. Mean and standard deviation were calculated for three replicates using Microsoft Excel. ANOVA was used to know the significant difference for the different treatment combinations. Significance was established at probability $p < 0.05$.

Results and discussion

Proximate composition of functional pasta

The moisture content of the different pasta groups were determined as mentioned and the results are presented in Table 2. The moisture content ranged between 11 to 11.8% in all the samples and there is significant difference ($p < 0.05$) in the moisture content between the different treatment groups. The moisture content of 11 to 11.8 % is considered to be normal, but it was found that additional drying may be required (Rokey, 2000). Moisture content usually varies with different formulations and the extrusion conditions such as temperature, screw speed, feed moisture. Moisture loss during extrusion is due to the vaporization of water during the rapid pressure loss at the die opening (Moore, 1994). The fat content of the product ranged from 1.42 to 10.44% and significant difference ($p < 0.05$) was observed between the pasta products. The normal pasta was found to have the fat content of 1.42% because there was no extra fat added to this pasta whereas, in fish meat-enriched pasta, the value was 9.78% and this might

Table 1. Composition of different pasta

Type of Pasta	Maida	Water	Salt	Fish oil	Fishmeat
NP	1000 g	300 ml	20 g	-	-
FOP	1000 g	300 ml	16 g	1%	-
FP	800 g	240 ml	16 g	-	200 g
FFOP	800 g	240 ml	16 g	1%	200 g

NP-Normal pasta; FP-Fish pasta; FOP-Fish oil pasta, FFOP-Fish + Fish oil pasta

be due to the addition of minced oily fish such as sardine. Higher fat content was observed in fish and fish oil-enriched pasta which was found to be 10.44% and it significantly affects the extrusion condition. It was observed that the addition of lipid below 3% has little effect on extrusion condition (Harper, 1992) and it was in agreement with the present study in which 1% fish oil was added. If the fat content is higher in the product it can undergo slip in the barrel and expansion at the die will not occur properly. Protein content of the normal pasta and fish oil-enriched pasta was found to be 2.3%. The amount of protein was higher in fish meat and fish oil and fish meat-enriched pasta. It was found to be 4.82 and 4.84% respectively and the significant difference ($p < 0.05$) between the pasta products is due to the addition of fish meat which contains protein as a key ingredient. The addition of fish meat in pasta products increases the protein content and also the nutritive value. It is evident from this study that the protein value of 4.84% in fish oil and fish meat pasta will meet the daily value level and also satisfy the consumers. Studies were carried out to enrich protein in extruded products (Prasad et al., 2007). The ash and mineral content varies from 1.57% and 251 ppm in normal pasta, 2.71% and 321.2 ppm in fish pasta, 2.03% and 314.2 ppm in fish oil pasta, 2.91% and 367 ppm in fish and fish oil pasta and are presented in fig. 1 and 2 respectively. It was reported that the products made from fish were observed to have high ash and mineral content (Devi et al., 2013).

As the storage period increased, the oxidation parameters peroxide value (PV) and FFA were found to increase in fish or fish oil-enriched samples (Fig. 3 and 4). Initially, PV value was found to be 0.21 (meq O_2 kg^{-1} oil), 0.67 (meq O_2 kg^{-1} oil), 0.19 (meq O_2 kg^{-1} oil), 0.23 (meq O_2 kg^{-1} oil) for control, fish pasta, fish oil pasta and fish & fish oil pasta respectively. While the FFA value was 0.2063, 1.1138,

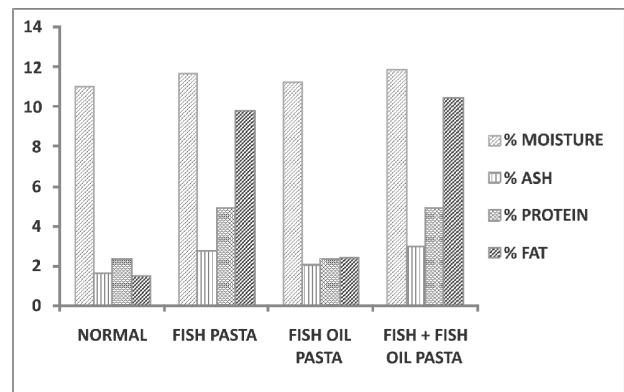


Fig. 1. Proximate composition % analysis of different pasta products.

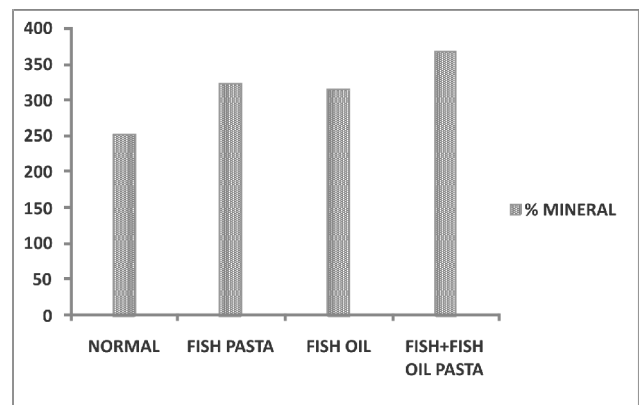


Fig. 2. Mineral content (ppm) of different pasta products

1.1105 and 0.2459% for control, fish pasta, fish oil pasta and fish and fish oil pasta respectively. A significant increase was observed ($p < 0.05$) in the PV and FFA when the storage period reached 8th week. Fish pasta showed higher FFA as well as PV at the end of storage period which was followed by fish oil pasta. The same trend was observed for the FFA value during storage period. Fish and fish oil pasta showed lower FFA and PV at the end of storage

Table 1. Proximate composition (%) of different pasta products.

	Control	Fish pasta	Fish oil pasta	Fish and fish oil pasta
Moisture	11±0.16	11.53±0.09	11.41±0.20	11.80±0.06
Ash	1.57±0.02	2.71±0.03	2.05±0.02	2.91±0.06
Protein	2.30±0.02	4.82±0.04	2.30±0.02	4.84±0.05
Fat	1.42±0.04	9.78±0.11	2.31±0.04	10.44±0.07
Mineral	251±3.33	321±3.60	314±2.72	367±3.51

Values are expressed as mean ± standard deviation of three determinations.

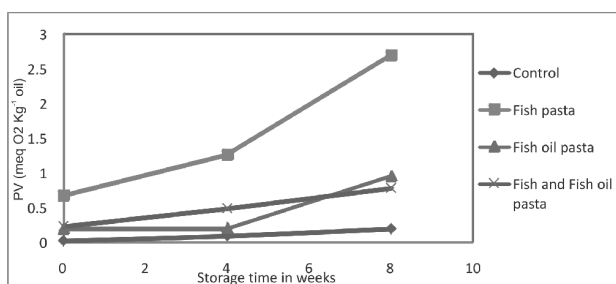


Fig. 3. Peroxide value (meq O₂ Kg⁻¹ oil) of different pasta products

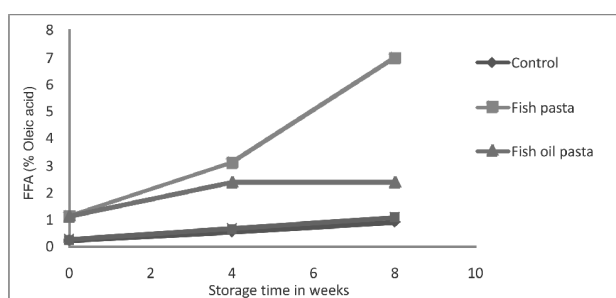


Fig. 4. Free fatty acid value (as % oleic acid) of different pasta products

period. Normal pasta showed the lowest PV and FFA, which contain no added oil. Effects of extrusion cooking on lipid oxidation has been described in earlier studies (Martin et al., 1993; Gutkoski & El-Dash, 1999). The increase in the oxidation parameters with respect to the increase in the storage time was directly related to the loss or reduction in the content of n-3 fatty acids. The

reduction in the value of EPA and DHA in fish-enriched pasta products was reported and it was observed that the EPA and DHA content was reduced from 2.4 and 3.2% to 0.4-0.64 and 0.98-1.15% respectively (Devi et al., 2013). From the present study, it was observed that the PV and FFA values were higher for fish meat and fish oil (1%)-enriched pasta, however the fish and fish oil-enriched pasta showed lower FFA and PV. A similar lipid oxidation study in spaghetti-enriched with LC n-3 PUFA in the form of marine oil powder (1.2%) containing EPA and DHA was carried out. It was reported that there is an increase in the value of PV from 7.1 to 43.4 meq O₂ kg⁻¹ of fat over 12 months and from 7.1 to 16.2 meq O₂ kg⁻¹ at 55°C for 27 days, equivalent to 18 months at room temperature. Oxidised fatty acids increased in fortified spaghetti from 4.8 to 13.8 g 100 g⁻¹ of fat under light exposure over 12 months and from 4.8 to 7.8 g 100 g⁻¹ of fat at 55°C in 27 days (Verardo et al., 2009). This is in agreement with the present study in which the amount of oxidation products increased with storage time of one month.

The fatty acid profile (mg 100 g⁻¹ of pasta) corresponding to different groups of pasta are shown in Table 2 and it revealed that EPA and DHA content in all the pasta samples ranged from 0.47 - 1.64% and 0.19 - 1.17% respectively. It is clear from the result that the maximum value of EPA and DHA was found in fish meat and fish oil-enriched pasta (293 mg 100 g⁻¹). While fish meat and fish oil-enriched pasta contained 181 mg 100 g⁻¹ and 57 mg 100 g⁻¹ respectively. Linolenic acid content of all the

Table 2. Fatty acid profile of functional pasta

Treatments	Normal pasta	Fish oil pasta	Fish meat Pasta	Fish + fish oil pasta
Fatty acid (%)				
Myristic acid	0.72%	14.36%	14.58%	1.05%
Palmitic acid	21.06%	33.15%	32.46%	24.27%
Palmitoleic acid	0.53%	12.05%	11.11%	1.56%
Stearic acid	1.95%	6.39%	8.20%	8.87%
Oleic acid	29.22%	17.44%	18.95%	30.83%
Linoleic acid	41.76%	9.02%	7.40%	20.60%
Linolenic acid	0.57%	2.01%	1.36%	6.52%
Arachidic acid	3.06%	0.88%	1.67%	1.14%
Behenic acid	0.34%	0.58%	0.85%	0.96%
Eicosapentaenoic acid	0.47%	1.26%	1.06%	1.64%
Docosahexaenoic acid	0.19%	1.15%	0.79%	1.17%

pasta samples ranged from 8-681 mg. The total omega-3 fatty acid content of all the samples ranged from 17-974 mg. Fish oil and fish meat-enriched pasta samples were found to have higher omega-3 fatty acid content of 974 g, while fish oil-enriched pasta and control samples have lower omega-3 content of 104 and 17 mg respectively.

The fatty acid profile indicated that the prototype had EPA and DHA in levels that are required to meet the daily needs. The samples enriched with fish oil and fish meat are found to meet the daily recommended level of omega-3 fatty acid content per serving of 100 g. It also has a protein content of 3.79% which acts as an additional nutrient along with omega-3 fatty acid. The omega-3 target level of > 1% was achieved with an LNA, EPA and DHA content of 974 mg 100g⁻¹ in fish meat and fish oil-enriched pasta. Hence the pasta developed is found to have functional value. Omega-3 fatty acid level was found to be 314, 104 and 17 mg in fish meat, fish oil and normal pasta respectively.

Extruded products like pasta products are popularly used as snack products. Usually, pasta products are prepared using cereals like wheat, which are limiting in some essential amino acids. In order to increase the nutritive value of such products, the supplementation with protein rich fish meat is an alternative. In addition to this, the incorporation of fish meat and fish oil further increased the functional value of the product and it would further help to improve the nutritional quality apart from adding a distinct flavor and taste. The under-utilized fish also can be utilized for development of these products which will improve the nutritional value and reduce the cost of the product.

References

- Amira, F., Annahas, K., Damila, R., de Morais, Joia, B. M., Ana, C., de Aguiar, Visentainer, J. V. and Giriboni, A. R. G. (2013) Incorporation of omega-3 on an extruded snack with golden flaxseed. *J. Food Sci. and Engg.* 3: 317-322
- AOAC (1975) Fatty acid analysis, Official methods of Analysis, 12th edn., Association of Official Analytical chemists, Washington DC
- AOAC (2000) Official Methods of Analysis, 17th edn., Association of Official Analytical chemists, Washington DC
- Devi, L. N., Aparna, K. and Kalpana, K. (2013) Utilization of fish mince in formulation and development of pasta products. *Int. Food Res. J.* 20: 219-224
- Gopalan, C., Rama Sastry, B.V. and Bala Subramanian, S.C. (2004) Nutritive value of Indian foods. National Institute of Nutrition, ICMR, Hyderabad 45-67
- Gutkoski, L. C. and El-Dash, A. A. (1999) Extrusion cooking effects on oxidative stability of oat coarse milling product. *Pesq. Agro. Bras.* 34: 119-127
- Harper, J. M. (1992) A comparative analysis of single- and twin-screw extruders. In: *Food Extrusion Science and Technology* (Kokini, J. L., Ho, C. and Karwe, M. V., Eds), pp.139-148, Marcel Dekker Inc., New York
- Iafelice, G., Caboni, M. F., Cubadda, R., Criscio, D. T., Trivisonno, M. C. and Marconi, E. (2008) Development of functional spaghetti enriched with long chain omega-3 fatty acids. *Cer. Chem.* 85: 146-151
- Kolanowski, W., Jaworska, D., Weibrodt, J. and Kunz, B. (2007) Sensory assessment of microencapsulated fish oil powder. *J. Amer. Oil Chem. Soc.* 84: 37-45
- Liu, M., Wallmon, A., Pellrud, R., Wallin, R. and Saldeen, T. (2001) Effect of stable fish oil and simvastatin on lipoproteins in plasma in patients with hyperlipidemia. *Hygiea* 23: 1027-1034
- Martin, D., Godber, J. S., Setlhako, G., Verma, L. and Wells, J. H. (1993) Optimizing rice bran stabilization by extrusion cooking. *Lous. Agri.* 36: 13-15
- Moore, G. (1994) Snack food extrusion. In: *The Technology of Extrusion Cooking* (Frame, N. D., Ed) pp 110-143, Blackie Academic & Professional, London
- Prasad, N., M. Swamy, S. T. Babu Sha and A. D. Semwal (2007) Protein quality of sorghum soy based extruded snack food. *J. Food Sci. Technol.* 44(2): 165-167
- Rokey, G. J. (2000) Single screw extruders. In: *Extruders in Food Applications* (Riaz, M. N., Ed), pp 25-49, Technomic Publishing Co., Lancaster, PA
- Shavikla, G. R., Olafsdottir, A., Sveinsdotir, K., Thorkelsson, G. and Rafipour. (2011) Quality characteristics and consumer acceptance of a high fish protein puffed corn fish snack. *J. Food Sci. Technol.* 48: 668-676
- Simopoulos, A. P. (2000) Role of poultry products in enriching the human diet with n-3 PUFA, human requirement for n-3 polyunsaturated fatty acids. *Poultry Sci.* 79: 961-970
- Verardo, V., Ferioli, F., Riciputi, Y., Iafelice, G., Marconi, E. and Caboni, M. F. (2009) Evaluation of lipid oxidation in spaghetti pasta enriched with long chain n-3 polyunsaturated fatty acids under different storage conditions. *Food Chem.* 114: 472-477
- Young, G. and Conquer, J. (2007) Omega-3s and their impact on Brain Health. In: *Marine Nutraceuticals and Functional Foods* (Barrow, C. J. and Shahidi, F., Eds), pp 63-88, CRC Press, Boca Raton