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DEVELOPMENT AND ORGANOLEPTIC EVALUATION OF IRON RICH CORN BASED EXTRUDED SNACKS

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ABSTRACT

The study was designed to produce acceptable extruded snack of high nutritional quality and iron content. Different extruded snacks were prepared by fortifying corn with iron rich foods like moth bean, lotus stem (LS), karonda (KP), garden cress and niger seeds (GC and NS), amaranth and Bengal gram leaves (AL and BL). The LS, KP, GC, NS, AL and BL were added to the different extruded snacks in four levels *i.e.* 2.5, 5, 7.5 and 10 %. Moth bean was added to all the extruded snacks at 20 % level. Organoleptic evaluation of the snacks revealed that LS and KP incorporated extruded snacks were acceptable till the level of 10 % showing overall acceptability of 7.81 and 7.56 respectively. The GC, NS, BL and AL incorporated snacks were acceptable till the levels of 7.5%, 5% and 7.5% with the overall acceptability scores 7.40, 7.96, 7.46, 7.6 respectively. The developed supplemented snacks had higher protein, ash, iron and low carbohydrate in comparison to the control (corn snacks). They also had significantly higher iron content ranging from 15.4 to 21.3 g/100g DM, compared to the control having 3.9 mg/ 100g DM.

Keywords: Extruded snacks, organoleptic evaluation, proximate analysis and iron content.

INTRODUCTION

Nutrition and diet are important factors in combating deficiency diseases among children. The incidents of protein energy malnutrition and micro-nutrient deficiency especially iron are common among children. Iron deficiency has been found to be a major nutritional problem in India. It is a problem of serious health significance and has impact on psychological and physical development, behaviour, work performance and immune system (WHO 2008).

In India, the prevalence of anaemia is universal. Data from district household survey (2004) revealed that 98% of adolescent girls and 96% of pregnant women suffer from some form of anaemia. The latest data from National Family Health Survey (NFHS- 3, 2005- 2006) shows that nearly four out of five young children in the 6- 35 months age are anaemic (79.2 % from NFHS 3) which adversely affects their health, learning abilities and cognitive development.

India is one of the major contributors of agricultural produce to the world. Though the country has attained food security at the national level, hunger and malnutrition continue to haunt India. The main reason behind the lack in household food security is due to post harvest losses. Food processing is an important element to prevent post harvest losses and provide a better shelf life and nutrient quality. Among the processed foods, extruded products have better shelf life and are easily acceptable by all the age group (Kowsalya and Indra, 2010).

There is a strong thrust to develop such snacks which not only provide maximum nutrient but also are popular among children. Corn extruded products available in the market provides all the features for production of highly acceptable but are nutritionally deficient. In present study an effort has been made to develop and nutritionally evaluate a ready to eat extruded product using corn as basic indigredient supplemented with iron rich foods. These formulated extruded snacks can help in eradicating iron deficiency.

MATERIAL AND METHODS

PROCUREMENT OF INGREDIENTS

For preparation of extruded snacks corn (Zea mays), moth bean (*Vignaaconitifolia*), bengal gram leaves (*Cicer arietinum),* amaranth leaves (*Amaranthusgangeticus*), lotus stem (*Nelumbonucifera*), *karonda*(*Carissa carandas*), garden cress (*Lepidiumsativum*) and niger seeds (*Guizotiaabyssinica*)were procured in one lot from the local market of Ludhiana city and stored in air tight containers.

DESIGNING OF INGREDIENT MIXES AND DEVELOPMENT OF EXTRUDED SNACKS

All the ingredients were dried and grinded to form powder. The extruded products were based on corn. The standardized recipes for control samples was prepared

from corn flour (CF) alone. The mothbean (MB) was added to all the extruded snacks at 20% level. Other ingredients i.e. Bengal gram leaves (BL), amaranth leaves (AL), lotus stem (LS), karonda (KP), garden cress (GC) and niger seeds (NS) were added at 2.5, 5, 7.5 and 10% level with the replacement of corn flour. The garden cress and niger seeds used in the study were roasted and before adding them to the snacks. Roasting helped in reducing the bitterness of seeds. The extruded snacks were made by using a co- rotating intermeshing twin screw extruder (Clextral, Firminy, France). Twenty four types of extruded products were developed and standardized using the following combinations.

Treatment I (Control) – CF
Treatment II- CF + MB (20%) + LS (2.5, 5, 7.5 and 10 %)
Treatment III- CF + MB (20%) + KP (2.5, 5, 7.5 and 10 %)
Treatment IV- CF + MB (20%) + GC (2.5, 5, 7.5 and 10 %)
Treatment V- CF + MB (20%) + NS (2.5, 5, 7.5 and 10 %)
Treatment VI- CF + MB (20%) + BL (2.5, 5, 7.5 and 10 %)
Treatment VII-CF + MB (20%) + AL (2.5, 5, 7.5 and 10 %)

SENSORY EVALUATION OF DEVELOPED EXTRUDED SNACKS

The developed formulated snacks were evaluated thrice by a panel of 10 panelists from the department of Food and Nutrition, Punjab Agricultural University, Ludhiana. The panelists were asked to score the samples on the basis of their colour, appearance, texture, taste and overall acceptability by using a score card of 9 point Hedonic Rating Scale. The highly acceptable products along with the control were weighed, homogenized and oven dried at 60° ± 2°C. Dried samples were stored in air tight plastic bags for nutritional analysis.

NUTRITIONAL ANALYSIS

All the samples were analyzed in triplicates for moisture, ash, protein, crude fat and crude fibre on dry matter basis by AOAC method (2000). Carbohydrates were calculated by difference. Iron content was determined by digesting the sample with diacid mixture (nitric acid: perchloric acid, 5:1 v/v) and then analysed using atomic absorption spectrophotometer (AAS, Varian model, Piper, 1950).

STATISTICAL ANALYSIS

The data was statistically analysed using Statistical Package for Social Sciences (SPSS) version 16.0. ANOVA and tukey HSD (Honestly significant difference) test were used to obtain the difference in organoleptic scores, within different level of incorporation of the ingredients in extruded snacks. Level of significance was accepted at $p \leq 0.05$. Means and standard deviations for various parameters of sensory evaluation and proximate analysis were computed using MS Excel.

RESULT AND DISCUSSION

SENSORY EVALUATION

Sensory evaluation based on texture, flavour, appearance, taste and overall acceptability showed that all the extruded snacks incorporating amaranth leaves, Bengal gram leaves, lotus stem,*karonda*, garden cress seeds and niger seeds were found to be organoleptically acceptable. However, the acceptable level of incorporation varied in different formulations. In lotus stem incorporated extruded snacks (Table 1) the highest score for overall acceptability was at 2.5 % level *i.e*. 8.37 followed by LS 5 % with mean scores 8.03, LS 7.5 % (7.85) and LS 10 % (7.52). All the lotus stem incorporated snacks were highly acceptable. Lotus stem powder got easily blended with other ingredients without giving any off taste. Analysis by tukey HSD test, further revealed that significant difference ($p \leq 0.05$) appeared organoleptically among the treatments except the texture. Jain *et al* (2012) prepared extruded snacks from dried carrot, lotus stem, rice flacks, and niger seeds. The prior ingredients were added at different levels *i.e.* 5, 10, 15 and 20 per cent with the replacement of maize flour. Addition of these ingredients up to 10 per cent in raw material was found most acceptable at nine point hedonic rating scale. The mean scores for organoleptic characteristics of sweet and savory snack developed with composite flour ranged from 7.8 to 8.7 at nine point hedonic rating scale.

Karonda (KP) incorporated extruded snacks were also found to be highly acceptable. The reason for this seems to be its sour taste which made the snacks tangy. The highest overall acceptability was for 2.5 % and 5 % incorporation of *karonda*powder. The respective scores of overall acceptability ranged from 7.56 to 8.4 (Table 2). The taste and texture of *karonda* incorporated snacks showed non significant ($p \geq 0.05$) differences.*Karonda*(*Carissa carandas*) has been utilized in processed products such as in the preparation of jam, jelly, squash, syrup and chutney and is in great demand in the international market. Wani*et al* (2013) prepared jam of *karonda* fruit and found it acceptable in sensory evaluation.

Extruded snacks incorporating garden cress seeds (GC) scored highest at 2.5 % level of incorporation. The overall acceptability of the extruded snacks ranged from 6.43 to 8.0 (table 3). Significant difference ($p \leq 0.05$) were found in all the organoleptic characteristics of extruded snacks except for texture. In case of taste, non significant ($p \geq 0.05$) difference was found within LS 2.5 %, LS 5 % and LS 7.5%. The garden cress incorporated snacks seems to be acceptable till the level of 7.5 % incorporation. Lohekar and Arya (2014) developed value added instant garden cress seed *kheer* mix with four variations. The organoleptic evaluation revealed that among all variations the variation 'D' i.e. garden cress at 5 % level scored highest for colour (4.80), texture (4.75), taste (4.90), flavour (4.70) and overall acceptability (4.75) at 5 point scale.

The most acceptable niger seeds (NS) incorporated extruded snacks were at 2.5 and 5 % and their respective scores for overall acceptability were 8.08 and 7.96. Significant ($p \leq 0.05$) difference was found for all organoleptic scores of niger seeds incorporated extruded snacks. The niger seeds incorporated snacks was found to be acceptable till the level of 5 % incorporation (table 4). Amaranth leaves (AL) incorporated extruded snacks

showed the overall acceptability in the range of 5.62 to 8.18. The highest score was for 2.5 % incorporation followed by 5 and 7.5 %. There was significant ($p \leq 0.05$) difference found in all organoleptic scores except in texture at 2. 5, 7 and 7.5 % level of incorporation. The AL incorporated snacks were found to be acceptable till the level of 7.5 % (table 5).Singh *et al* (2009) prepared products like biscuits, *mathi*, *matar* and *sev* including 5 per cent dried amaranth leaf powder and found the products organoleptically acceptable.

The Bengal gram leaves (BL) incorporated extruded snacks showed the overall acceptability of 8.03 and 7.7 at the level of 2.5 and 5 % incorporation. Similarly the scores for taste at 2.5 and 5 % level of incorporation were 8.25 and 8.12. The scores were significantly different ($p \leq 0.05$) except at 2.5 and 5 % level of incorporation in case of texture, colour, taste and overall acceptability. The BL incorporated extruded snacks were acceptable to the level of 5 percent incorporation (Table 6).

Table 1: Sensory evaluation of Lotus stem extruded snacks

Treatments	Texture	Appearance	Colour	Taste	Overall
Control(CF)	8.5 ±0.53^{a}	8.62±0.51^{a}	8.75 ± 0.46 ^{a}	8.37±0.51 ^{a}	8.56±0.32 ^{a}
CF+MB(20%)+ LS (2.5%)	8.37±0.51 ^{a}	8.25±0.46 ^{ab}	8.37 ± 0.74 ^{ab}	8.5±0.53 ^{a}	8.37±0.26 ^{ab}
CF+ MB(20%) +LS (5%)	8.12 ±0.35 ^{a}	8.25±0.8 ^{ab}	8.0 ± 0.53 ^{ab}	8.37±0.51 ^{a}	8.18 ± 0.17^{bc}
CF+MB (20%)+LS (7.5%)	8.12± 0.35 ^{a}	7.87± 0.4^{bc}	8.12 ±0.70 ^{ab}	8.25±0.46 ^{a}	8.03 ± 0.20 ^{bc}
CF+MB (20%)+LS (10 %)	8.0 ± 0.54^{a}	7.37± 0.51^{c}	7.75± 0.46 ^{b}	8.12± 0.35 ^{a}	7.81 ± 0.22 ^{c}

Note – CF: Corn flour; MB: Mothbean; LS: lotus stem, Values are expressed as mean ± SD = Significant at 5 %, $^{a-c}$ Means within each row with different superscripts are significantly ($p \leq 0.05$) different

Table 2: Sensory evaluation of*Karonda* extruded snacks

Treatments	Texture	Appearance	Colour	Taste	Overall
Control (CF)	8.3± 0.5 ^{a}	8.75±0.46 ^{a}	8.5± 0.53 ^{a}	8.12± 0.35 ^{a}	8.43± 0.22 ^{a}
CF+MB(20%)+KP(2.5 %)	8.25± 0.4 ^{a}	8.37± 0.51^{a}	8.62± 0.7 ^{a}	8. 37± 0.50 ^{a}	8.40± 0.22 ^{a}
CF+MB(20%)+KP(5 %)	8.25± 0.46 ^{a}	7.87± 0.83 ^{ab}	8.0± 0.5 ^{a}	8.25± 0.70 ^{a}	8.08± 0.28^{ab}
CF+MB(20%)+KP(7.5 %)	8.11± 0.35 ^{a}	7.3± 0.35^{b}	7.75± 0.8^{ab}	8.25± 0.40 ^{a}	7.87± 0.18^{bc}
CF+MB(20%)+KP(10 %)	7.75±0.46 ^{a}	7.37± 0.74^{b}	7.0± 0.75^{b}	8.10±0.64 ^{a}	7.56± 0.25^{c}

Note – CF: Corn flour; MB: Mothbean; KP: Karondapowder, Values are expressed as mean ± SD = Significant at 5 %, $^{a-c}$ Means within each row with different superscripts are significantly ($p \leq 0.05$) different

Table 3: Sensory evaluation of Garden cress extruded snacks

Treatments	Texture	Appearance	Colour	Taste	Overall
Control (CF)	8.3± 0.5 ^{a}	7.87± 0.83 ^{a}	7.87±0.35 ^{a}	7.87± 0.6 ^{a}	8.0± 0.26 ^{a}
CF+MB(20%)+GC(2.5 %)	8.25± 0.4^{ab}	7.75± 0.88 ^{a}	8.12± 0.35 ^{a}	7.87± 0.35 ^{a}	8.0± 0.29 ^{a}
CF+MB (20%)+GC (5 %)	7.62±0.51^{bc}	8.0± 0.53 ^{a}	7.87± 0.64 ^{a}	7.62± 1.1 ^{a}	7.78± 0.31^{ab}
CF+MB(20%)+GC(7.5 %)	7.37± 0.51^{c}	7.62± 0.7 ^{a}	7.0 ± 0.75^{b}	7.62± 0.74 ^{a}	7.40± 0.42^{b}
CF+MB (20%)+GC(10%)	7.0± 0.53^{c}	7.2± 1.03 ^{a}	5.62± 0.74^{c}	5.87± 0.35^{b}	6.43± 0.2^{c}

Note – CF: Corn flour; MB: Mothbean; GC: Garden cress, Values is expressed as mean ± SD = Significant at 5 %, $^{a-c}$ Means within each row with different superscripts are significantly ($p \leq 0.05$) different

Table: 4 Sensory evaluation of Niger seeds extruded snacks

Treatments	Texture	Appearance	Colour	Taste	Overall
Control (CF)	8.37± 0.5 ^{a}	8.37± 0.74 ^{a}	8.37± 0.51 ^{a}	7.87± 0.3^{ab}	8.24± 0.26^{a}
CF+MB(20%)+NS (2.5 %)	8.12±0.35 ^{a}	8.0± 0.53 ^{a}	8.25± 0.70 ^{a}	8.25± 0.4 ^{a}	8.08± 0.2 ^{a}
CF+MB(20%) +NS (5 %)	8.12± 0.35 ^{a}	7.87± 0.64^{ba}	7.75± 0.70^{ab}	8.12±0.64^{ab}	7.96± 0.4 ^{a}
CF+MB(20%) +NS (7.5%)	6.87± 0.64^{b}	6.75±0.46 ^{b}	7.0 ± 0.53^{b}	7.37± 0.51^{b}	6.75±0.37^{c}
CF+MB (20%)+NS (10%)	6.37± 0.7 ^{b}	4.5± 0.92^{c}	4.75±0.8^{c}	4.75± 0.88^{c}	5.08±0.55^{c}

Note – CF: Corn flour; MB: Mothbean; NS: Niger seeds, Values are expressed as mean ± SD = Significant at 5 %, $^{a-d}$ Means within each row with different superscripts are significantly ($p \leq 0.05$) different

Table 5: Sensory evaluation of Amaranth leaves extruded snacks

Treatments	Texture	Appearance	Colour	Taste	Overall
Control	8.12±0.3 [a]	8.12±0.3 [a]	8.5±0.53 [a]	8.5± 0.53 [a]	8.31± 0.17 [a]
CF+MB (20%)+AL (2.5%)	8.25±0.9 [a]	8.0± 0.53 [ab]	8.12± 0.35 [ab]	8.37± 0.51 [a]	8.18± 0.22 [a]
CF+MB (20%) +AL (5%)	8.0± 0.53 [a]	7.75± 0.46 [ab]	7.75± 0.46 [ab]	8.12± 0.64 [ab]	7.90± 0.29 [b]
CF+MB (20%) +AL(7.5%)	7.75± 0.9 [a]	7.37± 0.51 [b]	7.37± 0.51 [b]	7.37± 0.5 [b]	7.46± 0.2 [b]
CF+MB (20%) +AL (10%)	5.75± 0.8 [b]	5.57± 0.74 [c]	5.37± 0.8 [c]	5.87± 0.64 [c]	5.62± 0.4 [c]

Note – CF: Corn flour; MB: Mothbean; AL: Amaranth leaves, Values are expressed as mean ± SD = Significant at 5 %, [a-c] Means within each row with different superscripts are significantly ($p \leq 0.05$) different

Table 6: Sensory evaluation of Bengal gram leaves extruded snack

Treatments	Texture	Appearance	Colour	Taste	Overall
Control	8.12± 0.64 [a]	8.5± 0.53 [a]	8.25± 0.4 [a]	8.25±0.4 [a]	8.28± 0.24 [a]
CF+MB (20%) +BL (2.5 %)	8.0± 0.5 [a]	7.75± 0.4 [ab]	8.12± 0.3 [a]	8.25± 0.4 [a]	8.03± 0.2 [a]
CF+MB (20%) +BL (5 %)	8.25± 0.46 [a]	7.37± 0.5 [bc]	7.5± 0.5 [a]	8.12± 0.3 [a]	7.6± 0.17 [a]
CF+MB (20%) +BL (7.5%)	7.62± 0.74 [b]	6.62± 0.5 [c]	5.8± 0.35 [b]	6.62± 0.51 [b]	6.68± 0.2 [b]
CF+MB (20%) +BL (10%)	5.75± 0.70 [c]	5.62±0.9 [d]	5.3± 0.9 [c]	5.57± 1.03 [b]	5.62± 0.6 [c]

Note – CF: Corn flour; MB: Mothbean; BL: Bengal gram leaves, Values are expressed as mean ± SD = Significant at 5 %, [a-c] Means within each row with different superscripts are significantly ($p \leq 0.05$) different

NUTRITIVE CONTENT OF EXTRUDED SNACKS

Nutritive content of the acceptable snacks is presented in table 7. The moisture content of the extruded snacks ranged from 7.23 to 10.5 g/100gDM.The ash content in food products is an index of mineral contents. The ash content of extruded snacks ranged from 2.2 to 4.5 g/100g DM, being maximum in GC 7.5% and minimum in control (CF). After garden cress, the high ash content was in BL 5% (4.09) followed by AL extrudates. The garden cress seeds contained ash content of 4.25 g/100g as reported by Muhammad Zia-Ul-Haq et al (2012). The high ash content in Bengal gram leaves was reported by Kaur (2011).

The crude fiber content of the extruded snacks ranged from 1.5 to 3.3g/ 100g DM with the highest content in LS 5% and lowest in KP 5%. All the lotus stem snacks had significantly ($p \leq 0.05$) high fiber content than other extrudates and this is attributed to the high fiber content in lotus stem. The fat content in the developed extrudates was found low ranging from 0.7 – 1.7 g/100gDM with the highest content in NS 5% supplemented snacks and the lowest in LS 7.5%. The results showed that there was significant ($p \leq 0.05$) difference between the fat content of the snacks.

The protein content of all the accepted extruded snacks ranged from 12.1 to 16.9 g/100g DM. The protein content was highest in GC (7.5%) incorporated extruded snacks while; the protein content of control (corn flour) was 9.1 g/ 100g DM. In extrudates, the additions of legume flour to cereal-based formulations have proven to positively impact their essential amino acid balance (Tharanathan & Mahadevamma, 2003). Mothbean has been identified as one of the potential protein food source (23.6 g/ 100g) as reported by Asha *et al* 2005. The AL and BL extrudates had high protein in the range of 13 to 14.2 mg/100g DM and 14.4 to 15.7 g/100g DM and this is attributed to the high protein content in these leaves. Akubugwo*et al* (2007) reported 17.9 g/100g DM of protein content in amaranth leaves. As pulses, dried leafy vegetables, nuts and oil seeds contain good amount of protein than cereal, levels of crude protein increased with the supplementation of these ingredients in the study in comparison to maize extrudates (control).

The carbohydrate content of the extruded snacks range from 66.6 to 74.9 g/100g with the highest value in KP 5% and the lowest value was seen in GC 7.5% The carbohydrate content of the supplemented extruded products were at par with the control *i.e.* 74.5 g/100g. The carbohydrate values of the snacks decreased with the increasing protein content.Lohekar and Arya (2014) developed value added instant kheer mix including garden cress seeds and it was found to contain protein 16.99g, fat 5.41g, total minerals 3.48 g, fiber 3.88 g and iron 28.79 mg.The energy content of the snacks range from 332 to 355 kcal/100g. The highest energy content was seen in GC 7.5 and the lowest was seen in LS 10%. The energy content of all the extruded snacks were at par with the control i.e. 344 Kcal. James and Nwabueze (2013) reported energy content of 382 kcal/100g in soybean extruded snacks.

Iron is a trace element needed for haemoglobin formation, normal functioning of the central nervous system and in the oxidation of carbohydrates, protein and fats (Adeyeye and Otokiti, 2009). The analysed total iron content of the extruded snacks ranged from 15.4 to 21.3 mg/100g being, lowest in AL 2.5% and highest in GC 7.5% and NS 5%. All the developed snacks had high iron content as expected due to the addition of iron rich ingredients. The iron content of the snacks ranged from 15.4 to 23.1mg/ 100g DM whereas, the iron content of control was 3.9 mg/ 100g (figure 1). Garden cress seeds extrudates had significantly ($p \leq 0.05$) high iron content than others and it showed 79 to 82% increase in iron content in comparison to the control. After GC, the second highest iron content was seen in NS 5% extruded snacks and they showed 78 to 80% increase in iron content in comparison to the control.Garden cress seeds are highly rich in iron as reported by Kotagi*et al* (2013). In the present study, the amaranth leaves and Bengal gram leaves extrudates had good amount of iron content that range

from 15.4 to 17.3 mg/100g and this may be attributed to the high amount of iron present in these leaves. The iron content of lotus stem (LS) 2.5, 5, 7.5 and 10 % was 17.2, 17.43, 19.5 and 19.42 mg respectively. Similarly the iron content of*karonda* powder (KP) 2.5, 5, 7.5 and 10 % was 16.8, 15.7, 16.95 and 18.5 mg/ 100 g DM respectively. The total iron content in supplemented extruded snacks was found to increase in the range of 72- 82% in comparison to the control.

Table 7: Proximate composition of extruded snacks (g/100g)

Treatments	Moisture	Ash	Crude fiber	Crude fat	Crude protein	CHO	Energy (Kcal)
CF(Control)	9.2^{a}±.2	2.2^{c}±0.4	2.8^{ab}±0.05	1.1^{bc}±0.17	9.1^{c}±1.2	74.5^{a}±4.2	344^{a}±16.2
LS 2.5 %	10.5^{a}±1.4	2.5^{c}±0.3	3.2^{a}±0.45	0.77^{cd}±0.1	13.8^{ab}±1.2	69.1^{a}±2.9	339^{a}±13.2
LS 5 %	9.01^{a}±1.1	3.3^{b}±0.3	3.3^{a}±0.50	0.86^{cd}±0.06	12.7^{bc}±1.12	70.5^{a}±3.2	340^{a}±12.1
LS 7.5 %	9.2^{a}±1.1	3.9^{ab}±0.7	2.3^{cd}±0.78	0.7^{d}±0.09	13.9^{ab}±1.85	68.1^{a}±3.7	335^{a}±10.1
LS 10 %	9.5^{a}±0.6	3.8^{b}±0.23	2.7^{b}±0.73	0.78^{cd}±0.13	14.0^{ab}±1.15	67.3^{a}±4.1	332^{a}±11.2
KP2.5 %	9.6^{a}±0.9	3.3^{bc}±0.66	2.0^{cd}±0.3	0.85^{cd}±0.10	12.3^{bc}±1.91	71.9^{a}±5.1	344^{a}±20.2
KP 5 %	8.3^{a}±1.0	2.3^{c}±0.17	1.5^{e}±0.26	0.86^{cd}±0.10	12.1^{bc}±1.01	74.9^{a}±5.6	351^{a}±16.2
KP7.5 %	8.7^{a}±1.5	2.7^{bc}±0.24	1.8^{d}±0.3	0.83^{cd}±0.14	13.9^{ab}±0.6	72.0^{a}±2.1	346^{a}±18.2
KP 10 %	8.9^{a}±0.3	3.2^{b}±0.1	1.9^{d}±0.37	0.9^{bcd}±0.1	13.8^{ab}±1.8	71.1^{a}±3.9	348^{a}±15.3
NS2.5 %	7.8^{a}±0.6	3.54^{b}±0.1	3.2^{a}±0.54	1.3^{b}±0.13	15.08^{ab}±1.1	69.4±7.8^{a}	348^{a}±15.7
NS 5%	7.23^{a}±0.4	3.81^{b}±0.2	2.8^{ab}±0.8	1.7^{a}±0.79	15.4^{ab}±2.3	70.6^{a}±5.6	353^{a}±13.6
GC 2.5 %	9.79^{a}±0.3	3.2^{bc}±0.1	2.7^{ab}±0.08	1.0^{bcd}±0.2	16.06^{ab}±0.8	68.5^{a}±4.9	347^{a}±14.2
GC 5 %	7.85^{a}±1.0	4.2^{a}±0.07	2.9^{ab}±0.76	0.9^{bcd}±0.08	15.08^{ab}±1.9	69.0^{a}±6.2	353^{a}±13.2
GC 7.5 %	7.85^{a}±0.6	4.5^{a}±0.10	3.0^{ab}±0.87	1.1^{bcd}±0.24	16.9^{a}±1.1	66.6^{a}±5.3	355^{a}±12.9
AL2.5 %	9.56^{a}±0.7	3.5^{b}±0.5	2.3^{c}±0.03	0.82^{cd}±0.13	14.2^{ab}±1.05	69.2^{a}±5.3	336^{a}±14.3
AL5 %	9.4±1.2^{a}	3.92^{ab}±0.5	3.1^{a}±0.41	0.76^{cd}±0.07	13^{abc}±1.5	69.7^{a}±4.4	338^{a}±±9.1
AL7.5%	8.5^{a}±0.9	4.04^{ab}±0.6	2.9^{ab}±0.77	0.83^{cd}±0.09	13.9^{ab}±1.4	69.8^{a}±5.1	342^{a}±13.4
BL2.5 %	9.05^{a}±1.9	3.38^{bc}±0.4	2.0^{e}±0.56	0.78^{cd}±0.14	15.7^{ab}±1.9	69.1^{a}±6.2	346^{a}±15.6
BL 5 %	8.78^{a}±1.0	4.09^{ab}±0.2	2.3^{c}±0.43	0.72^{cd}±0.08	14.4^{ab}±1.7	68.6^{a} ±3.9	342^{a}±23.1

Values are expressed as mean ± SD, Significant at 5 %, $^{a-c}$ Means within each row with different superscripts are significantly ($p \leq 0.05$) different.

(MF: Maizeflour; MB: Mothbean; LS: lotus stem, KP:*karonda*, GC: Garden cress seeds, NS: Niger seeds, AL: Amaranth leaves, BL: Bengal gram leaves

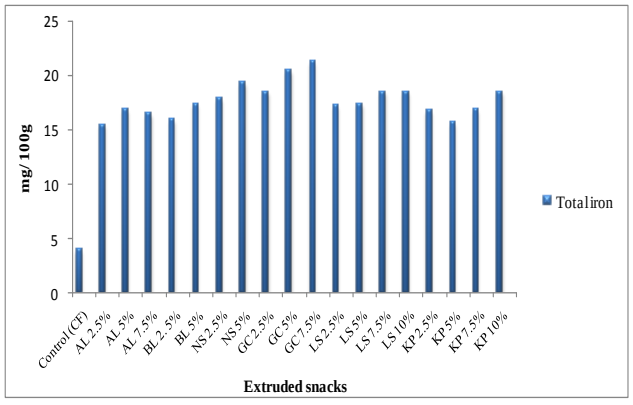

Fig. Iron content of extruded snacks

CONCLUSION

The extrusion cooking is one of the contemporary food processing technologies applied for preparation of variety of ready to cook foods, snacks, specialty and supplementary foods. Foods are meant not only to satisfy hunger but also to provide essential nutrients and prevent nutrition related diseases and improve physical and mental well being of consumers. Thus, the extruded snacks formulated using different iron rich foods could provide health benefits beyond its basic nutrition.

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