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Microbiological and Storage Quality Attributes Analysis of *Papaver somniferum* (Poppy) Fortified Fish Nuggets

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Efficacy of ground poppy seed paste fortification in fish nuggets was analyzed. The use of ground poppy seed in fish nuggets formulation had no effect on moisture and protein content. However, it did have significant ($p<0.05$) on lowering fat and pH content, higher emulsion stability and higher cooking yield in the developed designer product. Fish nuggets having 5% ground poppy seed were having significantly ($p<0.05$) better sensory scores. The ground poppy seed treated fish nuggets were having significantly ($p<0.05$) lower TBA and FFA value. The microbial load of developed product was also recorded significantly ($p<0.05$) lower. The fish nuggets prepared with fortification of ground poppy seed was found to be suitable for consumption even on 21st day of its refrigeration storage based on TBA, FFA, microbiological and sensory profile. Thus, fish nuggets with good to very good acceptability were developed with incorporation of ground poppy (*Papaver somniferum*) seed in it.

Keywords: Fat replacer, Fish nuggets, *Papaver somniferum (poppy),* Microbiological quality, Storage quality**.**

Consumer has greater interest regarding demand for those foods having health enhancing properties, especially, low fat non vegetarian product owing to human health and nutritional correlation (Choi *et al*., 2010; Gok *et al*., 2011). Consumers are also aware about type and class of dietary protein and fat consumed. So, the food industry motivate themselves to develop meat product consists of less amount but quality fat and protein in it(Yildiz-Turp and Serdaroglu, 2008).Several diseases occurred are related to excessive dietary fat, forced consumers to be more careful on the amount as well as quality of fat consumed on daily basis. High fat intake increases risk of obesity and other lifestyle diseases. The quality and amount of fat consumed is closely related to high blood cholesterol, arteriosclerosis and coronary heart disease (USDA and USDHHS, 1995). The meat and traditional meat products consist of high amount of fat which can be associated with cardiovascular health of consumers (Ozvural and Vural, 2008).

Papaver somniferum (poppy) is widely grown as an annual crop is mainly cultivated to produce edible oil which consists of approximately 73% of linoleic acid, 10% of Palmatic acid and 13% of oleic acid. These unsaturated fatty acids help in lowering serum cholesterol were reported (Bozan and Tameli, 2003). These also contain poly-phenols like tannic acid, ellagitannin that act as antioxidant. Poppy extract has traditionally been used to relax smooth muscle tone and as a sedative analgesic and anti-tussive. It is used as a vehicle in chemotherapy and to cure insomnia. Poppy seeds contain many plant derived chemical compounds that are known to have anti-oxidant, disease preventing and health promoting properties. (Imaijumi, *et al*., 2000).

Addition of poppy seed paste in various fish nuggets provides different delicacies and

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novelties. It may act as fat replacer in fish products. It may increases unsaturated fatty acid concentration of developed fish nuggets. Decreasing cholesterol may have significant application for consumer's health. Sensorial properties of fish nuggets may improved by ground poppy seed addition. Antioxidant property of poppy seed may enhance its shelf-life properties.

Therefore, the present study aims to use poppy seed paste in emulsion based fish meat products viz. fish nuggets and to determine its effect on quality of fish meat nuggets.

MATERIALS AND METHODS

Raw material

Boneless fish meat of *Pangasius pangasius* fish belonging to Pangasidae family was procured from local market of Jammu. It was packed in sterilized polythene bags and frozen at -18±2°C until use. Poppy seed was procured from local market of Jammu. It was washed and dried properly followed by grinding to make into powder form.

Chemicals

All chemicals used were of food grade.

Preparation of Fish nuggets

Fish meat was cut and minced in a meat mincer (MOD-TC 23 R10 U.P. INOX, Marsango, Italy). Meat emulsion for fish nuggets was prepared in bowl chopper [MOD 25 2.8G 4.0, Marsango, Italy]. Crushed ice was added and blending continued for 1.5 minutes. Addition of refined vegetable oil, spice mixture, condiments and other ingredients and again mixed for 1.5 to 2 minutes to get the desired emulsion. The weighted quantity of the meat batter or emulsion was stuffed in rectangular stainless steel mould (17.5cm ×11.5cm ×5 cm) with parchment paper re-smeared with oil to avoid sticking. Mould was covered with lid and tied with thread. The mixture was subjected to steam cooking for 50±5 minutes in pressure cooker. The boxes were allowed to cool at room temperature after removal from pressure cooker. The brick shaped fish nugget so obtained were sliced and cut into pieces to get smaller nuggets.

The formulation in (%) was standardized, optimized and used for preparation of fish nuggets from fish meat- 68.6, added water- 9.1, vegetable oil- 8.9, condiment mixture-4.9, refined wheat flour - 4.1, spice mixture-1.9, table salt-1.6, monosodium glutamate- 0.4, sodium tripolyphosphate - 0.4, sodium nitrite -100 ppm. The fortification was done in the ratio of 5, 10, and 15% poppy with replacement in lean meat (wt./wt.). The nuggets were cooled and then stored in low density polyethylene pouches (200 gauge).These were stored in refrigerator (4±1°C) for evaluation of physico-chemical, microbiological profile and sensory parameters 0^{th}, 7^{th}, 14^{th} and 21^{st} day.

Analytical Techniques

pH

The pH of cooked nuggets sample was measured by the method of Keller *et al*. (1974). The pH was recorded by digital pH meter (Systronics Digital pH meter 802, Serial No. 603).

Proximate composition

Moisture, Crude protein, Crude fats, emulsion stability and cooking yield in both control and treated samples were done as per standard procedures. (AOAC, 2000).

Thio Barbituric Acid (TBA)

It was determined using the method of Witte *et al.* (1970).

Free Fatty Acid (FFA)

It was determined by method described by Koniecko (1979).

Microbiological Profile

Total plate count, Psychrotrophic count, Coliform count and Yeast and Mould count in the sample were determined by method described by APHA (1984). Readymade media (Hi-Media) were used for the analysis.

Sensory Evaluation

It was carried for various attributes viz. color and appearance, flavor, juiciness, texture and overall acceptability by a panel of trained members composed of scientists based on a eight-point Hedonic scale, wherein 8 denoted "extremely desirable" and 1 denoted "extremely undesirable" (Seman et al., 1987). Seven members of the panel replicated the experiment thrice (n = 21). Panellists were comfortably seated in a noise and odour free room which was suitably illuminated. Coded samples for sensory evaluation were prepared.

Statistical Analysis

The results were analyzed statistically for analysis of variance in one way as well as two way and least significant difference tests as per (Snedecor and Cochran, 1997). In significant

effects, least significant differences were calculated for a pair wise comparison of treatment means.

Experimental Design

The fish meat of *Pangasius pangasius* fish was utilized in the preparation of nuggets with incorporation of *Papaver somniferum* (poppy). The standardization and optimization of fish nuggets was done by substituting in the ratio 0% (control), 5%, 10% and 15% level of poppy seed paste replacing lean meat (wt/wt).. The developed designer products were evaluated based on physio-chemical, proximate, microbiology, sensory and storage quality on 0^{th}, 7^{th}, 14^{th} and 21^{st} day during refrigeration storage at (4±1°C).

RESULTS AND DISCUSSION

Table.1 depicted the effect of poppy seed paste on physico-chemical properties of fish nuggets. The inclusion of poppy seed paste in fish nuggets lowered down its pH. It may be due to greater fatty acid content in poppy seed. The moisture and protein content in treated product was comparable with control. It may be due to similar moisture and protein level in both fish meat and ground poppy seed paste. However, the fat content in the treated product significantly ($p<0.05$) reduced. Similarly, Yilmaz, (2004) and Turhan *et al.* (2005) reported decreased fat content with addition of ground poppy seed paste in meat balls and meat burgers respectively. This can be attributed to higher protein content and lower saturated fat content of ground poppy seed paste. The emulsion stability and cooking yield significantly ($p<0.05$) increased in treated product as compared to control. Similar results were reported of better emulsion stability and cooking yield due to better moisture retention by ground poppy seed paste. Higher PUFA content and moisture retention of ground poppy seed paste may be attributed to its stabilizer and binder effect (Serdaroglu *et al*. 2004 and Pinero et al. 2008)

Table.2 depicted the effect of poppy seed paste on sensory attributes of fish nuggets. All the sensory scores viz. colour, appearance, flavour, juiciness, texture and over all acceptability of 5%

Table 1. Effect of *Papaver somniferum*(poppy) on physico-chemical properties of fish nuggets. (Mean ±SE)*

Parameters	0% (control)	5%	10%	15%
pH	6.43 ± 0.11^{d}	6.27 ± 0.14^{c}	6.04 ± 0.08^{b}	5.94 ± 0.03^{a}
Moisture	58.96±1.27	58.16±1.40	58.06±1.43	57.66±1.24
Protein	16.33±0.50	16.35±0.36	16.26±0.31	16.16±0.31
Fat	10.93 ± 0.46^{d}	9.81 ± 0.47^{c}	9.51 ± 0.38^{b}	8.96 ± 0.57^{a}
Emulsion stability	90.90 ± 0.41^{a}	91.15 ± 0.43^{b}	91.91 ± 0.30^{c}	92.01 ± 0.27^{d}
Cooking yield	87.86 ± 0.17^{a}	88.65 ± 0.33^{b}	89.95 ± 0.22^{c}	89.99 ± 0.26^{d}

*Mean± SE with different superscripts in a row wise (lower case alphabet) and column wise (upper case alphabet) differ significantly ($P<0.05$).n=6 for each treatment.

Table 2. Effect of *Papaver somniferum* (poppy) on sensory Attributes of cooked fish nuggets. (Mean ±SE)*

Attributes	0% (control)	5%	10%	15%
Colour and Appearance	6.18 ± 0.17^{b}	7.43 ± 0.13^{d}	6.50 ± 0.12^{c}	4.01 ± 0.12^{a}
Flavour	6.28 ± 0.17^{b}	7.12 ± 0.11^{d}	6.65 ± 0.18^{c}	4.42 ± 0.13^{a}
Juiciness	6.22 ± 0.18^{b}	7.34 ± 0.13^{d}	6.42 ± 0.16^{c}	4.23 ± 0.11^{a}
Texture	7.38 ± 0.14^{c}	6.87 ± 0.11^{b}	7.43 ± 0.16^{d}	4.39 ± 0.17^{a}
Overall Acceptability	7.26 ± 0.13^{b}	7.76 ± 0.19^{d}	7.41 ± 0.11^{c}	4.52 ± 0.19^{a}

*Mean± SE with different superscripts in a row wise (lower case alphabet) and column wise (upper case alphabet) differ significantly ($P<0.05$).n=6 for each treatment.

Table 3. Storage quality of *Papaver somniferum* (poppy) treated fish nugget in terms of physico-chemical properties during refrigeration storage (4±1^{0}C). (Mean ±SE)*

Treatments	Storage days			
	0th day	7th day	14th day	21st day
TBA(mg malonaldehyde/kg)				
Control	0.299±0.0134^{Ad}	0.427±0.0005^{Ac}	1.050±0.0011^{Ab}	1.304±0.0007^{Aa}
(5%) *Papaver somniferum*	0.297±0.0182^{ABd}	0.392±0.0009^{Bc}	0.673±0.0006^{Bb}	0.824±0.0009^{Ba}
(10%) *Papaver somniferum*	0.295±0.0280^{BCd}	0.360±0.0005^{Cc}	0.624±0.0007^{Cb}	0.780±0.0006^{Ca}
(15%) *Papaver somniferum*	0.291±0.0145^{Ca}	0.323±0.0005^{Dc}	0.560±0.0007^{Db}	0.760±0.005^{Dd}
pH				
Control	5.78±0.007^{Ad}	5.87±0.009^{Ac}	6.21±0.011^{Ab}	6.62±0.005^{Aa}
(5%) *Papaver somniferum*	5.75±0.166^{ABd}	5.77±0.009^{Bc}	6.10±0.011^{Bb}	6.36±0.008^{Ba}
(10%) *Papaver somniferum*	5.72±0.133^{BCd}	5.73±0.010^{Cc}	6.05±0.007^{Cb}	6.26±0.008^{Ca}
(15%) *Papaver somniferum*	5.69±0.170^{Cd}	5.69±0.009^{Dc}	5.89±0.005^{Db}	6.20±0.008^{Da}
FFA				
Control	0.098±0.0005^{Ad}	0.175±0.0008^{Ac}	0.235±0.0005^{Ab}	0.372±0.0006^{Aa}
(5%) *Papaver somniferum*	0.090±0.0063^{Ad}	0.141±0.0009^{Bc}	0.215±0.0009^{Bb}	0.330±0.0005^{Ba}
(10%) *Papaver somniferum*	0.083±0.0140^{Bd}	0.098±0.0008^{Cc}	0.190±0.0008^{Cb}	0.244±0.0009^{Ca}
(15%) *Papaver somniferum*	0.079±0.0217^{Cd}	0.081±0.0008^{Cc}	0.151±0.0007^{Cb}	0.225±0.0047^{Ca}

*Mean± SE with different superscripts in a row wise (lower case alphabet) and column wise (upper case alphabet) differ significantly (P<0.05).n=6 for each treatment.

Table 4. Changes in microbiological profile of *Papaver somniferum* (poppy) treated fish nugget at refrigeration temperature (4±10C). (Mean ±SE)*

Treatments	0th day	7th day	14th day	21st day
TBA(mg malonaldehyde/kg)				
Total Plate Count (log_{10}cfu/g)				
Control	2.71±0.0083^{Ad}	3.76±0.0097^{Ac}	4.17±0.0089^{Ab}	5.21±0.0082^{Aa}
(5%) *Papaver somniferum*	2.33±0.0076^{Bd}	3.31±0.0109^{Bc}	3.89±0.0087^{Bb}	4.45±0.0095^{Ba}
(10%) *Papaver somniferum*	1.81±0.0069^{Cd}	3.21±0.0079^{Cc}	3.58±0.0097^{Cb}	3.83±0.0075^{Ca}
(15%) *Papaver somniferum*	1.77±0.0063^{Dd}	2.93±0.0081^{Dc}	3.28±0.0093^{Db}	3.37±0.0062^{Da}
Psychrotrophic Count (log_{10}cfu/g)				
Control	ND	ND	1.99±0.021^{Ab}	2.93±0.0159^{Aa}
(5%) *Papaver somniferum*	ND	ND	ND	1.77±0.0137^{Ba}
(10%) *Papaver somniferum*	ND	ND	ND	0.91±0.0126^{Ca}
(15%) *Papaver somniferum*	ND	ND	ND	0.84±0.0121^{Da}
Coliform Count (log_{10}cfu/g)				
Control	ND	ND	ND	ND
(5%) *Papaver somniferum*	ND	ND	ND	ND
(10%) *Papaver somniferum*	ND	ND	ND	ND
(15%) *Papaver somniferum*	ND	ND	ND	ND
Yeast and Mold Count (log_{10}cfu/g)				
Control	ND	ND	2.51±0.0009^{Ab}	3.67±0.0103^{Aa}
(5%) *Papaver somniferum*	ND	ND	ND	2.33±0.0116^{Ba}
(10%) *Papaver somniferum*	ND	ND	ND	1.87±0.0117^{Ca}
(15%) *Papaver somniferum*	ND	ND	ND	1.53±0.0115^{Da}

*Mean± SE with different superscripts in a row wise (lower case alphabet) and column wise (upper case alphabet) differ significantly (P<0.05).n=6 for each treatment.

ground poppy seed paste incorporated in fish nuggets was significantly ($p<0.05$) higher than other types of fish nuggets. Ground poppy seed paste may be responsible for increased lightness, redness and yellowness values (Turhan *et al.* 2005 and Yildnaz and Daglioglu, 2003). The texture of the treated product was found to be better due to its higher PUFA content and moisture retention capacity of ground poppy seed paste may be as a good binder and stabilizer (Pinero *et al.* 2008 and Gok *et al.* 2008). The flavour was light till 5% incorporation of Ground poppy seed paste in meat burger was supported by the findings of (Gok *et al.* 2011).

Table.3 showed storage quality of fish nugget in terms of physico-chemical properties during refrigeration storage. The TBA value in case of control fish nuggets was recorded to be greater than 21st day of refrigeration storage made it unsuitable for human consumption. However the TBA value in ground poppy seed paste treated fish nuggets were found to be suitable for human consumption even on 21st day of refrigeration storage, as the value of TBA were found to be less than 1 on day 21st of refrigeration storage. This may be attributed to anti-lipolytic effect and anti-oxidant effect because of ellagitannin, PUFA and tocopherol content in poppy seeds. Higher poly unsaturated fatty acid, tocopherol and phytosterol content of various poppy seed exhibits anti-lipolytic and anti-oxidant effect (Erinic *et al.* 2009).It was further supported of total replacement of pork back fat with walnut on the nutritional profile of frankfurters Ayo (2007).

Table 5. Changes in the sensory attributes of aerobically packaged *Papaver somniferum* (poppy) treated fish nugget during refrigerated storage at (4±1°C). (Mean ±SE)*

Treatments	Storage period(days)			
	0th day	7th day	14th day	21st day
Colour and appearance				
Control	6.59 ± 0.100^{Ca}	6.07 ± 0.109^{Cb}	5.59 ± 0.097^{Dc}	4.95 ± 0.141^{Ad}
(5%) *Papaver somniferum*	7.47 ± 0.118^{Aa}	6.85 ± 0.093^{Ab}	6.42 ± 0.096^{Ac}	5.97 ± 0.090^{Ad}
(10%) *Papaver somniferum*	7.08 ± 0.096^{Ba}	6.42 ± 0.096^{Bb}	6.04 ± 0.090^{Bc}	5.40 ± 0.121^{Bd}
(15%) *Papaver somniferum*	6.39 ± 0.086^{Da}	5.88 ± 0.116^{Db}	5.38 ± 0.102^{Cc}	4.54 ± 0.127^{Dd}
Flavour				
Control	6.53 ± 0.094^{Ba}	5.93 ± 0.130^{Bb}	5.58 ± 0.074^{Bc}	3.96 ± 0.108^{Bd}
(5%) *Papaver somniferum*	7.15 ± 0.098^{Aa}	6.74 ± 0.061^{Ab}	6.35 ± 0.061^{Ac}	4.85 ± 0.076^{Ad}
(10%) *Papaver somniferum*	6.74 ± 0.131^{Ba}	6.12 ± 0.119^{Bb}	5.77 ± 0.112^{Bc}	4.09 ± 0.105^{Bd}
(15%) *Papaver somniferum*	6.77 ± 0.081^{Ba}	6.22 ± 0.073^{Bb}	5.89 ± 0.113^{Bc}	4.16 ± 0.070^{Bd}
Texture				
Control	7.41 ± 0.088^{Aa}	6.82 ± 0.105^{Ab}	5.57 ± 0.086^{Ac}	4.62 ± 0.112^{Ad}
(5%) *Papaver somniferum*	7.51 ± 0.912^{Aa}	6.96 ± 0.126^{Ab}	5.71 ± 0.127^{Ac}	4.77 ± 0.146^{Ac}
(10%) *Papaver somniferum*	7.43 ± 0.110^{Aa}	6.87 ± 0.137^{Ab}	5.64 ± 0.092^{Ac}	4.65 ± 0.140^{Ad}
(15%) *Papaver somniferum*	7.35 ± 0.076^{Aa}	6.75 ± 0.101^{Ab}	5.52 ± 0.087^{Ac}	4.60 ± 0.052^{Ac}
Juiciness				
Control	6.80 ± 0.100^{Ca}	6.33 ± 0.105^{Cb}	5.59 ± 0.127^{Cc}	4.88 ± 0.090^{Cd}
(5%) *Papaver somniferum*	7.47 ± 0.080^{Aa}	6.97 ± 0.094^{Ab}	6.40 ± 0.101^{Ac}	5.52 ± 0.050^{Ad}
(10%) *Papaver somniferum*	7.16 ± 0.110^{Ba}	6.66 ± 0.099^{Bb}	5.97 ± 0.094^{Bc}	5.21 ± 0.100^{Bd}
(15%) *Papaver somniferum*	7.04 ± 0.083^{BCa}	6.54 ± 0.108^{BCb}	5.85 ± 0.115^{BCc}	5.11 ± 0.074^{BCd}
Overall acceptability				
Control	6.75 ± 0.094^{Ca}	6.21 ± 0.083^{Cb}	5.41 ± 0.134^{Cc}	3.96 ± 0.116^{Cd}
(5%) *Papaver somniferum*	7.44 ± 0.096^{Aa}	7.16 ± 0.081^{Ab}	6.34 ± 0.083^{Ac}	5.01 ± 0.091^{Ad}
(10%) *Papaver somniferum*	7.16 ± 0.076^{Ba}	6.73 ± 0.107^{Bb}	5.94 ± 0.096^{Bc}	4.58 ± 0.115^{Bd}
(15%) *Papaver somniferum*	6.87 ± 0.096^{Ca}	6.33 ± 0.089^{Cb}	5.55 ± 0.123^{Cc}	4.17 ± 0.062^{Cd}

*Mean± SE with different superscripts in a row wise (lower case alphabet) and column wise (upper case alphabet) differ significantly ($P<0.05$). Mean values are scores on 8 point descriptive scale where 1- extremely poor and 8- extremely desirable. n = 21 for each treatment.

The pH value of all types of fish nuggets were reported significantly ($p<0.05$) higher value during refrigeration period. However the pH value of ground poppy seed paste treated fish nuggets recorded comparatively lesser inclination in pH value as compared to control fish nuggets. The less inclination of pH was reported with incorporation of poppy seed oil in Turkish Sucuk (Gok *et al.* 2011).

The FFA contents of all types of fish nuggets was significantly ($p<0.05$) higher during their refrigeration storage. However the rate of inclination of FFA values was significantly ($p<0.05$) lower in ground poppy seed paste incorporated fish nuggets as compared to control fish nuggets. It may be attributed to greater unsaturated fatty acid content in poppy seed (Erinic *et al.* 2009). Similar reports were observed by (Illikan *et al.* 2009), who concluded addition of hazelnut oil exhibited anti-lipolytic oil in Turkish fermented fish sausages. Kayaardi, and Gok, (2004) also concluded simila results while replacing beef fat with olive oil on quality characteristics in Turkish soudjouk (sucuk).

Table.4 depicted the changes in microbiological profile of aerobically packaged ground poppy seed paste incorporated fish nuggets during refrigeration storage. The total plate count in ground poppy seed paste incorporated in fish nuggets were recorded significantly ($p<0.05$) lower in comparison to controlled fish nuggets. It clearly indicated that that poppy seed is having antibacterial effect. The bacterial load was found to be less in poppy seed oil fortified Turkish Pastirma (Gok *et al.* 2008). It was further supported by antimicrobial effect of various oil seeds and bran fortified reduced fat frankfurters (Choi *et al.* 2010).

The psychrophillic count were found to be significantly ($p<0.05$) lower in comparison in treated fish nuggets as compared to controlled fish nuggets. However, psychrophiles were not detected till 7th day of refrigeration storage. These findings will be attributed to anti-psychrophillic potential of poppy seed. The psychrophiles did not appear till 7th day of refrigeration storage due to more than a week of incubation period required by most of psychrophillic bacteria. The coliforms were not detected on any day of storage period in any of the fish nuggets. It may be due to strict hygienic condition and correct method followed during preparing and processing of various types of fish nuggets. This was further supported by Ozcan and Cigdem (2006), who stated the presence of alpha-tocopherol and gama-tocopherol in poppy seed paste which were having antioxidant and antimicrobial property. Anti psychrophillic and anti coliformic action was also reported while working on nutritional profile of restructured beef steak with added walnuts. Serano, *et al.* (2005)

The yeast and mould count were not detected till 7th day which may be attributed to longer incubation period of most yeast and mould. The yeast and mould were recorded significantly ($p<0.05$) lower in treated fish nuggets as compared to control. It may be attributed to antifungal effect of poppy seed in fish nuggets (Ellikan *et al.* 2009). Poppy seed oil were incorporated meat product were recorded to possess anti-microbial as well as anti-mycotic properties (Gok *et al.* 2008) and (Choi *et al.* 2010).

Table.5 presented the changes in sensory attributes of ground poppy seed paste fortified aerobically packed fish nuggets during refrigeration storage. All the sensory scores irrespective of control or treated fish nuggets were recorded significantly ($p<0.05$) lower values during all days of refrigeration storage. However, 5% incorporation of ground poppy seed paste incorporated fish nuggets were recorded highest sensory values. The rate of decline of sensory values in treated product shows significantly ($p<0.05$) lower as compared to control fish nuggets. This clearly exhibited antimicrobial anti-lipolytic, anti-mycotic and antioxidant property of poppy seed. Inclusion of poppy seed in meat product was recorded higher colour, texture, juiciness, and flavour scores (Ercoskin and Demirci Ercoskin, 2010 and Pinero *et al.* 2008). Enhancement of the nutritional status and quality of fresh pork sausages following the addition of linseed oil, fish oil and natural antioxidants was also reported Valencia *et al.* (2008) and Kim, (2013).

CONCLUSIONS

Ground poppy seed replacement was found effective in lowering fat content, increasing emulsion stability and cooking yield of fish nuggets. It was also evident that sensory scores

were also higher in ground poppy seed treated fish nuggets. The storage quality was also improved with incorporation of ground poppy seed as it acts against lipid peroxidation and lipolysis. Moreover, addition of ground poppy seed declined the microbial load. The product developed with 5% ground poppy seed incorporation were higher sensory scores and found suitable for consumption even on 21st day of refrigeration at 4±1°C.

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