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RESEARCH ARTICLE

ENHANCING NUTRITIONAL QUALITY OF CORN EXTRUDED SNACK BY INCORPORATING MOTHBEAN (*Vignaaconitifolia*) AND GARDEN CRESS SEEDS (*Lepidiumsativum*)

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ABSTRACT

The corn extruded snacks were supplemented with moth bean and garden cress in order to enhance the nutritional quality of the snacks. The garden cress (GC) was added to different extruded snacks at the level of 2.5, 5%, 7.5% and 10% level while, moth bean (MB) was added at the level of 20 % to the corn flour. The developed snacks were acceptable till 7.5% level of garden cress incorporation. The organoleptically acceptable snacks were analysed for nutritional evaluation. All the developed extruded snacks incorporating MB and GC were high in protein ranging from 15.08 to 16.9g/100g in comparison to the corn extruded snack (9.1 g). The iron and calcium content of the snacks ranged between 18.4 to 21.3 mg/100g and 54.6 to 57.3mg/100g DM respectively, which were significantly ($p \leq 0.05$) higher than the control. The essential amino acids like methionine and cystine content of the snacks was significantly higher than control, it ranged from 105.3 to 109.5 mg/100g DM and 102.3 to 109.2mg/ 100gDM, whereas their content in corn extruded snack (control) was 84.6 and 99.2mg/100gDM. The lysine content of MB and GC snacks was significantly ($p \leq 0.05$) higher than the corn extruded snacks. The antinutrients like oxalate and phytate content were low ranging from 1.3 to 2.1 mg/100g and 128 to 144 mg/100g respectively. The developed snacks had high protein, iron, iron bioavailabilty, invitrocarbohydrate and protein digestibility.

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INTRODUCTION

The incidents of protein energy malnutrition and micro-nutrient deficiency is common among children. Nutrition and diet are important factors in combating deficiency diseases among children. Snacks have become an important part of the diet of many individuals including children (Thakur &Saxena, 2000). Well prepared snacks can help in managing weight, hunger, health and energy. Now a day's extruded products are most popular among children. Extrusion cooking is a high temperature short time (HTST) process that is widely popular in the food and feed industries, due to several advantages like faster processing time, considerable saving in energy leading to lower price of the products, possible production of oil free puffed products etc.

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Extrusion process markedly improve the nutritional availability of the ingredients. Several ready-to-eat extruded snacks have been reported exclusively from cereals or their blends with legume etc (Jisha *et al.,* 2010). Corn extruded products provides all the features for production of highly acceptable extruded snack foods but are nutritionally deficient. So, basic corn extruded snacks can be enriched with legume like moth bean and garden cress seeds (both rich in iron and protein). Moth bean (*Vignaaconitifolia* L.) consumption is limited only to some states in India. Though information available on the nutritive value of moth bean is limited. Moth bean seeds contains 24.1% protein, 0.8% fiber, 1.3% fat and 3% ash. It is a rich source of iron which is about 9.6mg/100g. Presence of anti-nutritional factors is one of the main drawbacks limiting the nutritional and food qualities of moth bean (Salve and Mehrajfatema 2011). Garden cress (Lepidiumsativum) belonging to the family Cruciferae is an underutilized crop. The edible whole seed is known to have health promoting properties. Garden cress seeds are richest source of protein, iron, folic acid, calcium, vitamin A and E. Since, it is best source of iron it often helps to cure anaemic conditions (Saravanan *et al.,* 2012). Apart from this, it is a rich source of omega 3 fatty acids which help to lower cholesterol in hyper cholesterolemic patients (Parameshwari and Nazni, 2012). Nowadays, various extruded snacks especially maize based are available in the market but are nutritionally deficient. There is a strong thrust to develop such snacks which not only provide maximum nutrient but also must be liked by all age groups especially children. Thus, the objectives of the study is to make nutritious corn based extruded snacks supplemented moth bean and garden cress.

MATERIALS AND METHODS

Materials

Raw material for making extruded snacks like maize (Zea mays), moth bean (*Vignaaconitifolia*) and garden cress seeds (*Lepidiumsativum*) were procured from the local market of Ludhiana city.

Development of extruded snacks

The extruded snacks were made with corn flour (CF), moth bean (MB) and garden cress (GC). Garden cress seeds were added to different extruded snacks at the level of 2.5, 5, 7.5 and 10%. The garden cress seeds were roasted before adding them to extrusion mixture. Roasting helps in reducing the bitterness of these seeds. Moth bean was added at the level of 20% to both the mixtures. The standardized recipes for control samples were prepared from corn flour. The extruded snacks were made using a co- rotating intermeshing twin screw extruder (Clextral, Firminy, France). The following treatments were given

Treatment I (Control) – CF
Treatment II- CF+ MB (20%) + GC (2.5, 5 and 7.5%)

Nutritional analysis

The developed extrudates were analysed for proximate, minerals, limiting amino acids, antinutrients, *in vitro* iron bioavailability and *in vitro* protein and carbohydrate digestibility.

Proximate analysis

All the samples were analyzed in duplicates. Moisture, Ash, protein, crude fat and crude fibre content was evaluated on dry matter basis by AOAC method (2000). Carbohydrate was calculated by difference.

Minerals

Elements namely iron, zinc and calcium were estimated using atomic absorption spectrophotometer (AAS, Varian model, Piper, 1950). Samples were digested with diacid mixture (nitric acid: perchloric acid, 5:1 v/v) and then analyzed by AAS.

Limiting amino acids

Three limiting amino acids were determined namely lysine, methionine and cystine. Lysine was estimated by the method given by Carpenter (1960), methionine was determined by the method of Horn *et al.* (1946) and cystine was estimated by the method given by Lidell and Saville (1959).

Antinutrients (Phytate and oxalates)

The method for phytate was determined by Haung and Lantzsch (1983). In this method, 1 g of sample was added to HCL for extraction which was .followed by addition of ferric solution and bipyridine solution. Absorbance was read at 519 nm. Oxalate were estimated by the procedure given by Abeza *et al.* (1968).

In vitro iron bioavailability

In this method, 2g of sample was mixed with HCL and then treated with hydroxylamine solution, acetate buffer and alpha-alpha dipyridyl solution. The method of analysis was given by Rao and Prabhavati (1978)

In vitro protein and starch digestibility

In vitro protein analysis method was estimated by Akson and Stachman (1964). In this, the sample was first treated with pepsin followed by pancreatin solution. The residue was analysed for nitrogen content by macrokjeldahl method. The digestibility coefficient was calculated by subtracting the residual protein from the initial protein. The method of *in vitro* starch was determined by Singh *et al.* (1982).

RESULTS AND DISCUSSION

Proximate composition

Proximate composition of the extruded snacks has been shown in table 1. The ash content in developd snacks is an index of mineral contents. The ash content in GC extrudates was significantly ($p \leq 0.05$) higher than the control and it was found to be in the range of 3.2 to 4.5g/100g and this is attributed to the high amount of minerals present in garden cress. The protein content of the developed snack was significantly higher ($p \leq 0.05$) than the corn extruded snack (9.1 g/100g). Muhammad Zia-Ul-Haq *et al.* (2012) reported high ash and protein content in garden cress seeds *i.e.* 4.2 g/100g and 24.1 g/100g respectively. The fat content in the snacks was low, as there was no additional fat added to the snacks. The fat content of the snacks ranged from 0.9 to 1.1 g/100g. The carbohydrate content of the snacks ranged from 66.6 g to 69 g/ 100g. The carbohydrate content of the control (74.5 g/ 100g) was higher than the garden cress extrudates vice versa the protein content of the developed snacks was higher than the control. Iwe and Ngoddy (2005) developed extruded snacks from soyabean and sweet potato flour and found that with increase in sweet potato content the carbohydrate values of extruded products increased. The carbohydrate content of extruded snack of sweet potato and soy flour in the ratio of (1:4) and (4:1) was 52.84 g and 73.58/ 100g DM whereas, the protein content was 38.15 g and 16.32 g/ 100g DM respectively.

Minerals

The minerals *viz.* iron, calcium and zinc were analysed for the developed extruded snacks (Table 2).

Table 1. Proximate composition (g/100g)

Treatments	Moisture	Ash	Crude fibre	Crude fat	Crude protein	CHO	Energy
Control(CF)	9.2^{ab}±1.2	2.2^{c}±0.02	2.8^{b}±0.05	1.1^{b}±0.3	9.1^{b}±1.27	74.5^{a}±4.2	344^{a}±16.2
CF+MB+GC2.5 %	9.79^{a}±0.3	3.2^{bc}±0.04	2.7^{b}±0.08	1.0^{b}±0.11	16.06^{a}±1.93	68.5^{a}±4.9	347^{a}±14.2
CF+MB+GC5%	7.85^{bc}±1.1	4.2^{ab}±0.01	2.9^{b}±0.76	0.9^{b}±0.07	15.08^{a}±1.7	69.0^{a}±6.2	353^{a}±13.2
CF+MB+GC7.5 %	7.85^{c}±1.2	4.5±0.09^{a}	3.0^{b}±0.87	1.1^{b}±0.05	16.9^{a}±1.2	66.6^{a}±5.3	355^{a}±12.9

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. Minerals (mg/100g)

Treatments	Iron	Calcium	Zinc
Control(CF)	3.9^{b}±0.7	13±1.2^{b}	1.9±0.6^{b}
CF+MB+GC2.5 %	18.4^{a}± 2.26	54.6±3.2^{a}	3.8±0.8^{a}
CF+MB+GC 5 %	20.4^{a}± 2.55	57.3±5.1^{a}	2.6±0.9^{ab}
CF+MB+GC7.5 %	21.3^{a}± 1.52	56.3±4.0^{a}	3.1±1.1^{ab}

Values are expressed as mean±SD = Significant at 5 %

$^{a-b}$Means within each row with different superscripts are significantly ($p \leq 0.05$) different

Table 3. Limiting amino acids (mg/100g)

Treatments	Methionine	Lysine	Cystine
Control(CF)	84.6^{b}±7.2	201.5^{b}±10.0	99.2^{b}±5.1
CF+MB+GC2.5 %	109.5^{a}±8.1	300.9^{a}±7.3	109.2^{ab}±3.4
CF+MB+GC 5 %	108.5^{a}±5.2	306.8^{a}±9.1	102.3^{b}±2.1
CF+MB+GC7.5 %	105^{a}±6.3	299.9^{a}±7.5	105.8^{b}±4.3

Values are expressed as mean±SD = Significant at 5 %

$^{a-b}$Means within each row with different superscripts are significantly ($p \leq 0.05$) different

Table 4. Antinutrients (mg/100g)

Treatments	Oxalate	Phytate
Control (CF)	1.1^{b} ±0.1	100^{b} ±10.8
CF+MB+GC2.5 %	2.1^{a} ±0.3	130^{ab} ±5.6
CF+MB+GC 5 %	1.7^{ab} ±0.2	128^{ab} ±6.1
CF+MB+GC7.5 %	1.3^{ab} ±0.04	144^{a} ±5.1

Values are expressed as mean±SD = Significant at 5 %

$^{a-b}$Means within each row with different superscripts are significantly ($p \leq 0.05$) different

Table 5. In vitro iron bioavailability, invitroprotein and carbohydrate digestibility (%)

Extruded snacks	Invitro iron (%)	Invitroprotien (%)	Invitro CHO (%)
Control(CF)	14.1^{b}±0.51	70^{a} ±4.0	72.8^{a} ±2.0
CF+MB+GC2.5 %	14.9^{ab}±1.93	75.2^{a} ±3.1	79.2^{a} ±7.0
CF+MB+GC 5 %	15.3^{ab} ±0.58	72.1^{a} ±0.5	82.6^{a} ±5.2
CF+MB+GC7.5 %	17.8^{a} ±0.45	78.5^{a} ±5.0	77.3^{a} ±6.0

Values are expressed as mean±SD = Significant at 5 %

$^{a-b}$Means within each row with different superscripts are significantly ($p \leq 0.05$) different

The iron content of the developed snacks was 18.4, 20.4 and 21.3mg/100g at 2.5, 5 and 7.5 % level. The iron content of the extruded snacks was significantly ($p \leq 0.05$) higher than the control. Garden cress seeds are highly rich in iron as reported by Kotagi *et al.* (2013). Lohekar and Arya (2014) developed value added instant kheer mix including garden cress seeds and found 28.7 mg/100g of iron content. Charunuch *et al.* (2008) produced an acceptable extruded snack of high nutritional quality using thai brown rice for the programs against anemia and malnutrition. The snacks were fortified with iron fortificants (ferrous sulphate, ferrous lactate and ferrous fumarate). It was found that ferrous sulphate as iron fortificant provides the good appearance of extruded snacks and meet the requirements of iron as well as lower production cost. The calcium content of the snacks were significantly ($p \leq 0.05$) higher than the control. The calcium content of the snacks ranged from 54.6 to 57.3 mg/100g. Seventy four to seventy nine percent increase in calcium content was observed in extrudates in comparison to the control. Moth bean was added at 20% level to all the extrudates. The mothbean has been identified as one of the potential source of calcium (202mg/100g) as reported by Asha *et al.* (2005). The garden cress seeds contain high calcium content (266 mg/100g) as reported by Muhammad *et al.* (2012). Kotagi *et al.* (2013) reported 29.30 mg/ 100g of calcium content in millet extruded snack supplemented with garden cress seeds. Lohekar and Arya (2014) developed value added instant kheer mix including garden cress seeds and found 484.66 mg/100g of calcium content in it. Zinc is an important element needed in body as it is involved in normal function of immune system (Osredkar and Sustar 2011). The zinc content in the snacks ranged from 2.6 to 3.8mg/ 100g and these values were significantly higher than control (0.9 mg/100g). The garden cress seeds contains high zinc content (7 mg/100g) as reported by Muhammad (2012)

Essential amino acids and antinutrients

The essential amino acids like methionine, lysine and cystine contents of the extruded snacks were analysed (Table 3). All the amino acids analysed were higher in the fortified extrudates than control. GC extrudates had methionine content in the range of 105.3 to 109.5 mg/100g protein whereas, the methionine content in the control was 84.6mg/100g protein. The lysine content of the GC extrudates range from 299 to 306 mg/100g which was significantly higher than control (201 mg/100g) The cystine content of the snacks ranged from 102.3 to 109.2mg/ 100g whereas, the cystine content of the control was 99.2 mg/100 g DM. The antinutrients like oxalates and phytate content of the extruded snacks were analysed (Table 4). The percentage of oxalate was highest (2.1 mg) in case of 2.5 % niger seeds incorporated snacks followed by GC 7.5 %. The highestphytate content was seen in GC 7.5 % snacks i.e. 144 mg/ 100 g DM.

In vitro iron bioavailability, protein and carbohydrate digestibility

The *in vitro* iron bioavailability of the snacks ranged from (14.9 to 17.8%) in the extruded snacks and these value were higher than normal iron bioavailability levels in food. On the basis of intake data and isotope studies, iron bioavailability has been estimated to be in the range of 5–12% in vegetarian diet (Hurrel and Egli 2010). In the present study, the iron bioavailability in the developed extruded snacks was high due to the fact that extrusion process diminishes the antinutrients present in food and thus making nutrients more available to the body (Ruiz *et al.,* 2008). The *in vitro* protein and carbohydrate content in the snacks ranged from 72.1 to 78.5% at different levels. Alonso *et al*. (2000) reported extrusion cooking as the best method in comparison to other processing methods as it significantly decrease the antinutrients like trypsin, chymotrypsin and alpha amylase activity in extruded snacks made from faba and kidney beans and thus improving the protein digestibility. The *in vitro* carbohydrate content of the snacks ranged from 77.3 to 82.6 mg/100g. Extrusion process favours starch digestibility properties while maintain availability of other nutrients. He also found that extrusion treatment significantly increased the in vitro digestibility of pea starch. This may be explained in such a way that the increased shearing action develops heat through dissipation of mechanical energy and causes loss of structural integrity and increases enzyme susceptibility (Camrie 2000).

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