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ORIGINAL ARTICLE

Quality of ω-3 fatty acid enriched low-fat chicken meat patties incorporated with selected levels of linseed flour/oil and canola flour/oil

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Abstract The aim of the present study was to compare the nutritional, processing and sensory characteristics of low-fat ω-3 enriched fatty acids chicken meat patties (CMP) prepared with the incorporation of 4% linseed flour (T_1), 2% canola flour (T_2), 3% linseed oil (T_3), and 4% canola oil (T_4) and to estimate their cost of production. The total fat and crude fiber content was increased ($P<0.05$) with the incorporation of linseed flour. The emulsion stability and cooking yield was greater ($P<0.05$) in T_4 among all the treatments. The percent shrinkage was lower ($P<0.05$) in linseed/canola oil incorporated CMP than their respective flours. The colour and appearance and flavour scores were lower ($P<0.05$) in canola flour than canola oil incorporated CMP. The texture scores were not influenced ($P<0.05$) in linseed-and canola-treated products. The overall acceptability was greatest ($P<0.05$) in T_4 whereas, lowest ($P<0.05$) in T_2 among all treated products. The cost of production was increased by 3–5% with the incorporation of linseed and canola oil whereas it was almost same for control and linseed flour.

Keywords Chicken meat patties · ω-3 fatty acid · Linseed flour/oil · Canola flour/oil · Sensory quality · Cost of production

Introduction

Meat has a negative image of high calorie diet, low-fiber and rich in saturated fatty acids and cholesterol, and may lead to increase in the incidence of chronic and degenerative illness especially cardiovascular diseases, colon cancer, obesity etc. However, now it is proved that it is not only the quantity of lipids but the quality with a balanced fatty acids ratio also very important. Various Health Agencies has recommended that the dietary fat intake should be 15%–30% of the total energy out of which 10% energy intake may be contributed by the saturated fatty acids. This was further emphasized that the ratio of polyunsaturated fatty acids (PUFA) to saturated fatty acids (P/S) should be more than 0.4 (Department of Health U.K. 1994; WHO 2003; Simopoulos 2002). Therefore, different approaches were employed to develop low-fat meat products (Sandrou and Arvanitoyannis 2000) with specific fatty acid composition. These approaches include dietary manipulations of the food animals, trimming of fat in carcasses, replacement of added animal fat with vegetable oil or other non-meat fat in the processed meat products without altering the sensory quality. Moreover, the usage of ω-3 rich fat sources viz olive oil, linseed oil, canola oil etc. for the formulation of processed meat products is being extended.

Canola, linseed and their oil have been used in numerous ways for their medicinal properties from generations. These are known to reduce LDL, bad cholesterol and triglycerides. Canola contains 30% fat, 7% of ALA (alpha linolenic acid; n-3) and 30% of LA (linoleic acid; n-6) whereas linseed has ALA (51.9–55.2%), LA 44.6–51.5% and 21% protein (Erasmus 1987). In 1985 United States Food and Drug Administration granted GRAS status to canola oil (Mccurdy 1990) for the incorporation in different food products. Various scientists used these ingredients in different meat products such as linseed oil in pork sausages (Valencia et al. 2008), canola oil in oriental-style pork meat balls (Jose et al. 1996) and canola oil pre-emulsified with soy protein isolate (SPI) in Dutch style fermented sausages

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(Pelser et al. 2007). All the workers found significant effect on PUFA/SFA ratio and ω-6/ω-3 ratio. Moreover, canola and linseed flour are rich source of fiber, which can compensate the dietary fiber requirements. Therefore, the low-fat ω-3 fatty acid and fiber enriched chicken meat patties (CMP) with the incorporation of canola flour and oil, linseed flour and oil were developed and their effect on the processing and sensory quality attributes was studied. Further, the marketability of developed novel product depends upon its cost of production.

Hence, the present study was envisaged with an objective to study the processing, nutritional and sensory quality of developed novel low-fat CMP with lower levels of total fat and SFA, better ratio of n-6/n-3 PUFA and to estimate its cost of production.

Materials and methods

Treatments Chicken meat of spent male broiler fowls (IBL-80) of the age group of 7–9 months was used in the study. The level of incorporation of different additives and formulation was selected on the basis of preliminary trials and previous research in our laboratory (Singh et al. 2010, 2011) The standardized formulation (Table 1) of low-fat chicken meat patties with 4% linseed flour (T_1), 2% canola flour (T_2), 3% linseed oil(T_3), and 4% canola oil(T_4) was followed. Both the flours were added with the replacement of lean meat whereas oils were added as a replacement of added fat (5% refined soyabean oil) in the formulation. All the ingredients, spices and condiment mix were used in the study were purchased from the local market. Eighty gram patty was moulded in a moulder of dimensions 76 mm diameter and 17 mm height. The patties were cooked in a pre-heated hot air oven (Narang Scientific Works, New Delhi, India) at 185±5 °C for 20 min as per standardized methodologies by Singh et al. 2010. The products were cooled and samples were drawn for the analytical and sensory quality evaluation.

pH and proximate analysis The pH, moisture, protein, fat, crude fiber and ash content of CMP were determined by standard methods using combined glass electrode of an digital pH meter (SAB 5000, LABINDIA, Mumbai, India), hot air oven (Narang Scientific Works, New Delhi, India), Kjeldahl assembly (Jain Scientific Glass Works, Ambala, India), Soxhlet apparatus (Jain Scientific Glass Works, Ambala, India), crude fiber assembly and muffle furnace (LABCO India Limited, Ambala, India), respectively (AOAC 1995).

Emulsion stability and cooking yield Emulsion stability and cooking yield of CMP was determined following the standard protocols and expressed as percentage of the cooked meat.

Dimensional parameters The dimensional parameters viz. percent gain in height, decrease in diameter and percent shrinkage were measured with the help of vernier caliper and determined according to the standard equations (El-Magoli et al. 1996)

Peroxide value The method as described by Koniecko (1979) was used and results were expressed as meq/kg of the meat.

Energy/Calorie value Estimates of total calories in cooked CMP were calculated on the basis of 100 g portion using atwater values for fat (9 kcal/g), protein (4.02 kcal/g) and carbohydrate (4 kcal/g). The calories contributed by additives were based on the level of incorporation and composition. An analysis of the percentage of carbohydrate in the meat samples was not performed therefore, the calorie values were estimates and not actual values.

Sensory evaluation A seven member sensory panel selected from the students and faculty of GADVASU, evaluated the samples for the attributes; appearance and colour, texture, flavour, juiciness and overall acceptability using 8-point descriptive scale (Keeton 1983), where 8=extremely desirable and 1=extremely undesirable. The samples were presented to the individual panelist in isolation. The samples were warmed in a microwave oven for 20 sec before serving to the sensory panelists and drinking water was provided to rinse the palate in between the sample analysis.

Cost of production To estimate accurate cost of production of CMP under commercial conditions, the expenditure incurred in terms of recurring and non recurring items, the capital invested and its interest, labour charges, depreciation on machineries, water and electricity charges, rent paid and over head expenses were taken under consideration in addition to cost of ingredients. As the study was conducted in the laboratory of Department of Livestock Products Technology, GADVASU, Ludhiana. Therefore, the capital investment and its interest and building rent were not previewed, however the overhead expenses including depreciation of machineries were taken into account. The dressed chicken carcass was purchased from university poultry farm whose price is fixed by the committee on the basis of prevalent market price.

Statistical analysis Data were analyzed statistically on 'SPSS-12.0' software packages (SPSS Inc. Chicago, IL, USA) as per standard methods (Snedecor and Cochran 1994). Duplicate samples were drawn for each parameter and the experiment was repeated thrice (n=6). The cooking yield and dimensional parameters of the chicken meat

Table 1 Formulation of chicken meat patties

Ingredients	Control	Levels of incorporation (%)			
		T_1	T_2	T_3	T_4
Lean meat	72.6	68.6	70.6	72.6	72.6
Chilled water	7.0	7.0	7.0	7.0	7.0
Refined wheat flour	4.0	4.0	4.0	4.0	4.0
Egg white	5.0	5.0	5.0	5.0	5.0
Table salt	1.4	1.4	1.4	1.4	1.4
Spice mix	1.5	1.5	1.5	1.5	1.5
Condiment mix	3.0	3.0	3.0	3.0	3.0
Sugar	0.3	0.3	0.3	0.3	0.3
Sodium tripolyphosphate	0.2	0.2	0.2	0.2	0.2
Sodium nitrite	120 ppm	120 ppm	120 ppm	120 ppm	120 ppm
Refined soybean oil	5.0	5.0	5.0	2.0	1.0
Linseed flour	–	4.0	–	–	–
Canola flour	–	–	2.0	–	–
Linseed oil	–	–	–	3.0	–
Canola oil	–	–	–	–	4.0

patties were recorded for 8 samples and the experiment was repeated three times i.e. n=24. Sensory evaluation was performed by a panel of seven member judges for three times, so total observations being 21 (n=21). Data was subjected to analysis of variance and means were compared by critical difference tests.

Results and discussion

The comparative evaluation of the physicochemical characteristics including proximate analysis, processing parameters and sensory attributes of the chicken meat patties incorporated with selected optimum levels of 4% linseed flour (T_1), 3% linseed oil (T_3), 2% canola flour (T_2) and 4% canola oil (T_4) was carried out with control patties (5% refined soybean oil) and the results were statistically analyzed and tabulated in Table 2 and 3.

Physicochemical characteristics Perusal of Table 2 revealed that the highest pH among raw emulsions was recorded for T_3. The change in pH of the emulsion with respect to linseed oil might be attributable to higher pH of linseed oil which is in the range of 7.8±0.01. However, the product pH remained comparable in all the treatments irrespective of the type of the flour or oil. In general, the pH of cooked patties increased from raw emulsion pH due to concentration of the components in products with moisture loss during cooking. The mean moisture percent did not show any significant (P<0.05) change in all the cooked products. The fat content was recorded highest for T_1 which was significantly (P<0.05) higher than treatments and control. This might be due to the fact that linseed flour comprises of 35% fat (Berglund 2002) and canola flour of 30% fat (Erasmus 1987). Both the flours were added as a replacement to the lean meat content whereas oils were added as a partial replacement of added fat (refined soyabean oil). It was further observed that the total fat content in all the products remained well below the threshold level of low-fat meat products (<10% total fat; Keeton 1994). The protein content was significantly (P< 0.05) higher in CMP incorporated with canola flour (T_2) than control and other treatments. It may be attributable to the higher proteins in canola flour (Fonnesbeck et al. 1984). The change in the protein content of processed product with the incorporation of the non-meat ingredients was observed by various workers(Mugueza et al. 2001; Kumar and Sharma 2004a, b; Nissar et al. 2009). Total crude fiber content varied significantly (P<0.05) with the incorporation of canola and linseed flour in the CMP. The maximum crude fiber content was measured for the CMP fortified with linseed flour and subsequently in chicken meat patties with canola flour and minimum for the control chicken meat patties. The significant (P<0.05) change in the crude fiber content was due to the composition and level of incorporation of linseed and canola flour in chicken meat patties. It was further confirmed by the documented reports on composition of linseed and canola flour which reported 41% and 8.6% of the crude fiber, respectively (Berglund 2002; Fonnesbeck et al. 1984). The mean moisture protein ratio and peroxide value remained comparable irrespective of the type and quantity of the added fat in the product. Our results are in consonance with the findings of Turp and Serdaroglu (2008) and Pelser et al. (2007) in the different

Table 2 Physicochemical characteristics of the chicken meat patties incorporated with selected level of the linseed and canola flours/oils

Characteristics	Treatments				
	Control	T_1	T_2	T_3	T_4
pH emulsion	6.1±0.05[a]	6.1±0.01[a]	6.1±0.02[a]	6.2±0.02[b]	6.1±0.02[a]
pH product	6.3±0.02	6.3±0.07	6.3±0.02	6.3±0.08	6.3±0.06
Moisture (%)	63.5±0.45	63.0±0.54	63.0±0.63	63.0±0.68	62.0±0.76
Fat (%)	7.7±0.09[a]	8.2±0.04[b]	8.0±0.15[ab]	7.3±0.10[a]	7.2±0.15[a]
Protein (%)	18.3±0.18[a]	18.4±0.07[a]	19.0±0.12[b]	18.3±0.12[a]	18.4±0.20[a]
Ash (%)	2.3±0.06[a]	2.6±0.08[b]	2.5±0.07[b]	2.7±0.16[b]	2.6±0.19[b]
Total crude fiber (%)	0.42±0.02[a]	1.9±0.03[c]	0.68±0.04[b]	–	–
Moisture protein ratio	3.4±0.16	3.4±0.30	3.4±0.14	3.3±0.24	3.4±0.19
Peroxide value (meq/kg)	5.6±0.15	5.9±0.29	5.5±0.43	5.9±0.31	5.4±0.41
Energy (kcals/100 g)	151.9±0.35[a]	158.3±0.28[b]	157.5±0.32[b]	152.5±0.35[a]	151.0±0.41[a]
Energy/patty (kcals)	104.2±0.04[a]	108.6±0.05[b]	108.2±0.07[b]	106.3±004[a]	105.3±0.05[a]

n=6, T_1=4% linseed flour, T_2=2% canola flour, T_3=3% linseed oil, T_4=4% canola oil

Mean±SE with different superscripts in same row differ significantly ($P<0.05$)

processed meat products with different types of added fat. The peroxide values of the CMP had no difference but lowest peroxide value was recorded for the T_2 and T_4 incorporated with canola flour and oil. It might be due to the innate quality of canola oil to resist the oxidation (Wanasundara and Shahidi 1994). The calorie content was recorded significantly ($P<0.05$) higher for T_1 and T_2 than T_3, T_4 and control, might be due to the higher fat percent in these patties. However, the increase in calorie content was less than 4% in CMP with linseed and canola flours.

Processing quality The emulsion stability and cooking yield (Table 3) were recorded highest for treatment T_4, which were significantly ($P<0.05$) better than T_2, T_3 and control. It may be due to better protein-fat interaction and gel formation with canola oil. The moisture and fat retention was also recorded better for T_4 (data not presented here). The dimensional parameters were significantly ($P<0.05$) influenced with change in the type of added fat. The percent gain in height was higher in T_2 than T_1 and it was recorded highest for T_4, which was significantly ($P<0.05$) better than all the treatments and control. It might be due to enhancement in the swelling nature of CMP and refined wheat flour used as binder in the formulation with the incorporation of canola oil. The minimum shrinkage percent was recorded for T_4 however, it was comparable to T_3 and control. The literature is almost silent on the effect of linseed and canola flour/oils on the processing characteristics of meat products especially chicken meat patties.

Sensory quality Sensory attributes (Table 3) varied significantly ($P<0.05$) for all the attributes except texture of the product. The colour and appearance scores were recorded minimum for the canola flour (T_2) and maximum for control patties however, these were comparable in control and CMP incorporated with linseed and canola oil. The lower colour and appearance scores for T_2 were due to dark brownish colour of the canola flour, which significantly

Table 3 Processing and sensory characteristics of the chicken meat patties incorporated with selected levels of linseed and canola flours/oils

Parameter	Treatments				
	Control	T_1	T_2	T_3	T_4
Emulsion stability (%)	94.6±0.33[a]	95.8±0.28[ab]	93.8±0.55[a]	93.2±0.65[a]	96.6±0.43[b]
Cooking yield (%)	86.3±0.37[a]	85.8±0.57[a]	86.2±0.56[a]	87.9±0.81[a]	91.1±0.85[b]
Gain in height (%)	16.1±0.39[b]	13.9±0.39[a]	20.9±0.74[c]	19.4±0.72[bc]	30.7±0.81[d]
Decrease in diameter (%)	8.8±0.36[a]	10.6±0.69[b]	13.3±0.37[c]	8.5±0.90[a]	10.2±0.83[b]
Shrinkage (%)	4.5±0.14[a]	6.5±0.20[b]	7.7±0.32[c]	3.9±0.32[a]	3.9±0.58[a]
Sensory evaluation*					
Colour and appearance	7.2±0.01[c]	6.7±0.04[b]	6.2±0.03[a]	7.3±0.09[c]	7.2±0.12[c]
Flavour	7.2±0.02[c]	6.9±0.02[b]	6.2±0.10[a]	6.7±0.12[ab]	7.0±0.12[c]
Texture	7.2±0.03	6.8±0.18	6.9±0.12	7.2±0.11	7.1±0.10
Juiciness	7.3±0.09[b]	6.9±0.12[ab]	6.6±0.18[a]	7.1±0.12[b]	7.2±0.11[b]
Overall acceptability	7.3±0.03[c]	6.9±0.05[b]	6.5±0.11[a]	7.1±0.12[b]	7.2±0.03[c]

T_1=4% linseed flour, T_2=2% canola flour, T_3=3% linseed oil, T_4=4% canola oil

n=6, **n*=21, T_1=4% of linseed flour, T_2=2% canola flour; 8- point descriptive scale, where 8 is=extremely desirable and 1=extremely undesirable

Mean±SE with different superscripts in same row differ significantly ($P<0.05$)

(P<0.05) deteriorated the consumer acceptance. The colour and appearance scores with linseed flour were better because product incorporated with aforesaid flour had lighter appearance than product with canola flour. Similarly, flavour scores were also minimum for T_2. The sensory panelists awarded lower flavour scores to CMP incorporated with linseed oil, might be due to strong odour of the linseed oil. Similar findings were observed by Vereshagin and Novitskaya 1965; Valencia et al. 2008. The sensory panel rated all the products comparable with respect to texture however, the juiciness was significantly (P<0.05) higher for CMP with oils (T_3 and T_4). This might be due to more water adsorption by the flour than oil (Kumar and Sharma 2004a, b). The overall acceptability scores for T_4 and control were comparable and were significantly (P<0.05) better than other treatments. The sensory panelists rated CMP with canola flour as poorest amongst all the treatments. Therefore, the authors recommended that this product need further improvement in its sensory attributes before final marketing. The ω-3 fatty acid content was recorded highest for T_3 whereas n-6/n-3 ratio was recorded minimum for T_3 and highest for control (data not presented, Singh et al. 2010, 2011). Therefore, nutritionally superior with comparable sensory attributes low-fat ω-3 fatty acid enriched CMP can be successfully prepared with the incorporation of linseed flour (4%) and linseed oil (3%) and canola oil (4%).

Cost of production The total cost of production of CMP was combination of expenditure incurred for formulation or recurring cost and overhead or non-recurring cost. The formulation costs include price of lean meat, additives, spice mix, condiment mix. The final cost of production of cooked products was calculated on the basis of their average cooking yield of control as well as developed patties (Table 3). Whereas, the overhead costs including labour charges, depreciation on machinery, water and electricity charges were taken as overhead expenditure in addition to cost of ingredients. The cost analysis revealed that formulation cost forms 88.16% of expenses, whereas the overhead expenses were 11.84% of total cost of the product.

The production cost of ω-3 enriched CMP incorporated with linseed flour was calculated as minimum and CMP with 4% canola oil as maximum. The increase in cost of production of chicken meat patties from the control was only 2.93% for linseed oil and 5.43% for canola oil incorporated CMP, however the cost of production of CMP incorporated with linseed flour was decreased by 0.78% from the control.

Conclusions

The present day consumers are health conscious and demand nutritious and reasonably priced food items. Therefore, ω-3 fatty acid enriched, low-fat, low-calorie, high fiber chicken meat patties developed in the study with the incorporation of 4% linseed flour, 3% linseed oil and 4% canola oil can cater the demand of such consumers. Moreover, the developed product has a nominal rise in the price. Hence, it can be exploited for marketing in domestic and foreign market to fetch better revenues.

References

AOAC (1995) Official methods of analysis, 16th edn. Association of official analytical chemists, Washington, D.C

Berglund DR (2002) Flax: New uses and demands. In: Janick J, Whipkey A (eds) Trends in new crops and new uses. ASHS Press, Alexandria, pp 358–360

Department of Health, UK (1994) Nutritional aspects of cardiovascular disease, report on Health and Social Subject No. 46. Her Majesty's Stationary Office, London

El-Magoli SB, Laroia S, Hansen PMT (1996) Flavour and texture characteristics of low-fat ground beef patties formulated with whey protein concentrate. Meat Sci 42(2):179–193

Erasmus U (1987) Oil in seeds In: Fat that heal, fat that kills. Alive publishers, Book Publishing Company, USA

Fonnesbeck PV, Lloyd H, Obray R, Romensburg S (1984) IFI,Tables of feed composition. International Feedstuffs Institute, Utah State University, Logan, pp 607

Jose N, Xiong YL, Jose C (1996) Chemical, physical, and sensory characteristics of oriental meatballs as affected by binding agents. Annual Meeting Institute of Food Technologists, June 24–26, New Orleans, USA

Keeton JT (1983) Effect of fat and sodium chloride/phosphate levels on the chemical and sensory properties of pork patties. J Food Sci 48:878–881

Keeton JT (1994) Low-fat meat products—Technological problems with processing. Meat Sci 36:261–276

Koniecko EK (1979) Handbook for meat chemists. Chap.6. Avery Publishing Group, Inc, Wayne, pp 53–55

Kumar M, Sharma BD (2004a) The storage stability and textural, physico-chemical and sensory quality of low-fat ground pork patties with carrageenan as fat replacer. Int J Food Sci Tech 39:31–42

Kumar M, Sharma BD (2004b) Efficacy of barley flour as fat substitute on processing quality and storage stability of low-fat ground pork patties. J Food Sci Tech 41(5):496–502

Mccurdy SM (1990) Effect of processing on the functional properties of canola/rapeseed protein. J Am Oil Chem Soc 67:281–284

Muguerza E, Gimeno O, Ansorena D, Bloukas JG, Astiasaran I (2001) Effect of replacing pork backfat with pre-emulsified olive oil on lipid fraction and sensory quality of Chorizo de Pamplona—a traditional Spanish fermented sausage. Meat Sci 59(3):251–258

Nissar M, Chatli MK, Sharma DK (2009) Efficacy of tapioca starch as a fat replacer in low fat buffalo meat patties. Buffalo Bull 28:18–24, 28

Pelser WM, Linssen JPH, Legger A, Jacques H (2007) Lipid oxidation in $n-3$ fatty acid enriched Dutch style fermented sausages. Meat Sci 75(1):1–11

Sandrou DK, Arvanitoyannis IS (2000) Low-fat/calorie foods: Current state and perspectives. Crit Rev Food Sci Nutr 40(5):427–447

Simopoulos AP (2002) The importance of the ratio of ω-6/ω-3 essential fatty acids. Biomed Pharmacother 56(8):365–379

Singh R, Chatli MK, Biswas AK, Sahoo J (2010) Effect of partial substitution with canola oil on the processing, nutritional and textural quality of omega-3 fatty acid enriched low-fat chicken meat patties. Indian J Poultry Sci 45:165–170

Singh R, Chatli MK, Biswas AK, Sahoo J (2011) Quality and storage stability of chicken meat patties incorporated with linseed oil. J Food Qual. doi:10.1111/j.1745-4557.2011.00395

Snedecor GW, Cochran WG (1994) Statistical methods, 8th edn. Iowa State University Press, Ames, Iowa

Turp GY, Serdaroglu M (2008) Effect of replacing beef fat with hazelnut oil on quality characteristics of sucuk—A Turkish fermented sausage. Meat Sci 78:447–454

Valencia I, O'Grady MN, Ansorena D, Astiasaran I, Kerry JP (2008) Enhancement of the nutritional status and quality of fresh pork sausages following the addition of linseed oil, fish oil and natural antioxidants. Meat Sci 80:1046–1054

Vereshagin AG, Novitskaya GV (1965) The triglyceride composition of linseed oil. J Am Oil Chem Soc 42:970–974

Wanasundara UN, Shahidi F (1994) Canola extract as an alternative natural antioxidant for canola oil. J Am Oil Chem Soc 71 (8):817–822

World Health Organization (WHO) (2003) 1 Diet, nutrition and the prevention of chronic diseases. WHO. Technical report series 916. Geneve, Switzerland