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# Development and quality evaluation of foxtail millet (*Setaria italica*) based extruded product using twin screw extruder

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**Abstract**
The current study aims at the development and quality evaluation of Foxtail Millet based Extruded product. Foxtail millet is potentially important source of protein. Foxtail Millet flour exhibit good extrusion characteristics which give smooth surface and crunchy texture. Both foxtail millet are rich in fiber, vitamins, energy, and protein. A total of five treatments with different proportions (100:0, 95:5, 90:10, 85:15, and 80:20) of the foxtail millet were given for development of product. Analysis of Physico-chemical parameters such as protein, fat, fiber, moisture, ash content and along with sensory evaluation for all the treatments was performed. Protein and Fat content increased gradually with increase in the Foxtail millet content whereas Moisture content % (max. 4.79 and min. 3.62), Ash content % (max. 0.55 and min. 1.42) and crude fiber % (max. 2.35 and min. 1.32), increased with an increase in the foxtail millet proportion. On optimization and evaluation of all the parameters and considering the results of sensory evaluation, $T_3$ sample containing (85:15) ratio of millet was found foxtail millet be the most optimum treatment.

**Keywords:** extrusion, foxtail millet, physico-chemical parameters, foxtail millet

## 1. Introduction
Food extrusion is a form of extrusion used in food processing. It is a process by which a set of mixed ingredients are forced through an opening in a perforated plate or die with a design specific to the food, and is then cut to a specified size by blades. The machine which forces the mix through the die is an extruder, and the mix is known as the extruded. Food products manufactured using extrusion usually has high starch content.
In the recent years there has been an increasing interest in the production of extruded foods, such as snacks, pastas, breakfast cereals, baby foods, pet foods etc. (Yadav and Chandra, 2015) [18]. India, minor millets are still the staple food to large section of people in the semi-arid regions, especially in the state of Karnataka where the foxtail millet is grown widely even under irrigation with yield as high as 3 t/ha (Bala Ravi, 2004). Minor millets account for less than 1% of the food grains produced in the world today. Thus they are not important in terms of world food production, but they are essential as food crops in their respective agro-ecosystems. They are mostly grown in marginal lands or under agricultural conditions where major cereals fail to give sustainable yields. They are considered as crops of food security because of their sustainability in adverse agro-climatic conditions. Foxtail millet (*Setaria italica*), also called as Korralu (Telugu), Navane (Kannada) and Thinai (Tamil), is the second-most widely planted species of millets and the most important in East Asia.
In India, foxtail millet cultivation is confined mainly to the states of Karnataka (49%), Orissa (11%), Maharashtra (16%), Tamil Nadu (9%) and Andhra Pradesh (7%). In Karnataka, the area and production of foxtail millet are 42436 ha and 14001 tonnes, respectively (Anon, 2016). It is a good source of phosphorous, iron and vitamins like thiamine, riboflavin, folin and niacin.
In the extruder, the food mix is thermo-mechanically cooked at high temperature under pressure and shear stress generated in the screw barrel assembly. The cooked melt is then texturized and shaped in the die. The thermo-mechanical action during extrusion brings about starch gelatinization, protein denaturation, and inactivation of enzymes, microbes and many anti nutritional factors. All this occurs in a shear environment, resulting in a plasticized continuous mass (Battacharya *et al.* 1994).
Based on type of construction extruders are classified into: Single screw and twin screw extruder. A typical single-screw extruder consists of a live bin, feeding screw, preconditioning cylinder, extruder barrel, die and knife. The live bin provides a buffer of raw material so the extruder can operate without interruption. For more flexibility & better control we use twin

screw extruders since single screw extruders have relatively poor mixing ability. These are generally categorized according to the direction of screw rotation and to the degree to which the screws intermesh. 1. Counter- rotating twin-screw extruders 2. Co-rotating twin screw extruders. In the counter-rotating position the extruder screw rotates in the opposite direction, whereas in the co-rotating position the screw rotates in the same direction.

Extrusion cooking as a continuous cooking, mixing, and forming process, is a versatile, low cost, and very efficient technology in food processing. It combines several unit operations including mixing, shearing, conveying, heating, puffing and partial drying, depending on the extruder design and process conditions. (Gordon L Robertson *et al*. 1993)

Rice (*Oryza sativa*) is a staple food crop for a large part of the world's human population, making it the second most consumed cereal grain. Rice provides more than $1/5^{th}$ of the calories consumed worldwide by humans. Rice contains approximately 7.37% protein, 2.2% fat, 64.3% carbohydrate, 0.8% fiber and 1.4% ash content (Zhoul *et al.* 2002).

## 2. Materials and Methods

This section describes the materials used, the methods applied, calculations used and factors considered in developing the extruded product by using twin screw extruder.

### 2.1 Procurement of raw materials

The raw material namely foxtail millet and rice (parmal long grain non-basmati) were procured from Maharashtra local market. Maize (yellow) was procured from local commercial supplier. All raw materials were cleaned and grounded separately in the grinder and passed through 0.88 mm sieve and stored in the cool and dry atmosphere for further experiments.

### 2.2 Twin screw extruder

The extruder used for this experiment was laboratory co-rotating twin-screw extruder (Basic Technology Pvt. Ltd., Model EB-10). The extruder was preassembled and skid-mounted and placed on 3 inches raised platform. The raised platform helps cleaning the extruder. The machine components which directly come in contact with feed material like screw, barrel, die are made of stainless steel for better hygiene. The main drive is provided with the 7.5 HP variable speeds motor (440 V; 3 phase; 50 Hz). It was provided with SIEMENS/ABB frequency drive to control the rpm precisely according to the need of the process. The output shaft of worm-reduction gear is provided with a torque limiter coupling consisting of torque limiter and roller chain type coupling. The torque limiter is a protective device that limits torque transmitted by the output shaft of worm-reduction gear.

First of all five trial run experiments were conducted to fix the feed combination of raw material as shown in Table 1. Here foxtail millet was fixed to (0-10) % as more fortification of it may injurious to the baby's health and maize was varied from (40-50) % and rice from (40-50) %. For these trial experiments we had kept barrel temperature fixed at 110 $^0$C, screw speed at 350 rpm, feed moisture content at 10% (wb), feeding screw at 24 rpm, cutting knife speed at 26 rpm.

Samples were poured into feed hopper and the feed rate was adjusted for easy and non-choking operation. The automatic cutting knife was fixed on a rotating shaft of knife powered by D.C. motor. The cutter was driven by variable speed by D.C. motor which was controlled by a knob placed on the panel board. The speed of cutter was fixed at 350 rpm for all experiments. Extruded were cut with a sharp knife, at the exit end of the die and left to cool at room temperature for about 20 min. The cylindrical extruded were dried at 50 °C for about 2 h to obtain dry extruded (Bhattacharya, 1997).

### 2.3 Chemical analysis

**1. Moisture Content**

Moisture content was determined by using hot air oven drying method 5 gm. of sample was taken in pre-weighed empty Petri plate and dried in hot air oven at 100 $^0$C for peel & at 60 $^0$C for juice till constant weigh were obtained. Plates were cooled in desiccators. The moisture content was calculated by using formula. (Ranganna, 1986).

$$\text{Moisture content (\%)} = \frac{\text{(Initial weight of sample)-(Final weight of sample) X 100}}{\text{Weight of sample taken}}$$

**2. Crude fiber**

The sample was treated with acid and acrylic to remove proteins and carbohydrates other than cellulose crude fiber or cellulose matter determined by trying to constant weight, weighing then ashing and then again weighing. The difference termed as crude fiber content expressed in percentage**.** (Ranganna, 1986).

**3. Ash content**

Ash content was done by the use of muffle furnace 2 gm. of dried sample was ignited is muffle furnace for 4-6 hrs. At 550 $^0$C. Total ash can be expressed as percentage. The ash was calculated using following formula. (Ranganna, 1986).

$$\text{\% Ash} = \frac{\text{Weight of crucible after ashing-Weight of empty crucible X 100}}{\text{Weight of sample}}$$

**4. Determination of Fat content**

The fat content of the sample was determined by the procedure as described in AOAC (1990) [8].

**Procedure**

5g of sample was weighed accurately, placed in thimble and plugged with cotton. The extractor-containing thimble was placed over a pre-weighted extraction flask (A). Fat content was determined by extracting the sample with solvent petroleum ether 60-80 $^0$C for 8 hr using Soxhlet extraction procedure. After extraction the excess of solvent was distilled off and the residual solvent was removed by heating at 80 $^0$C in oven for 4-6 hr. The fat content was determined as below.

$$Fat\ content\ (\%) = \frac{W2 - W1}{W} \times 100$$

Where,

$W_2$ = Final weight of flask + fat

$W_1$ = Initial weight of round flask

W = Weight of sample

**Determination of Fat Content**

About 2 g of sample was weighted accurately and transferred to a Micro-Kjeldahl flask. Then 4 grams of $CuSO_4$ and 10 g of $Na_2SO_4$ was added to the flask. 25 ml of concentrated $H_2SO_4$was added. The flask is heated gently in an inclined position till the light blue colour solution was obtained. Then the flask was heated on a high flame for three hours. Then the digestion mixture was cooled at the room temperature. The digest was wash into the distillation flask with distilled water. The distillation assembly was arranged to the receiving flask and 50 ml of 0.01N HCl with 2-4 drops of methyl red indicator was added. The distillation apparatus was connected with a delivery tube dipping in an HCl solution. Zn metal pieces are added to the distillation flask which was carefully added to the digestion mixture. It was rinse with water. Around 50-60 ml of 50% NaOH was added to it. Sufficient water was added to the flask. The $H_2O$ was started through the condenser. The solution was heated and it liberates $NH_3$. The liberated $NH_3$ was distilled into HCl solution. The heating was continuing was thrice, the initial volume of HCl in the receiving flask. The tap was open and washes down the condenser and the delivery tube into the receiver. The burner was put off. The distillate with 0.1N NaOH is titrated and slight pink colour was obtained. Conduct with blank determination.

## 2.4 Preparation of foxtail Millet Flour

Firstly good quality of foxtail millet was taken than it was clean to remove impurities present in it. After that sorting should be done and then milling is done through which we get flour and then sieving was carried out by using 30 mesh sieves and then stored in air tight container.

## 2.5 Composite flour preparation

The blend of flour were prepared first by mixing foxtail millet, rice and maize and calculated amount of water and flour was allowed to equilibrate for 15 min. First of all five trial run experiments were conducted to fix the feed combination of raw material as shown in Table 1. Here foxtail millet was fixed to (0-10) % as more fortification of it may injurious to the baby's health and maize was varied from (40-50) % and rice from (40-50) %. For these trial experiments we had kept barrel temperature fixed at 1100C, screw speed at 350 rpm, feed moisture content at 10% (wb), feeding screw at 24 rpm, cutting knife speed at 26 rpm. The samples were put in buckets and stored at 4 °C overnight. The feed material was then allowed to stay for 3 h to equilibrate at room temperature prior to extrusion. This pre-conditioning procedure was employed to ensure uniform mixing and proper hydration and to minimize variability in the state of feed material. The moisture content of samples was determined by hot air oven method (AOAC, 2005) [7] Table 1 Feed compositions used in trial runs.

**Table 1:** Feed compositions used in trial runs

| S. No. | Sample Code | Rice and Maize (flour %) | Foxtail millet Flour (%) | Temperature ($^0$C) | Screw speed (rpm) |
|---|---|---|---|---|---|
| 1 | $T_0$ | 50:50 | 0 | | |
| 2 | $T_1$ | 47.50 : 47.50 | 5 | | |
| 3 | $T_2$ | 45 : 45 | 10 | 110 | 350 |
| 4 | $T_3$ | 42.5 : 42.5 | 15 | | |
| 5 | $T_4$ | 40 : 40 | 20 | | |

## 2.4 Process flow chart of extruded product

Raw materials
(Maize flour, foxtail millet flour, rice flour)
↓
Composite flour preparation
(Blending of flours in appropriate proportions)
↓
Pre-conditioning (moisture adjusted to 10% wb)
↓
Extrusion cooking
(Barrel temp 90-110 $^0$C, twin screw speed 320-350 rpm)
↓
Drying of extruded (50 $^o$C for 2 hr)
↓
Oil spraying and spicing
↓
Packaging in LDPE bags
↓
Storage at Ambient temperature

**Fig:** Flow chart for development of extruded product

## 2.6 Foxtail Millet Based Extruded Product

The raw materials foxtail millet flour and maize flour, rice flour was procured from the local market. Foxtail millet flour and maize, rice flour was used for the formation of the basic blend for the extruded. The mixture was sieved twice to ensure removal of any gritty material or any foreign particle, if present, and also for proper mixing of the all the ingredients. Predetermined quantity of distilled water was added. The blend was then mixed to distribute the water throughout the mass. It was again sieved twice to break down the lumps formed due to water addition. The product development was made by mixing of foxtail millet flour. The ratios were taken for the development and quality evaluation of foxtail millet extruded product. The foxtail millet flour in different ratio, were taken for the development of extruded product, which are mentioned as follow $T_o$ (50:50), $T_1$ (95:05), $T_2$ (90:10), $T_3$ (85:15), $T_4$ (80:20).

## 2.7 Physical analysis

### 2.7.1 Expansion ratio

After the study it was seen that the expansion ratio of an extruded samples.

$$\text{Expansion ratio} = \frac{\text{Diameter of extruded product}}{\text{Diameter of die hole}} \times 100$$

### 2.7.2 Bulk density
After the study it was seen that the bulk density of an extruded samples.

$$\text{Bulk density \%} = \frac{4\text{m}}{\pi d^2 \text{l}} \times 100$$

### 2.7.3 Texture Profile Analysis (TPA)
Textural Analyzer (TA.XT Plus/TA.HD Plus) was used for measuring textural properties of extruded product. The experiments were carried out by different tests that generated a plot of force (kg) vs. time (s), from which texture values for the extruded product were obtained. Three replications of each combination were taken for analysis. During the testing, the samples were held manually against the base plate and the different tests were applied according to TA settings. The textural properties such as hardness, factorability, stickiness and work of shear were measured by using different tests viz. penetration test and bending test (Stable Micro Systems). A 2 mm cylindrical probe was used for the measurement of hardness of the extruded and three-point bend ring was used for bending test.

### 2.7.4 Sensory Evaluation
The Sensory characteristics of the product such as general appearance, colour, taste, and flavour were evaluated by panel of judges using nine point hedonic scale as per IS: 6273 (PART-II), 1971.

## 3. Results and Discussion
### 3.1 Chemical characteristics
The chemical properties of a developed extruded product such as moisture, ash, protein, fat, crude fiber, carbohydrate, calorific value were determined. The average values of chemical properties of foxtail millet based extruded product for all treatments are given in Table 1.

**Table:** Chemical properties of Foxtail mille based extruded product

| S. No | Combination | Moisture (%) | Ash (%) | Protein (%) | Fat (%) | Fiber (%) | Carbohydrate (%) | Calorific Value(kcl) |
|---|---|---|---|---|---|---|---|---|
| 1 | $T_0$ | 3.62 | 0.55 | 5.31 | 0.82 | 1.32 | 88.27 | 382.69 |
| 2 | $T_1$ | 3.81 | 0.68 | 5.80 | 1.02 | 1.57 | 87.08 | 381.06 |
| 3 | $T_2$ | 4.08 | 0.93 | 6.15 | 1.02 | 1.74 | 85.89 | 379.05 |
| 4 | $T_3$ | 4.37 | 1.23 | 6.63 | 1.10 | 1.95 | 84.48 | 376.5 |
| 5 | $T_4$ | 4.79 | 1.42 | 7.02 | 1.17 | 2.35 | 82.86 | 373.56 |

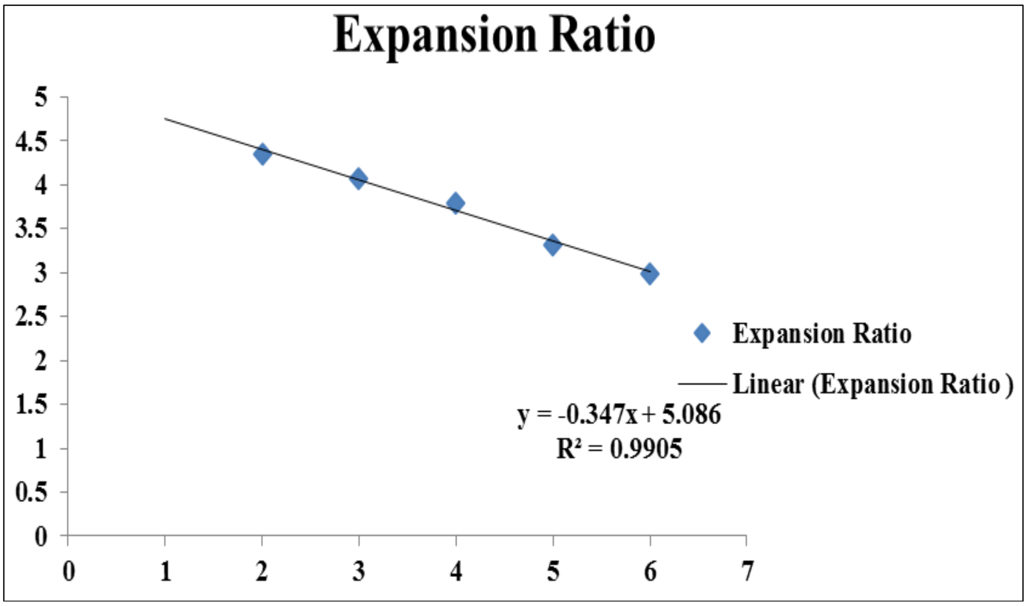
After the analytical study The nutritional composition of extruded product manufactured by twin screw extruder raw materials grains which was include foxtail millet flour, maize flour, rice flour The moisture percentage with different extrusion treatments was found to be in the range of 3.62 to 4.79%. After the study it was seen that the presence of moisture in sample $T_4$ was higher than the sample $T_0$ $T_1$, $T_2$ and $T_3$. The moisture of extruded product samples increased with increasing the level of Foxtail Millet. The ash percentage with different extrusion treatments was found to be in the range of 0.55 to 1.42%. The maximum ash was found in $T_4$ (1.42) whereas minimum in $T_0$ (0.55). The Protein percentage with different extrusion treatments was found to be in the range of 5.31 to 7.02%. The maximum Protein was found in $T_4$ (7.02) whereas minimum in $T_0$ (5.31). The Fat percentage with different extrusion treatments was found to be in the range of 0.93 to 1.56%. The maximum fat was found in $T_4$ (1.56) whereas minimum in T0 (0.93). The fiber percentage with different extrusion treatments was found to be in the range of 1.32 to 2.35%. The maximum fiber was found in $T_4$ (2.35) whereas minimum in $T_0$ (1.32). Carbohydrate percentage with different extrusion treatments was found to be in the range of 82.86 to 88.27%. The maximum Carbohydrate was found in $T_0$ (88.27) whereas minimum in $T_4$ (82.86). The maximum calories content was found in $T_0$ (382.69kcal) whereas minimum in $T_4$ (373.56kcal). It was observed that

### 3.2 Physical Characteristics of product
The physical properties of a developed extruded product such as expansion ratio, bulk density, texture and hardness were determined. The average values of physical properties of Foxtail mille based extruded product for all treatments are given in Table 2.

**Table:** Physical properties of Foxtail mille based extruded product

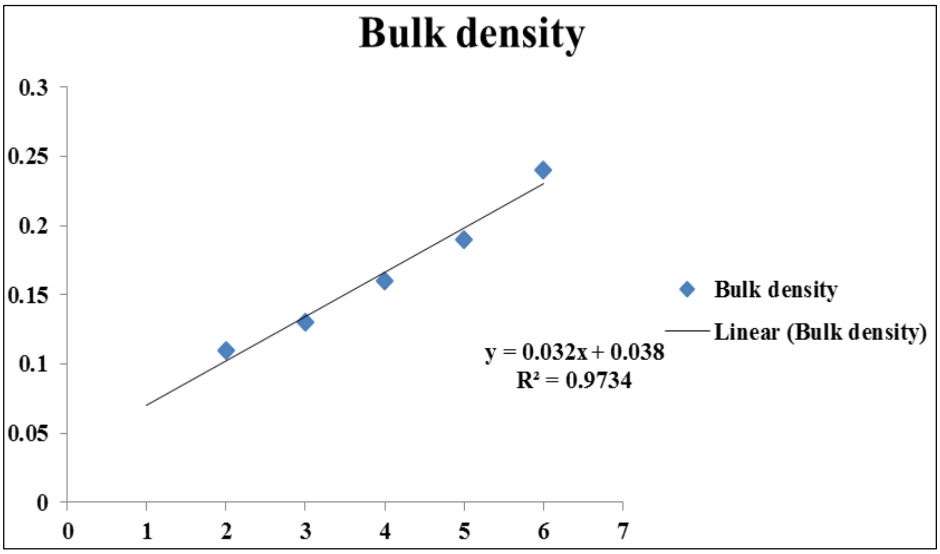
| S. No. | Treatments | Expansion ratio | Bulk density (g/cm$^3$) | Hardness (N) |
|---|---|---|---|---|
| 1 | $T_0$ | 4.34 | 0.14 | 7.84 |
| 2 | $T_1$ | 4.07 | 0.16 | 8.23 |
| 3 | $T_2$ | 3.78 | 0.16 | 10.46 |
| 4 | $T_3$ | 3.32 | 0.20 | 12.36 |
| 5 | $T_4$ | 2.98 | 0.26 | 14.81 |

### 3.3 Expansion ratio
After the study it was seen that the expansion ratio of an extruded samples. Fig. shows the decreasing pattern of expansion ratio with different extrusion treatments and Table shows the effect of different treatments on expansion ratio of extruded product. After the study it was seen that the expansion in sample $T_0$ was higher than the sample $T_1$, $T_2$, $T_3$ and $T_4$. The expansion of extruded product samples decreases with increasing the level of foxtail millet flour as shown in Fig. The maximum expansion was found in $T_0$ (4.34) whereas minimum in $T_4$ (2.98).




### 3.4 Bulk density

After the study it was seen that the bulk density of an extruded samples. Fig.4.10 shows the increasing pattern of bulk density with different extrusion treatments and Table 4.9 shows the effect of different treatments on bulk density of extruded product. After the study it was seen that the bulk density in sample T5 was higher than the sample$T_0$, $T_1$, $T_2$, $T_3$ and T4. The density of extruded product samples increases with increasing the level of kidney bean flour as shown in Fig. 4.10. The maximum density was found in $T_5$ (0.23) whereas minimum in $T_0$ (0.13).




### 3.2.3 Textural Properties of Extruded Product

The textural properties of extruded products are generally described by the hardness and crispness. The textural parameters studied were crispness, hardness and cutting strength and it was analyzed with help of textural analyzer (Yadav and Chandra, 2015) [18]. The hardness of an expanded extruded is a perception of the human being and is associated with the expansion and cell structure of the product.

## 4. Conclusion

The result of this dissertation concluded that the rice and maize and foxtail millet based extruded product was found optimum for the consumption by all age groups. The product is rich in protein content (7.02%) and fiber content (2.35%), hence it has a high nutritive value. This study can further be used for developing fiber rich snacks and ready to eat foods. As the fat content (1.42%) was low, thus it can be a good diet food also.

## 5. References

1. AACC. Approved Methods of American Association of Cereals Chemista. St. Paul, Minnesota, U.S.A, 1990.
2. Ainsworth P, Ibanoglu S, Plunkett A, Ozer EA. Physical and sensory evaluation of a nutritionally balanced gluten free extruded snack. Journal Food Engineering. 2006; 75(4):469-472.
3. American Association of Cereal Chemists. Approved Methods of the AACC. 10th Edition, Method, the Association St. Paul, MN, 2000, 44-15A.
4. Andi Sukainah, Abu Bakar Tawali, Salengke Amran Laga. The Effect of Fermentation on Adsorption Isotherm Corn Flour and Corn Crackers, International Journal of Scientific & Technology Research, 2013, 2(5).
5. Andi Sukainah, Abu Bakar Tawali, Salengke Amran Laga. The Effect of Fermentation on Adsorption Isotherm Corn Flour and Corn Crackers, International Journal of Scientific & Technology Research, 2013, 2(5).

6. AOAC. Official methods of analysis 16th Ed. Association of official analytical chemists. Washington DC, USA, 1995.
7. AOAC. Official method of Analysis. 18th Edition, Association of Officiating Analytical Chemists, Washington DC, Method 935.14 and 992.24, 2005.
8. AOAC. Method of analysis. Association of Official Analytical Chemical. Washington DC, 1990.
9. Chen CC, Shih1 YC, Chiou2 PWS, Yu B. Evaluating Nutritional Quality of Single Stage-and Two Stage-fermented Soybean Meal, 2010.
10. Gamlath Shirani a Ravindran Ganesh aranee Extruded products with Fenugreek (Trigonellfoenum-graecium) chickpea, and rice: Physical properties, sensory acceptability and glycaemic index, 2009.
11. Khalid Bashir, Dr. Vidhu Aeri, Lubna Masoodi. Physio - Chemical and Sensory Characteristics of Pasta Fortified With Chickpea Flour and Defatted Soy Flour, 2012.
12. Mary Omwamba, Symon Mahungu M. Development of a Protein-Rich Ready-to-Eat Extruded Snack from a Composite Blend of Rice, Sorghum and Soybean Flour, Food and Nutrition Sciences. 2014; 5:1309-1317.
13. Obatolu VA, Olusola OO, Adebowale EA. Qualities of extruded puffed snacks from maize/soybean mixture. Journal of Food Process Engineering. 2006; 29(2):149-161.
14. Qing-Bo Ding a, Paul Ainsworth a, Gregory Tucker b, Hayley Marson. The effect of extrusion conditions on the physico-chemical properties and sensory characteristics of rice-based expanded snacks, 2005.
15. Shivendra Singh, Shirani Gamlath, Lara Wakeling. Nutritional aspects of food extrusion: a review, 2006.
16. Wai-Bun Lui, Jinchya Peng. Physical, mechanical, biodegradable properties and energy absorption behavior of corn grit-polyvinyl alcohol cushioning extruded, 2004.
17. Yadav KC, Chandra R. Influence of green leafy vegetable incorporation and process variable on textural characteristics of extrudaten. Bioved. 2012; 26:95-105.
18. Yadav KC, Chandra R. Development of extrudate enriched with green leafy vegetable powder and its effect on nutritional characteristics. Bioved. 2015; 26:231-236.