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ORIGINAL ARTICLE

Quality characteristics and consumer acceptance of a high fish protein puffed corn-fish snack

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Abstract Corn snack fortified with 7% fish protein powder made from saithe (*Pollachius Virens*) surimi was selected by expert panel from industry for consumer studies in Iran and Iceland. They hedonically screened products with 3%, 5%, 7% and 9% fish protein powder. Snack containing 9% fish protein powder (FP) had significantly lower liking for odour, texture, flavour, and overall acceptability than the other three prototypes. Snacks fortified with 3%, 5%, and 7% FP had similar sensory attributes. Therefore, snack with the highest level of FP (7%) was selected for acceptance tests. It was seasoned with cheese powder, vegetable oil, salt, and colorant. The amount of protein, moisture, fat, ash and salt in fortified corn snack (FCS) was 12%, 2%, 31%, 3%, and 2% respectively. Consumers' acceptance was studied using a central location test method. Consumers were 6–16 years old children in two communities (Iceland and Iran). They liked FCS but Iranian children favoured it more than Icelandic children. Majority of parents of the participants expressed their willingness to choose this product when buying snacks.

Keywords Corn snacks · Fish protein · Fortification · Consumer acceptance · Icelanders · Iranians

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Introduction

Starchy snack products are widely consumed. They are usually low in protein and high in fat and carbohydrates (Ranhotra and Vetter 1991; Rhee et al. 1999, 2004). Incorporation of functional ingredients into starchy snack products by using extrusion cooking can increase their nutritional value (Riaz 2001; Rhee et al. 2004; Veronica et al. 2006). Fish, which is an excellent source of protein, omega-3 fatty acids and key minerals and vitamins (Altschul 1989), can be included in snack formula to increase protein content and improve nutritional value.

A few extrusion studies have demonstrated that is possible to develop snack foods fortified with fish flesh/protein (Maga and Reddy 1985; Clayton and Miscourides 1993; Choudhury 1994; Mathews et al. 2003; Shankar and Bandyopadhyay 2005; Kong et al. 2008; Pansawat et al. 2008; Dileep et al. 2010). Snacks fortified with fish muscle/protein were accepted by American consumers (Kong et al. 2008), Malaysian consumers (Huda et al. 2001), Indonesian consumers (Huda et al. 2000), and Indian consumers (Maga and Reddy 1985).

Market for children's food is growing and children have an increasing influence on future convenience foods and purchasing behaviour (Dodds 2008). Despite difficulties in sensory analysis and consumer studies with children, it is

extremely important to obtain information about children's liking for foods, because it can provide valuable data for the development of new products for children (Ward et al. 1999; Guinard 2001; Thybo et al. 2004). Central location test is the most frequently used method for sensory acceptance (Boutrolle et al. 2005). It is usually conducted in an area where potential consumers/purchasers are likely to pass, such as shopping malls (Meilgaard et al. 2007).

Fish consumption in Iran is increasing rapidly due to increased aquaculture and fisheries productions (FAO 2009a). Per capita fish consumption that was only 1 kg in 1980 had reached 10 kg in 2009 (Shilat 2010). Expansion of aquaculture throughout the country together with an increase in people's knowledge of fish as a healthy food is helping to change attitude towards fish and fishery products (Shaviklo 2006; FAO 2009b). Fish consumption in Iran is inversely related to age of consumers. Youth and children like fish and fishery products more than elderly people (Salehi 2006; Shilat 2008).

In Iceland there is a strong tradition for consumption of seafood and per capita consumption is among the highest in the world. It was 47 kg in 2007. However, consumption has decreased compared to the year 1960 when per capita consumption of fish was 61 kg gutted fish with head (Farmers Association of Iceland 2009). In 2002 fish consumption in Iceland had decreased by 30% since 1990 (Steingrimsdottir et al. 2003). A further decrease in fish consumption was reported by Sveinsdottir et al. (2009). Fish consumption was considerably lower among the youngest consumers. Over 40% of 15 years old Icelandic girls were in danger of getting too little iodine in the diet and need to increase their fish consumption (Steingrimsdottir et al. 2003). One way could be to develop ready-to-eat fishery products, e.g., fish fortified snacks.

Fortified corn snack with fish mince is commercially produced in Iran (ISIRI 2008) and the production is based on a patent (IFRO 2008). Market demand for fortified corn snack with higher amount of fish protein is growing in the country, but there are technical obstacles for increasing fish mince content when using single screw extruder. So the idea of using fish protein powder was generated to respond to this demand. On the other hand development of corn snacks containing dried fish powder already failed in Iceland due to instability of product's quality. This study can provide valuable data for food producers and health professionals for developing fortified snack products with fish protein. The objectives were: (1) to develop an acceptable fortified corn snack with the highest level of fish protein powder using single screw extruder and (2) to determine the quality characteristics the product in order to recommend level of incorporation of fish protein in extrusion conditions for developing healthy snack products and (3) to get information on consumers acceptance and attitudes towards extruded corn snack fortified with a high level of fish protein powder.

Materials and methods

Raw materials

Yellow corn grits used in this study contained 12.1% moisture, 6.2% protein, 0.9% fat, 0.6% ash and 80.2% carbohydrate were purchased from Golnab-e Urmiah (Urmia, Iran). Fish protein powder made from saithe (*Pollachius virens*) surimi with 2% moisture, 70% protein, 0.9% fat, 3.3% ash, and 23.4% carbohydrate was obtained from Matis (Reykjavik, Iceland). Ingredients for coating and seasoning of snacks i.e. hydrogenated vegetable oil, salt, cheese powder, whey powder, and colorant (E110) were obtained locally (Qazvin, Iran). A regular Danish puffed corn snack which is marketed and consumed in Iceland was obtained from a local supermarket (Reykjavik, Iceland) to be tested in acceptance test as control. Another control sample (Iranian regular corn snack) was provided by SIPA snack company (Qazvin, Iran).

Development and selection of prototype

Four prototypes of puffed corn snacks were formulated based on a patent (IFRO 2008) to optimize the ratio of corn grits, fish protein powder and water for developing high protein fortified snack. The ratio of corn grits: fish protein powder: water in prototypes A, B, C and D was: 85:3:12, 75:5:20, 65:7:28, and 55:9:36. A continuous line for corn snack processing (Tabriz Food Machinery, Tabriz, Iran) was used for experiments. Corn grits, fish protein powder and water were mixed in a ribbon blender. The mixture was fed at a speed of 300 kg/h with a pressure 5.5±0.5 bar into a single screw extruder with a barrel temperature of 160±5 °C. The die consisted of a 12-hole die with each hole being 4 mm wide. The screw was 8 cm wide and 23 cm long. Puffed extrudates were passed directly into a rotary dryer using hot air for reducing moisture to 2.5–3%. Extrudates were transferred continuously into a snack coater to be coated/seasoned with a mixture of vegetable oil, salt, cheese powder and colorant at a temperature below 60 °C. Cooled snacks were packed in polythene bags and stored in ambient temperature (23±2 °C).

Evaluation of prototypes was done by a panel of 4 trained and experienced experts in snack processing to select a fortified corn snack with the highest possible level of fish protein powder to be used in consumer surveys (Sieffermann 2005). The evaluation and selection was based upon fish protein content, highest scores of sensory liking (appearance, odour, taste, texture and overall acceptability) and comments about prototypes. Nine-point hedon-

Table 1 Means of hedonic rating (1–9) for sensory attributes and overall acceptability of corn snacks fortified with 3% to 9% FP evaluated by four individual experts

Formula		A	B	C	D
Odour	*	8.7±0.45[a]	7.5±0.24[a]	6.7±0.39 [a]	4.5±0.49[b]
Texture	**	8.0±0.34[a]	7.7±0.39[a]	7.3±0.37[a]	3.6±0.47[b]
Flavour	**	8.5±0.32[a]	7.2±0.38 [a]	6.4±0.29 [ab]	4.5±0.38[b]
Colour	**	7.9±0.44[a]	6.2±0.29 [a]	5.6±0.58 [ab]	3.6±0.48[b]
Overall	*	8.5±0.49[a]	7.8±0.18[a]	7.7±0.36[a]	5.3±0.29[b]

A: Corn snack with 3% fish protein, B: Corn snack with 5% fish protein, C: Corn snack with 7% fish protein, D: Corn snack with 9% fish protein, Different small letters show significant difference within a row (* $p<0.05$, ** $p<0.01$). Scale of 1 = dislike extremely, 9 = like extremely.

ic scale ranging from 1 (extremely dislike) to 9 (extremely like) was used to determine acceptability of odour, flavour, texture and colour of unseasoned samples as well as overall acceptability (Mathews et al. 2003; Kong et al. 2008). The experts were asked to first evaluate each sample by sniffing alone and then by tasting. They rinsed their mouths with water after tasting each sample.

Physicochemical properties

Proximate composition was determined according to AOAC (1990) methods. Crude protein content was determined using the Kjeldahl method (Kjeltex System-Texator, Sweden). Crude lipid content was determined by the Soxhlet method (Soxtec System-Texator, Sweden). Ash content was determined by heating samples overnight at 550 °C. Moisture content was determined by drying samples for 4 h at 105 °C until constant weight was achieved.

Peroxide value was determined by the modified AOCS method (1990) and expressed as milliequivalent of oxygen per kilogram of lipid. Water activity (a_w) of corn snacks was measured by using a Novasina water activity meter (Novasina RTD 500, Switzerland). About two grams of ground samples were put into the instrument and a_w was measured automatically after starting the program.

Colour of ground corn snacks was measured by placing them in a test tube (25 mm in diameter) which was read in a Minolta CR-400 Chroma Meter (Minolta Camera Co. LTD. Osaka, Japan) in Lab* measuring mode with CIE Illuminant C. Colour was measured three times turning the test tube 120° between measurements. Results were given as lightness (L*), redness (a*) and yellowness (b*).

Microbial analysis

Total plate count, sulphite-reducing clostridia, *E-coli, entrobacteriaceae spp*., moulds and yeasts and *salmonella spp.* were measured in three samples of each type of snack using national standard methods for corn snacks microbiology (ISIRI 2008).

Acceptance tests

Fortified corn snack (FCS) with 7% fish protein powder along with two commercial samples (without fish protein); Iranian corn snacks (ICS) and Danish corn snacks (DCS) which are popular in Iran and Iceland respectively, were used in the acceptance tests in Iceland and Iran simultaneously. The acceptance tests involved the use of 2 questionnaires; one for acceptance test with children and the other for investigating adult's attitudes toward snack consumption and healthy foods. The acceptance test questionnaire was based on a 7-point category hedonic scale (Meilgaard et al. 2007; Gacula et al. 2009). The questionnaire consisted of 2 parts. In the first part children were asked to indicate their liking; super good (7), good

Table 2 Proximate composition (%) and water activity (a_w) of three corn snacks used in acceptance tests

Samples	Moisture	Protein	Fat	Ash	Salt	a_w
DCS	3.6±0.23[a]	6.8±0.41[b]	31.1±0.15	3.8±0.41[a]	2.7±0.23[a]	0.23±0.005[a]
ICS	2.5±0.15[b]	6.5±0.32[b]	30.5±0.14	2.5±0.33[b]	1.5±0.31[b]	0.13±0.002[b]
FCS	2.3±0.14[b]	11.8±0.20[a]	31.2±0.21	3.1±0.24[a]	1.9±0.49[b]	0.14±0.003[b]

Values are means of 2 analyses. *DCS* Danish corn snacks; *ICS* Iranian corn snacks; *FCS* Fortified corn snacks. Different small letters show significant difference within a column ($p<0.05$).

Table 3 Colour characteristics of corn snacks used in acceptance tests

Samples	Lightness (L*)	Redness (a*)	Yellowness (b*)
DCS	33.1±0.65[a]	6.1±0.11[c]	23.1±0.42[a]
ICS	33.1±0.11[a]	9.6±0.21[b]	21.1±0.56[b]
FCS	32.9±0.23[a]	11.1±0.94[a]	21.2±0.53[b]

Values are means of 2 analyses. *DCS* Danish corn snacks; *ICS* Iranian corn snacks; *FCS* Fortified corn snacks. Different small letters show significant difference within a column ($p<0.05$).

(6), rather good (5), neither good nor bad (4), rather bad (3), bad (2) and super bad (1), after tasting each of three snack types. The second part of the questionnaire included questions about age, gender and snack consumption frequency (often, sometimes and never). Consumers consisted of 90 children 6–16 years old in each country. The surveys were performed in a shopping mall in Rasht (Iran) and at a swimming pool in Reykjavik (Iceland). Each sample (1.5–2 g) was placed in 50 g white plastic cups coded with 2-digit random numbers. Presentation of samples to the consumers, along with sheets of the questionnaire, was in a random order. Consumers were asked if they would like to take part in a survey and were informed on how to do the test. Information about ingredients was not given to the consumers.

The designed questionnaire for adults involved 16 questions about their age, gender, education, number of child/children 6–16 years old in the household, frequency of snack purchasing; two times a year or less (1), 3–10 times a year (2), once a month (3), 2–3 times per month (4), once a week (5), twice a week (6), more than 3 times a week (7), importance of healthy diet to them, importance of knowing nutritional quality/list of ingredients of snacks before purchasing, if they choose snacks with low salt/fat, if they recommend FCS to their kid(s), how healthy or unhealthy were fish, snacks, food fortified with fish protein, food rich in salt/trans fat. They were asked to indicate their opinion of the questions and statements of the questionnaire by checking one option from fully disagree (1) to fully agree (7) or from very unhealthy (1) to very healthy (7). The questionnaires were prepared in English and translated into Icelandic and Persian.

Statistical analysis

Analysis of variance (ANOVA) was carried out on the results in the statistical program NCSS 2000 (NCSS, UT, USA). The program was used to calculate multiple comparisons using Duncan's test to determine if sample groups were different (Duncan 1955). Student's *t*-test was used to determine if there was a difference in the consumer survey between nationalities. All differences were considered significant at $p<0.05$.

Results and discussion

Sensory evaluation for prototype selection

Scores for sensory attributes and overall acceptability of unseasoned puffed corn snacks fortified with 3–9% fish protein powder evaluated by individual experts for prototype selection are presented in Table 1. Formula D, containing 9% fish protein powder had significantly lower liking in odour, texture, flavour, and overall acceptability than the other three formulae. Colour scores of FCS decreased significantly with increased fish protein in the formula. No significant differences were observed for odour, texture, flavour, colour and overall acceptability between types A, B, and C containing 3, 5, and 7% fish protein powder respectively. The upper level for fish protein powder in the snack formula was therefore 7%. The experts all agreed the product with 9% fish protein powder differed from the other products in sensory quality. Formula C, with 7% added FP was therefore selected to be used in acceptance tests due to the scope of this study.

Physicochemical properties

Moisture content in the extruded products ranged from 2.3% in FCS to 3.6% in DCS. The moisture content of DCS was significantly higher than that in ICS and FCS, possibly because of different drying machine/procedures during

Table 4 Microbial analysis of three corn snacks used in acceptance tests

Analysis	Danish corn snack	Iranian corn snack	Fortified corn snack
Total plate count at 22 °C (log cfu/g)	3.5±1.08	2.5±1.46	3.0±1.18
Sulfite-reducing clostridia (log cfu/g)	<10	<10	<10
E. coli (log cfu/g)	0	0	0
Entrobacteriaceae spp. (log cfu/g)	<10	<10	<10
Mould and Yeast (log cfu/g)	<10	<10	<10
Salmonella spp. (log cfu/g)	0	0	0

Values within a row are means of 3 analyses. Differences between snack types were not significant ($p>0.05$).

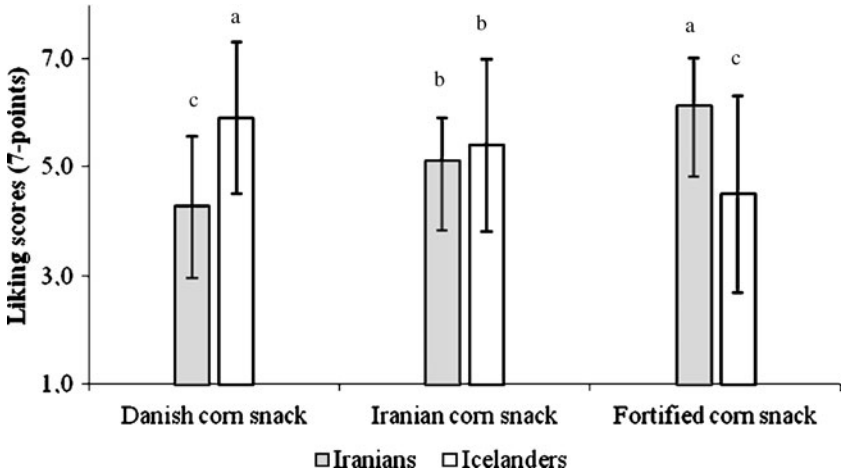

Fig. 1 Means of liking scores for three corn snacks rated by 90 Iranians and 90 Icelandic children (6–16 years old). Fortified corn snack contained 7% fish protein. Other samples were regular corn snacks. Different small letters show significant difference ($p<0.05$)

processing. Protein content ranged from 6% in ICS to 12% in FCS. FCS had significantly higher protein content than other products because of the added fish protein powder. All three corn snacks had the same range (30–31%) of fat content. Ash and salt content in DCS were significantly higher than that in the other products. Peroxide value in all snacks was 0 (meq/1,000 g). Water activity of DCS was significantly higher than other products (Table 2) possibly due to different levels of moisture and drying methods. Foods with a_w values less than 0.3 are largely protected against lipid oxidation, non-enzymatic browning, enzymatic activity and microbial spoilage (Fontana 1998). The extruded FCS had a_w less than 0.3, suggesting that the product might have a long shelf-life.

Colour of the snack products varied significantly (Table 3). DCS was more yellow than the other types while ICS and FCS were redder. The reason was application of different colorants (paprika extract in DCS and sunset yellow in ICS and FCS) during coating process. Colour is important to attract consumers before they test a product (Francis 1991). External colour of corn snacks depends on coating material, especially the type and concentration of colorant. However, the internal colour comes from extruded raw material.

Microbial analysis

No differences were observed between snack types for all microbial analyses performed (Table 4). All microbial analysis values were within microbial standards for corn snacks (ISIRI 2008), confirming the safety of these products for the consumer survey.

Characteristics of consumers and acceptance tests

Altogether 90 Iranians and 90 Icelanders, 6–16 years old, completed the questionnaire. Gender ratio was 51% girls and 49% boys and the age of the participants was evenly distributed over the age 6–16. Significant difference was observed for frequency of snack consumption. About 47% of Iranian children and 18% of children in Iceland often consume snacks but only 2% of Iranians and 1% of Icelanders never consume snacks.

Differences were observed in liking between the nationalities (Fig. 1). Icelandic children liked DCS more than Iranian children, but Iranian children liked FCS more than Icelandic children. The differences between nationalities are possibly due to different culture, dietary habits and traditions of consumers (Myrland et al. 2000;

Table 5 Gender attitudes for liking[a] three corn snacks by 90 Icelandic and 90 Iranian children (6–16 years old)

Nationality	Danish corn snack	Iranian corn snack	Fortified corn snack
Icelanders			
Girls	5.6 ± 1.69^{a}	5.0 ± 1.87^{b}	4.0 ± 1.86^{c}
Boys	5.8 ± 1.22^{a}	5.6 ± 1.24^{a}	4.7 ± 1.34^{b}
Iranians			
Girls	4.7 ± 1.66^{b}	4.9 ± 1.67^{c}	6.2 ± 1.58^{a}
Boys	4.8 ± 1.56^{b}	4.9 ± 1.57^{c}	6.2 ± 1.47^{a}

[a] Liking scores; 1 =super bad, 7 = super good. Different small letters within a column show significant difference ($p<0.05$).

Table 6 Attitudes of adults with kid towards (snack) foods (88 Icelanders and 90 Iranians)

		Average scores (1–7)[a]		Fully disagree (%)		Fully agree (%)	
		Iranians	Icelanders	Iranians	Icelanders	Iranians	Icelanders
A healthy diet is very important to me.	***	6.6±0.91[a]	6.0±1.47[b]	0	2	63	56
I want to know the nutritional quality of snack before buying it.	**	6.4±1.48[a]	4.4±23[b]	4	17	72	16
I would choose snacks fortified with fish protein.	***	6.0±1.29[a]	4.5±1.67[b]	0	10	50	16
I would choose snacks with less salt.	*	5.7±1.77[a]	5.1±1.89[b]	7	8	48	31
I would choose snacks containing less trans fat.	***	6.5±1.14[a]	5.5±1.78[b]	2	7	69	37
Taste of snacks is much more important to me than the nutritional quality.	**	3.0±2.23[b]	4.6±1.87[a]	42	9	12	21
I never pay attention to the list of ingredients of snacks before buying it.	***	1.9±1.13[b]	3.6±2.14[a]	70	20	9	15
I would encourage my kid(s) to consume snacks fortified with fish protein rather than regular snack.	***	6.7±0.58[a]	5.0±1.57[b]	0	3	70	25

[a] 1 = fully disagree, 7 = fully agree. Different small letters show significant difference in the average scores between the groups (* $p<0.05$, ** $p<0.01$, *** $p<0.001$).

Verbeke and Vackier 2005; Pieniak et al. 2008; Neely et al. 2010a, b).

Liking was affected by gender but not by age or frequency of snack consumption (Table 5). Significant difference was observed in liking between Icelandic girls and boys. Icelandic girls liked ICS and FCS less than Icelandic boys and there was a descending trend for liking of ICS and FCS. Icelandic boys gave DCS and ICS the same score. Both genders liked FCS less than the other two types of snacks. As seen in Table 5, liking scores given by Iranian girls and boys were the same; however there seemed to be a significant ascending trend for liking of FCS for both genders.

Adults' responses to the snack survey

Of the 178 participants who completed the questionnaire, 88 adults were Icelanders (42% male and 58% female) and 90 adults were Iranians (32% male and 68% female) having 6–16 years old child/children. Average ages of Iranians and Icelanders in the survey were 38 and 43 years respectively. This difference was not significant. Of the consumers 62% of Iranians and 73% of Icelandic adults had university degree. The majority had one child between 6 and 16 years old in the household (47% Icelanders and 62% Iranians) while 38% of Iranians and 39% of Icelanders had two children between 6 and 16 years old.

Significant difference was found between nationalities in snack purchasing behaviour of adults with children. While 50% of Iranians indicated that they buy snacks once a week or more often, majority of Icelanders (86%) stated purchasing snacks 2–3 times per months or less. Answers regarding attitudes of adults towards snack foods indicate considerable differences between nationalities (Table 6). Majority of participants indicated that a healthy diet is important to them. Of the participants 72% of Iranians and 16% of Icelanders fully agreed on wanting to know the nutritional quality of snacks before purchasing them. Most consumers agreed with choosing snacks fortified with fish proteins. In response to questions about choosing snacks

Table 7 Attitudes of adults with kid towards healthiness/non-healthiness of (snack) foods (88 Icelanders and 90 Iranians)

		Average scores (1–7)[a]		Very unhealthy		Very healthy	
		Iranians	Icelanders	Iranians	Icelanders	Iranians	Icelanders
Is fish a healthy food?		6.8±0.56	6.8±0.42	0	0	81	86
Is snack a healthy food?	***	3.7±1.47[a]	1.8±0.92[b]	5	53	8	0
Are food products fortified with fish proteins healthy?	***	6.6±0.67[a]	4.6±1.33[b]	0	1	70	9
Are food products rich in salt healthy?	***	1.1±0.22[b]	2.0±1.14[a]	93	35	0	1
Are food products rich in trans fat healthy?		1.7±1.23	1.6±1.22	68	69	0	1

[a] 1 = very unhealthy, 7 = very healthy. Different small letters show significant difference in the average scores between the groups (**** $p<0.001$).

with less salt, 31% of Icelanders and 48% of Iranians fully agreed on choosing such products. Regarding trans fats, 37% of Icelanders and 69% of Iranians fully agreed on choosing snacks with less trans fat.

When asked about the importance of the taste of snacks, 42% of Iranians and 9% of Icelanders fully disagreed that taste of snack is much more important to them than the nutritional quality. It seems taste of snack is more important to the Icelanders which is in line with how they react to the questions about salt and trans fats. It was noted that the majority of Icelanders and Iranians pay attention to ingredients list of snacks before purchasing them. The majority of both nationalities agreed that they would encourage their children to eat snacks fortified with fish protein rather than regular snack, but Icelanders were not nearly as positive toward fortified snacks as Iranians. It seems Icelanders prefer to have fish protein from original fish products but not from fortified foods, possibly due to high per capita consumption of fish and fishery products in Iceland and dietary habits.

Attitudes of adults towards healthiness of snack foods are given in Table 7. Both nationalities indicated that fish is a healthy food. They stated that snack is not a healthy food but Icelanders thought snack is unhealthier. Majority of Iranians (70%) answered that food products fortified with fish protein are very healthy while the majority of Icelanders had not the same opinion. When asked about healthiness of food products rich in salt, participants in both countries generally considered it unhealthy Iranian even more so (Table 7). Majority of consumers of both nationalities noted that food products rich in trans fat are very unhealthy. Estimated per capita snack consumption in Iran is about 5 kg (Iran Ministry of Industries and Mines 2007) which is why local authorities have been trying to inform the public about risks connected to consumption of snack products high in fat and salt (Iran Ministry of Health 2003, 2005a, b). This may explain why Iranians had a high positive response on foods fortified with fish protein and negative response on food rich in salt/trans fat.

Fish consumption per capita and dietary habits vary significantly between Iranians and Icelanders. Icelanders have easy access to fresh/frozen fish fillets/steaks and other fishery products. Fish consumption in Iceland is about two fish meals per week (Sveinsdottir et al. 2009) but Iranians consume less than two fish meals per month (Shilat 2005, 2008). However educational programs and developing fish based products have been affecting dietary habits and consequently increasing fish consumption in Iran. It is reported that incorporating fish/shellfish to popular formulated food would be welcomed by people and stated that production of such ready-to-eat products might be a good way to increase seafood consumption in Iran. Accordingly the production and consumption of such products in the country are increasing but also due to their taste and convenience (Shaviklo 2005a, b, 2007; Rafipour et al. 2008; IFRO 2009).

This survey revealed a good possibility for incorporating fish to an extrusion cooking process to provide a nutritious snack food which could aid in increasing fish protein consumption in both countries especially in Iran where the children eat snacks more often. Although fish fortified corn snacks are not marketed in Iceland it could be feasible to use extrusion technology to develop such products based on consumers' preferences.

Conclusion

Extrusion of corn grits with fish protein powder can produce an expanded fortified snack that is more nutritious than the widely consumed regular corn snacks. It would also provide another avenue for fish utilization and increasing fish consumption. Children in Iran liked FCS more than Icelandic children. The majority of parents of both nationalities would choose snacks fortified with fish protein and would encourage their kids to consume such products rather than regular corn snacks but Icelanders were not nearly as positive towards fortified snacks as Iranians. Therefore fortification of starchy snacks with fish/fish proteins could be a healthy option to boost children's nutritional intake and to increase fish protein consumption. Since Iranians consume more snacks, it can be concluded that fortified snacks with fish protein have much more effect on fish protein consumption of Iranian children than Icelandic children. FCS could be marketed successfully in Iran but should be reformulated for Icelanders or possibly other consumers based on their preferences. FCS has to replace other types of starchy snacks but not other and maybe healthier foods.

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