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Comparative study of fatty-acid composition of table eggs from the Jeddah food market and effect of value addition in omega-3 bio-fortified eggs



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Abstract Health consciousness has increased the desire of people around the world to consume functional foods. Omega-3 essential fatty acids are one among these beneficial and important health supplements without which a general predisposition to degenerative and stress related disorders can occur. Saudi Arabia has shown an alarming increase in obesity (Al-Nozha et al., 2005), diabetes (Alqurashi et al., 2011), and cardiovascular disease (Al-Nozha et al., 2004) in the last few decades mainly due to nutritional transitions and lifestyle alterations (Amuna and Zotor, 2008). Lack of nutrient dense foods and the prevailing food related disorder of obesity (Popkin, 2001; Prentice, 2014) especially render egg as a choice food to be value-added for attaining nutritional security in Saudi Arabia and in effect reverse the increasing incidences of lifestyle diseases. Nutritional intervention through a commonly consumed food product would be an important step in improving the health of the people, and reducing health care costs. As eggs are a frequently consumed food item in Saudi Arabia, enriching them with omega-3 fatty acids would be an excellent way to alleviate the existing problems. A significant deposition of omega-3 fatty acids in the eggs was observed when the diet of hens was supplemented with omega-3 fatty acids from either flaxseed or fish oil source. Inadequacy of omega-3 fatty acids could thus be rectified by producing omega-3 enriched eggs from

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hens supplemented with flaxseed or fish oil source, and thus contribute toward better health choice of the consumer.

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1. Introduction

Lifestyle diseases arising from nutritional deficiencies are taking alarming proportions in Saudi Arabia (Al-Nozha et al., 2005; Alqurashi et al., 2011; Al-Nozha et al., 2004; Popkin, 2001; Prentice, 2014). Growing trend in the consumption of junk food is leading to rapid onset of lifestyle disorders in Saudi Arabia (Amuna and Zotor, 2008). An increased consumption of omega-6 type of fats as in the diets in the western countries (Simopoulos, 2002; Massiera et al., 2010) is causing an imbalance in the recommended omega-6:omega-3 (n-6: n-3) fatty acid ratio (Ferrier et al., 1995). The American Heart Association (AHA) guideline recommends food practices that have a positive association with good health and do not disallow or limit egg consumption (Kritchevsky, 2004). Health professionals recommend a lowering of high cholesterol and increasing consumption of polyunsaturated fatty acids for better health outcomes.

Past four decades have seen drastic changes in the socio-economic conditions in Saudi Arabia. The beneficial effects of these changes have, however, unfortunately been paralleled by negative influences on the nutrition, and lifestyle of the Saudi population, resulting in adverse health conditions. A dietary shift from the high fiber and low fat diet of the past to the unhealthy diets in today's times has resulted in increased risk for cardiovascular problems, diabetes, and obesity (Musaiger, 2002). According to the Bahrain Medical Bulletin (Madani, 2000), strategies to prevent obesity in Saudi Arabia should include encouragement of outdoor physical exercise, decreased consumption of fatty foods, and lifestyle changes. Saudi Arabia has a high percentage of adults suffering from high cholesterol (Baba, 2000). High energy foods rich in fats and sugars (Musaiger, 1994, 2002) have increased the benchmark of total energy consumption per capita to 3000 kcal. Saudi recommendations allow energy intakes of 2100 kcal per capita (Khan and Al-Kanhal, 1998). Economic affluence has resulted in sedentary habits leading to fat consumption beyond the 30% of the allowed energy intake recommended for sedentary individuals (FAO, 1994). Therefore, there is an increased need for functional foods providing health benefits to the general population. Furthermore, increased health awareness has created recognition and consumer demand for nutritional products enhancing health.

Omega-3 fatty acids are one of the most sought after components in the functional food sector. It has been observed (Ramirez et al., 2001) that egg lipids are efficiently absorbed in the body, thereby increasing the bioavailability of docosa hexaenoic acid (DHA) and also increasing levels of high density lipoproteins (HDL). This makes the omega-3 enriched egg a potentially health benefitting functional food (Lewis et al., 2000; Gil et al., 2003; Hoffman et al., 2004; Yalcin and Unal, 2010). Eggs have been well accepted as a safe and nutritious food for all ages. Recommendations from the Canadian government require 0.5% of total energy intake as

omega-3 fatty acid based on the fact that North American diets are low in this nutrient (Health Canada, 1990). This has prompted the egg industry to step in to bring back omega-3 fatty acids into the food chain. Omega-3 enriched eggs would, therefore, serve as an ideal food to increase the amount of omega-3 fatty acids in the Saudi Arabian diet.

Egg is a balanced and nutrient rich inexpensive food containing high bioavailable protein, making it a reference food for protein quality (Herron and Fernandez, 2004). The Saudi poultry industry centers around two major products i.e. table eggs and broiler meat. Production of eggs has increased from 145 to 191 thousand tons from the year 2005 to 2009. Food Agriculture Organization figures of import for the major Arab countries during the years 2000–2005 showed a 66% increase, ranging from 465,000 to 770,000 tons, in a short period of 5 years. Production of table eggs has been estimated to increase by around 50% owing to population boom by around 25% and enhancement in per capita consumption of eggs (Freiji, 2008). The awareness that saturated fats and cholesterol are bad for health has turned away many consumers from meat and eggs and this is the main reason that is limiting popularization of poultry products in spite of immense nutritive values.

One of the most intriguing developments related to the food industry and public health in future may come from a higher demand of the essential omega-3 fatty acids, such as alpha-linolenic acid (ALA) eicosapentaenoic acid (EPA) and DHA in the food products. Traditionally, most of the omega-3 fatty acids in the diet have come from fish and fish oil but such foods are not eaten in enough quantities or the right kind of omega-3 rich fish are not consumed. In an effort to meet the growing demands of the health conscious consumers, egg as a nutrient dense food has been tapped (Drewnowski, 2005). The egg could serve as an unadulterated rich source of omega-3 fatty acid. Eggs contain a high density of nutrients and are a good source of proteins, vitamins, and lipids of high quality such as phospholipids and polyunsaturated fatty acids PUFAs (Meluzzi et al., 2000; Ruxton, 2010). In olden days, the country eggs contained a fairly good amount of omega-3 fatty acids and were healthy and safe for consumption. The present day poultry eggs are depleted of this essential nutrient because of intensive and industrialized poultry farming. Moreover, the health conscious consumer is dissuaded from consuming eggs because of its high fat content (Hu et al., 1999; Qureshi et al., 2007; Yaffee, 1991).

The fatty acid composition of yolk lipids can be altered depending upon the diet of the layer birds (Ahmed, 2009; Singh and Sachan, 2010). These omega-3 enriched eggs contain almost four fold DHA than the normal amount in commercially sold eggs (Lewis et al., 2000). Eggs produced from hens receiving conventional feeds tend to be relatively high in omega-6 fatty acids but poultry feed manipulation can be used successfully to either increase the amount of DHA directly using fish oil or indirectly by increasing the levels of precursor

ALA by feeding flaxseed (Jiang and Sim, 1993; Milinsk et al., 2003; Sparks, 2006).

Eggs enriched with omega-3 fatty acids could contribute to the dietary intake of omega-3 PUFAs and could be an alternative source of omega-3 fatty acids, which is derived normally from fish. Flaxseed in poultry feed for hens may prove to be a key food ingredient in establishing egg consumption for promoting better heart health in humans (Van Elswyk, 1997).

The objective of the present study was to evaluate and compare omega-3 fatty acid content in commercially sold eggs in Jeddah market and the eggs bio-fortified using omega-3 fatty acid sources, viz; flaxseed and fish oil, in the poultry diet. The aims of the experiment were to (1) study the levels of omega-3 fatty acids in the commercially sold eggs in Jeddah market to find out the need for compositional alterations of these fatty acids for egg production, (2) to select a suitable omega-3 poultry feed source for the production of omega-3 bio-fortified-eggs that would help us in establishing economic feasibility for large scale production, and (3) to establish the levels of omega-3 fatty acids required to be incorporated into the commercially available eggs, to bring back omega-3 fatty acids into the already existing food chain.

2. Materials and methods

2.1. Procurement of eggs

Commercial hen eggs were obtained fresh from well reputed departmental stores located at different places in Jeddah. For omega-3 fortification of eggs – thirty-six commercial strain hens aged 21 weeks were used for a period of 4 wks (21–25 wks age). The hens were randomly divided into three dietary treatment groups ($n = 12$ per group). The hens were housed individually in 60 cm floor space per hen and under similar management, light, and housing conditions. The feed differed in all the treatment groups. Feeding of crushed flax seed or fish oil and egg collection was conducted daily during the morning hours and eggs were stored at 4 °C for further experimentation.

2.2. Egg analysis

Eggs from 4th day of production each week were weighed and subsequently taken for analysis. Whole egg was separated using a separator and weights of yolk and albumin were recorded.

2.3. Diet

Diets were kept refrigerated till use daily. The birds were divided into following three dietary treatment groups:

1. Control group were fed the control diet (Layeration 18 Meal, containing Crude protein 18%, crude fat 3.50%, crude fiber 3.50%, Ash 13.50%, salt 0.40%, calcium 3.80%, phosphorus 0.60%, Vitamin A 10.00 IU/g, Vitamin D 3.00 IU/g, Vitamin E 10.00 IU/kg, Energy, kcal/kg 2750). Trace minerals added include copper, manganese, iron, iodine, selenium, and zinc. Mainly the control diet

contained corn (approx. 70%) soya bean extract (approx. 20%), and broken wheat, oats and millet in percentages of 2–5.

2. Flaxseed diet group were fed the control diet + 8% crushed flaxseed containing 52% ALA. A flaxseed variety containing 52% of the omega-3 fatty acid was used in the diet till the end of the trial (end of the 25th week). Appropriate percentage (8%) deductions in soyabean extract content of the control diet were done for the addition of crushed flaxseed.
3. Fish oil diet group were fed control diet + 1% fish oil containing 7.5% EPA and 14.2% DHA. Sardine fish oil containing 7.5% EPA and 14.2% DHA from Blue line foods, Goa, India was used for fortification of the control diet.

2.4. Nutritional and elemental analysis

Analysis of mineral components of egg was conducted by an independent National Accreditation Board for Testing and Calibration Laboratories (NABL) recognized laboratory, of India.

2.5. Fatty acid analysis in egg yolk

Fatty acid analysis of egg yolk was done by preparing methyl esters of the yolk fraction using the method of Masood et al. (2005). The methylated yolk fatty acid samples were re-suspended in chloroform and quantified by gas chromatography (Arvindakshan et al., 2003) performed on a Hewlett Packard gas chromatograph, model 5890, series II using a capillary column on a fused silica gel capillary column 30 m × 0.32 mm with a thickness of 0.25 (Supelco, USA).

2.6. Cholesterol estimation in egg yolk

Estimation of cholesterol in egg yolk was carried out by Atozyme cholesterol enzymatic kit. Briefly, cholesterol esters in the sample were first hydrolyzed by cholesterol esterase. Cholesterol was then oxidized by cholesterol oxidase to the corresponding ketone and hydrogen peroxide. 10-Acetyl-3,7-dihydroxyphenoxazine (ADHP) is utilized as a highly sensitive and stable probe for hydrogen peroxide. Horse radish peroxidase catalyzes the reaction of ADHP with hydrogen peroxide to yield the highly fluorescent product resorufin which is monitored using excitation wavelengths of 530–580 nm and emission wavelengths of 585–595 nm (Kishi et al., 2002).

2.7. Estimation of vitamin E in egg yolk

Estimation of vitamin E was done by the colorimetric method as described by Baker and Frank (1968). Briefly, after the proteins in the yolk were precipitated using equal quantity of absolute ethanol, the entire mixture was extracted using an equal volume of *n*-heptane. The α,α -dipyridyl is then added to an aliquot of the upper layer to estimate the main interfering component, β -carotene at 460 nm. Tocopherols reduce ferric to ferrous ions and then form a red colored complex with α,α -dipyridyl which is read at 520 nm, after 1.5 minutes using a spectrophotometer.

2.8. Sensory analysis

Thirty-seven volunteers aged 18–35 years (19 males and 18 females) were given six omega-3 enriched eggs per week to be consumed either as boiled eggs or fried eggs, and were given questionnaires to fill up. The eggs were to be taken either each once daily or two eggs thrice a week. The information for flavor, taste, mouth feel, yolk color, smell, texture, and overall acceptability of the omega-3 enriched eggs was collected from each volunteer using a questionnaire (Ferrier et al., 1995).

2.9. Statistical analysis

Data were checked for normality and transformed to natural logarithms or ranks if needed. The statistical analyses were done by using SAS PROC MIXED version 9.2 (SAS Institute Inc, Cary, NC, USA). Student unpaired *t*-tests or least significant difference test were used to compare groups within an endpoint. A probability of $P < 0.05$ indicated a difference was significant, and a probability of $P > 0.05$ to $P < 0.1$ indicated that significance was approached. Data are presented as mean \pm SEM.

3. Results

Fatty acid compositions of eggs of different commercial varieties from departmental stores in Jeddah are presented in Table 1. There was no significant difference among different varieties of eggs from the departmental stores with respect to the fatty acid composition. Table 2 shows the fatty acid compositions of eggs from hens fed flaxseed and fish oil fortified diets. The total saturated fatty acid content contributed by palmitic acid and stearic acid reduced slightly and omega-3 PUFA's increased, thereby positively shifting the PUFA: Saturated fatty acid ratio in the omega-3 enriched eggs. The

PUFA content of the two commercial egg varieties (13.71 ± 0.75 and 14.75 ± 0.41) was very less, though not significant, as compared to the omega-3 eggs (23.72 ± 1.51 and 21.37 ± 0.99) analyzed. The three omega-3 (n-3) fatty acids viz; ALA, EPA, & DHA were increased in all the omega-3 eggs studied. The omega-3 enriched eggs from the flaxseed source as well as fish oil source were quite comparable in terms of the omega-6:omega-3 ratio. The omega-3 enriched eggs exhibited a very low omega-6:omega-3 ratio of 3.33 ± 0.43 and 2.75 ± 0.32 for the flaxseed and fish oil fed group respectively. Contrarily the commercial eggs analyzed from the two outlets showed a higher omega-6:omega-3 ratio of 29.58 ± 1.45 and 32.17 ± 3.03 respectively. Sensory analysis on a group of volunteers showed that omega-3 enriched eggs from the flaxseed source were more acceptable and palatable as compared to the ones produced using a fish oil source which exhibited a fishy after taste and odor.

Table 3 shows the elemental analysis of all the eggs studied. Potassium, vitamin D, E, B6, folate, and B12 levels showed a slight increase in the omega-3 eggs as compared to the commercially sold eggs.

4. Discussion

Egg being a nutrient dense, cheaply available, and commonly consumed food, needs to be assessed on its fatty acid composition, for improving its health components. Consumption of omega-3 fatty acids has majorly been associated with improved health.

Omega-3 enriched eggs through their increased amounts of omega-3 fatty acids could confer benefits similar to that observed on consuming fish oil supplements. Satiety levels are increased on consumption of eggs (Vander Wal, 2005) thereby decreasing the risk for metabolic disorders in overweight individuals according to a study by Mutungi et al. (1991). Large population studies (Hu et al., 1999; Kritchevsky and Kritchevsky, 2000; Kritchevsky, 2004), show that consumption of one egg per day does no harm in increasing cholesterol levels in humans and poses no risk of CVD in non-diabetic subjects.

Also the omega-3 fatty acids from eggs are more bioavailable to humans as noted in earlier studies (Ferrier et al., 1995) and have the capacity to reduce heart disease risk (Oh et al., 1991). Because of the benefits associated with omega-3 fatty acids, their levels in different types of eggs was evaluated. Evaluation of the levels of omega-3 fatty acids especially DHA in the commercial eggs sold in the Jeddah market, found them to be almost negligible. The commercial eggs also contained a high amount of saturated fat (45.28 ± 0.10 and 45.57 ± 0.14) as compared to the omega-3 eggs analyzed which is around 39.19 ± 0.22 and 40.23 ± 0.52 for the flaxseed and fish oil fed groups respectively. Our preliminary trial of feeding different sources of omega-3 fatty acids viz; fish oil and flaxseed for depositing omega-3 fatty acids into egg yolks yielded good results. Minor differences were noticed in the omega-3 eggs produced from the flaxseed as well as fish oil source. It was found that omega-3 eggs could be produced from both ALA (flaxseed source) and DHA (fish oil source) which are quite comparable in terms of DHA, omega-6:omega-3 ratio, and MUFA/Saturated fatty acid levels. There was a slight non-significant increase in saturated fatty acid levels in the fish

Table 1 Fatty acid analysis of commercial eggs from different outlets.

Fatty acid	Outlet 1	Outlet 2
SFA-Myristate	00.07 \pm 0.04	00.11 \pm 0.01
SFA-Palmitate	32.50 \pm 0.06	32.40 \pm 0.25
SFA-Stearate	12.71 \pm 0.05	13.07 \pm 0.37
Oleate	40.87 \pm 0.86	39.50 \pm 0.55
Linoleic acid	11.37 \pm 0.59	12.33 \pm 0.39
Gammalinoleic acid	00.10 \pm 0.00	00.10 \pm 0.00
Alpha-linolenic acid	00.23 \pm 0.03	00.23 \pm 0.03
Arachidonic acid	01.80 \pm 0.20	01.87 \pm 0.17
Eicosapentaenoic acid	00.00 \pm 0.00	00.00 \pm 0.00
Docosahexaenoic acid	00.22 \pm 0.02	00.22 \pm 0.02
Total saturated fatty acid (SFA)	45.28 \pm 0.10	45.57 \pm 0.14
MUFA	40.86 \pm 0.86	39.50 \pm 0.55
n-6 PUFA	13.26 \pm 0.73	14.30 \pm 0.43
n-3 PUFA	00.45 \pm 0.03	00.45 \pm 0.03
Total PUFA	13.71 \pm 0.75	14.75 \pm 0.41
PUFA:Sat	00.30 \pm 0.02	00.32 \pm 0.01
MUFA:Sat	00.90 \pm 0.02	00.87 \pm 0.02
n6:n3	29.58 \pm 1.45	32.17 \pm 3.03

There was very little difference in the concentration of fatty acids in the commercial eggs from different outlets.

Table 2 Fatty acid analysis of omega-3 eggs from different sources.

Fatty acid	Control	Flax seed source	Fish oil source	Probability
SFA-Myristate	00.07 ± 0.04	00.03 ± 0.03	00.03 ± 0.03	NS
SFA-Palmitate	32.57 ± 0.69	29.35 ± 1.35	31.17 ± 0.59	NS
SFA-Stearate	12.59 ± 0.12	10.47 ± 1.87	09.03 ± 0.42	NS
Oleate	39.40 ± 0.94 A	36.36 ± 0.84 B	38.19 ± 0.67 AB	$P < 0.10$
Linoleic acid	12.43 ± 0.18	15.15 ± 1.81	14.27 ± 1.11	NS
Gammalinoleic acid	00.10 ± 0.00	01.12 ± 1.04	00.08 ± 0.02	NS
Alpha-linolenic acid	00.13 ± 0.03 A	01.87 ± 0.51B	00.06 ± 0.04 A	$P < 0.008$
Arachidonic acid	01.83 ± 0.20	01.82 ± 0.10	01.35 ± 0.17	NS
Eicosapentaenoic acid	00.07 ± 0.03	00.19 ± 0.06	00.07 ± 0.04	NS
Docosahexaenoic acid	00.22 ± 0.02 A	03.57 ± 1.37 B	05.61 ± 0.28 B	$P < 0.01$
Total saturated fatty acid(SFA)	45.22 ± 0.72 A	39.19 ± 0.22 B	40.23 ± 0.52 B	$P < 0.0004$
MUFA	39.40 ± 0.94	37.36 ± 1.83	38.19 ± 0.67	NS
n-6 PUFA	14.37 ± 0.14	25.16 ± 6.43	15.64 ± 1.21	NS
n-3 PUFA	00.42 ± 0.02 A	05.63 ± 0.82 B	05.73 ± 0.21 B	$P < 0.0004$
Total PUFA	14.78 ± 0.15 A	23.72 ± 1.50 B	21.37 ± 0.99 B	$P < 0.002$
PUFA:Sat	00.32 ± 0.01 A	00.59 ± 0.04 B	00.53 ± 0.03 B	$P < 0.002$
MUFA:Sat	00.87 ± 0.04 A	00.91 ± 0.01 AB	00.95 ± 0.01 B	$P < 0.1$
n6:n3	34.58 ± 1.34 A	03.33 ± 0.43 B	02.75 ± 0.32 B	$P < 0.0001$

NS = nonsignificant. AB = means with unlike superscripts are different ($P < 0.05$) by least significant difference test.

Table 3 Nutritional and elemental analysis of the commercial egg, country egg and omega-3 enriched eggs from different sources.

Test	Units	Outlet 1	Outlet 2	Control diet	omega-3 eggs (from flax source)	omega-3 eggs (from fish source)
<i>Nutritional analysis</i>						
Weight	(g)	50.67	50.5	50.95	50.87	51.5
Moisture	%	75.02	73.04	75.88	75.25	75.08
Fat	%	13.02	12.54	13.2	12.75	12.78
Cholesterol	(mg)	239.79	235.66	239.5	220.35	215.67
Protein	%	12.12	12.22	11.8	12.1	12.2
Energy value	kcal	165.1	167.2	168	166.8	168
Ash	%	1.01	1.21	1.25	1.18	1.01
<i>Minerals and trace elements</i>						
Sodium	mg	124	121.6	125	120.8	122
Potassium	mg	124.5	126	120	218	215
Calcium	mg	50.2	50.18	48	50.28	50.54
Phosphorus	mg	223.8	225	227	219	220
Magnesium	mg	8.8	8.79	9.02	8.87	8.88
Iron	mg	1.55	1.58	1.47	2.15	2.03
Zinc	mg	1.00	1.015	1.1	1.09	1.13
Copper	mg	0.014	0.013	0.009	0.011	0.014
Iodine	mg	0.038	0.041	0.028	0.040	0.039
Chlorine	mg	169.7	170.7	158	169.8	170.2
Sulfur	mg	150.9	150.12	145	152.9	151.3
Selenium	mg	ND	ND	ND	ND	ND
<i>Vitamins</i>						
A	IU	628	635	620	642.8	652
D	IU	43.8	44.7	45.1	48.68	49.3
E	mg	0.98	1.2	1.1	1.79	1.82
Niacin	mg	0.061	0.065	0.05	0.062	0.07
B1	µg	0.05	0.051	0.038	0.051	0.046
B6	mg	0.128	0.132	0.133	0.138	0.139
Folate	µg	44.8	46.2	46.04	49.32	50.2
B12	µg	1.08	1.05	1.05	1.23	1.27
Biotin	µg	19.62	19.65	19.68	19.77	19.82
Pantothenic acid	mg	1.2	1.18	1.01	1.23	1.24

oil group as compared to the ALA (flaxseed source) group which may be due to the saturation in the fish oil. Major changes in diet were not possible as they affected the hen and egg parameters which have not been included in this study. Cholesterol levels in the commercial eggs studied did not vary considerably (Milinsk et al., 2003; Rowghani et al., 2007) though it was only slightly reduced in the omega-3 eggs.

In terms of fatty acid composition, a decrease in the saturated fatty acid levels and an increase in omega-3 fatty acid levels were noted. Thereby the omega-6:omega-3 ratios were considerably lower in omega-3 eggs than the commercial eggs studied. Our experiments show that omega-3 eggs have an edge over the commercial eggs in terms of cholesterol content, vitamin E content, and levels of potassium, vitamin D, E, B6, folate, B12 as well as polyunsaturated fatty acids.

Mineral analysis showed an increase in the potassium and iron content of omega-3 eggs as compared to the commercial eggs showing a possible increase in absorption of these elements due to dietary changes. Omega-3 fatty acids may possibly enhance the utilization of these nutrients.

Eggs produced from fish oil source had a slight fishy unpleasant odor which would affect consumer compliance and palatability. This was in accordance to earlier results by Sedoski et al. (2012). On the other hand the omega-3 PUFA enriched eggs produced using a flaxseed diet were found to be very similar to the regular country eggs in terms of odor, taste, and appearance, similar to findings of Marshall et al. (1994).

Moreover 8% flaxseed (2.5% ALA) can be bio-converted to almost the same amount of DHA (around 5%) with a fish oil feed of 1%. Therefore considering that both flaxseed and DHA feed can deposit almost the same amount of DHA into the egg, flaxseed seems a more economically viable proposition. Further studies on egg production and bird parameters with different feeds and different concentrations for a longer period of time are necessary to evaluate the economic feasibility of producing omega-3 eggs in Saudi Arabian conditions.

It has been shown that none of the commercially sold eggs in the Jeddah market contained significant amounts omega-3 fatty acids. Our study further showed that the healthy omega-3 fatty acids can be incorporated into the egg using both flaxseed as well as fish oil as a supplemental feed source and brought into the food chain. Therefore the intake of omega-3 eggs would contribute in achieving the recommended intake values of LC-PUFAs as given by the Nutrient Reference Values for Australia and New Zealand, 2006. Consumer awareness and preferences for better health benefits (Zhao et al., 2007) would help in creating a healthier environment in Saudi Arabia.

5. Conclusion

Nutritionists all over now advise eating foods promoting health benefits, rather than the earlier food avoidance therapy thereby adopting an overall holistic approach. Omega-3 enrichment in eggs and other nutritional products containing omega-3 fatty acids are universally accepted today for their protective health benefits. Due to the inadequacy of omega-3 fatty acids in the commercially available eggs in Jeddah, value addition of the existing commercial eggs is deemed necessary. Also as compared to the fish oil source, producing omega-3

eggs from flaxseed source could be a viable option to promote better health to the common man. Moreover as egg is consumed by people of all ages, this positive step toward omega-3 egg production would be quite instrumental in generating health awareness through a universally accepted product. A balanced diet comprises of all the three omega-3 fatty acids as each one of them independently bears different properties and the conversion of ALA to EPA & DHA is variable according to age, gender and ailment. These omega-3 eggs from flaxseed fed group are unique in providing the parent ALA as well as the longer chained fatty acids EPA & DHA. Therefore the potential of omega-3 eggs appears bright as a marketing product in the near future.

Conflict of interest

The authors confirm that this article content has no conflict of interest.

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