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# Physico: Chemical and sensory properties of millet based ready to eat extruded snack

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**Abstract**
Food extrusion technology is a type of processing method which uses single screw or a set of screws to force food materials through a small orifice. When the food is forced, they get cooked due to high pressure, high shear and high temperature. The material gets puffed due to release of pressure and conversion of moisture to steam (Ainsworth, 2011). It reduces the microbial count and inactivates the enzymes. It is a multi-step, multi-function thermal or mechanical process which has permitted large number of food applications. Composite flour blended with finger millet, foxtail millet and peas was used to develop ready to eat extruded snack. The process was carried out using twin screw extruder at temperature (T1-60 $^{O}$C and T2- 100 $^{O}$C), feed moisture content (17.5%), feed composition consisted of finger millet: foxtail millet: peas: 36.70:36.80:26.30, constant screw speed 412 rpm, cutter speed 18 rpm and feeder speed 24 rpm. Finger millet flour was rich in calcium (280.33 g/100g) and polyphenols (94.50 GAE), foxtail millet had good amount of fiber (7.55 g/100g) and fat (4.6 g/100g) and peas was rich in protein (20.47g/100g) and ash (2.23 g/10g). It was observed that the final extruded product was rich in protein (15.72 g/100g), calcium (102.5 mg/100g) and carbohydrates (75.38 g/100g). The product had an acceptability index of 96.4%. The extruded product had good expansion ratio of 3.63, bulk density 0.06 g/cc, hardness 3.14 N, water absorption index 5.14 g/g, water solubility index 14.8% and true density 0.25 g/m$^3$.

**Keywords:** Extrusion, temperature, feed composition, feed moisture content, finger millet, foxtail millet, peas

## Introduction
Extrusion cooking is a process by which set of mixed ingredients are forced through an opening in a perforated die with a design specific to the food, and then cut into specific size by blades. For the development of composite millet based extruded RTE products three grains *viz*. finger millet, foxtail millet and peas were selected. Millets are small grains, grown in semiarid tropical regions and are climate resilient crops. They are rich in nutrients and have health beneficial phytochemicals. Nutritionally millets are similar or richer than cereals. They are gluten free, have low glycemic index, high in fiber and possess many bioactive compounds (Kannan *et al.* 2013) [8]. Dried peas are good source of protein and are utilized less for processing compared to bengal gram and green gram. Presently the extruded products available in the market are mainly produced by maize, rice and wheat. The consumers today demand for variety in food with better nutrition and health. Increasing obesity and other health complications due to consumption of refined foods is well documented. To combat these, millets which are gluten free, rich in macro and micronutrients, fiber could be the choice for development of health and functional foods. To balance the nutritional composition, and enrich the product with higher protein, millet and pulse combinations were considered for the development of RTE extruded product. Therefore, the objective of this study was to develop the extruded product rich in protein with good sensory and physical properties.

## Materials and Methods
The raw materials like finger millet (DHFM-78-3) and foxtail millet (DHFT-109-3) was procured from UAS, Dharwad and yellow peas (IPF-5-19) were procured from IIPR- Kanpur, U.P. The seasoning and oil was procured from local market Dharwad.

**Preparation of composite flour**

Response surface methodology was used to choose flour combinations with high amylopectin and protein of the several combinations of finger millet, foxtail millet and peas in the ratio of 36.70:36.80:26.30, resulted in high amylopectin and high protein hence this flour combination was selected. The flour blend was conditioned with known amount of water and refrigerated fpr 1 h. The composite feed was then allowed to stay for 30 min to equilibrate at room temperature prior to extrusion.

**Extrusion process**

The experiment was performed using a co- rotating twin – screw extruder (Basic Technology Pvt. Ltd. Kolkata, India). The barrel temperature was maintained at T1- 60 $^{O}$C and T2 – 100 $^{O}$C, screw speed at 412 rpm, die 3 mm cutter speed 18 rpm and feeder speed at 24 rpm. Extrudates were cut with sharp knife, at the exit of the die and left to cool at room temperature for about 20 min.

**Quality evaluation of millet based composite RTE extruded snacks**

The extruded snacks were analyzed for physical attributes *viz*. bulk density, expansion ratio, hardness, WAI, WSI and true density, proximate composition and sensory characteristics.

**Bulk density**

The bulk density (g/ml) of extruded products was measured by using 100 ml graduate cylinder by rapeseed oil displacement. The volume of 20 g randomize sample was measured for each test. The ratio of sample weight and the replaced volume in cylinder was calculated as density (Patil *et al*. 2007) [10].

$$\text{Bulk density} = \frac{\text{weight of extrudate}}{\text{Volume of extrudate}}$$

**Expansion ratio**

The expansion ratio was determined by the method as described by Harper (1981) [7]. The cross-sectional diameter of extrudates was determined using vernier caliper. The expansion ratio was calculated as the ratio of diameter of extrudates to that of die. Expansion ratio is De/Dd; where, De is cross sectional diameter of extrudates and Dd is diameter of die.

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

**Hardness test of extruded products**

Hardness was determined by texture analyzer (Stable micro system –TA-XT Plus). The maximum force to compress was measured. During compression of the product, the number of peaks or total length of the Force- Deformation (Time) curve was noted which gave the measurement of hardness. For extruded product the textural characteristics in terms of hardness was determined in a single compression test.

**Water -Absorption index and water solubility index**

The WSI and WAI was measured using a technique developed for cereals' (Anderson *et al.*, 1969).

$$\text{Water solubility index (g/g)} = \frac{\text{weight of solids in supernatant (g)}}{\text{Weight of dry solids (g)}}$$

$$\text{Water absorption index} = \frac{\text{weight of wet sediments (g)} \times 100}{\text{Weight of dry solids (g)}}$$

**True density**

True density of small millet based extruded products was determined as per the method suggested by Deshpande and Poshadri, (2011) [3]. A known weight (1 g) of extrudate was ground and the ground sample was poured into a burette containing toluene. The raise in volume in the burette was noted as the true volume of the sample. True density was calculated as follows:

True density = mass / true volume

**Proximate composition**

The proximate composition of protein, fat, crude fiber ash and carbohydrates of extruded RTE product was determined as per AOAC, 2005 procedures.

**Calcium – was determined by titrimetric method**

Calcium was precipitated as oxalate and was titrated with standard potassium permagnate (AOAC, 2005).

**Polyphenols:** Spectrophotometric method (Singleton and Rossi., 1965) [13]. Phenols react with phosphomolybidic acid in Folin-Ciocalteau reagent in alkaline medium and produced blue colored complex (molybdenum blue).

**Results and Discussion**

**Nutritional composition of flours**

The raw material finger millet, foxtail millet and peas were cleaned, milled and analyzed for proximate composition. The results indicated that the flour contained high moisture (14.02%) and protein (20.47 g/100g), where as foxtail millet had high fat (4.6 g/100g) and crude fiber (7.55 g/100g) and finger millet had high carbohydrates (71.61 g/100g), calcium (280.33 mg/100g) and polyphenols (94.5 GAE).(Table.1)

**Physical properties of extruded products**

The flour in the proportion of finger millet, foxtail millet and peas: 36.70:36.80:26.30, was blended and extruded to obtain millet based ready to eat extruded snack at the optimized conditions. The products were analyzed for the physical parameters expansion ratio, bulk density, expansion ratio, hardness, WAI, WSI and true density. The average values of physical properties of millet based extruded product are depicted in Table 2. It was observed that the expansion ratio and bulk density of extruded product was 3.63 and 0.06 g/cc, this may be due to high in temperature, low feed rate and lower moisture content, gelatinization process might have produced more expansion (Giri and Bandyopadhyay, 2000) [6]. The hardness of the extruded product was 3.14 N this may be due to extrusion process, the elastic swell effect and bubble growth effect which contributed to the change in structure of starch and thus texture and hardness change (Padmanabhan and Bhattachayrya 1989) [9]. The WAI and WSI was found to be 5.14 g/g and 14.8% and true density of 0.25g/m$^3$. Water absorption index is used to determine the extent of starch damage during extrusion cooking whereas, water solubility index gives a measure of gelatinization of starch in the extruded product. The extruded product developed from rice showed 0.02 g/cc bulk density, 5.34 expansion ratio, 38.07 g/g WAI, 1.88 WSI and 3.29 N hardness (Ding *et al.* 2005) [4]. Whereas extruded product developed from corn flour showed 0.28 g/cc bulk density, 4.10 g/g WAI, 39.9% WSI (Saini,

2015) [11]. The results showed that extruded product developed from millets has physical parameters are similar to the extrudates developed from rice and corn.

**Table 1:** Physical properties of extruded products

| Sl. No. | Physical parameters | Extruded |
|---|---|---|
| 1 | Expansion ratio | 3.63 |
| 2 | Bulk density (g/cc) | 0.06 |
| 3 | Hardness (kg) | 3.14 |
| 4 | WAI (g/g) | 5.14 |
| 5 | WSI (%) | 14.8 |
| 6 | True density (g/m$^3$) | 0.25 |

**Nutritional composition of millet based composite RTE extruded product**

The extrudate with and without seasoning was analyzed for nutritional components. RTE snack without seasoning had a moisture content 5.53, protein 15.72, fat 0.85, fiber 0.27, ash 2.33 and carbohydrates 75.38 g/100g (Table 2). The seasoned extrudate had moisture content 6.13, protein 15.81, fat 9.34, crude fiber 0.42, ash 3.53 and carbohydrates content 64.84 g/100g. It was observed that the fat content was higher in seasoned extruded product due to use of seasoning and use of ground nut oil. The extrudates developed from corn showed 12.26% protein, 66.01% carbohydrates, 1.28% fat, 10.58% crude fiber and 2.34% ash (Shruthi *et al*. 2016) [12]. Whereas the extruded product developed from rice refined wheat flour incorporating tomato powder showed 22.9% protein, 66.13% carbohydrates, 1% fat and 2.34% ash (Srivalli *et al.* 2016) [14]. The results showed that extruded product developed from millets has varying nutritional composition which is dependent on the ingredients used.

**Table 2:** Nutritional composition of millet based composite RTE extruded product

| Sl. No. | Parameters | Extruded | Seasoned |
|---|---|---|---|
| 1 | Moisture (%) | 5.53±0.25 | 6.13±01.18 |
| 2 | Protein (%) | 15.72±0.14 | 15.81±0.44 |
| 3 | Fat (%) | 0.85±0.17 | 9.34±0.16 |
| 4 | Crude fiber (%) | 0.27±0.04 | 0.42±00 |
| 5 | Ash (%) | 2.33±0.13 | 3.53±0.15 |
| 6 | Carbohydrates (%) | 75.38±0.6 | 64.84±0.32 |
| 7 | Calcium(mg) | 102.5±3.54 | 101.26±4.96 |

Values are mean ±SD of three replications

**Sensory analysis**

Sensory evaluation of millet based composite RTE extrudate product was carried out on the basis of appearance, colour, flavour, texture, taste and overall acceptability on a nine point hedonic scale. The quality was judged by the panel team consisting of 10 members. The overall acceptability index was 88.8. The average characteristics of extruded product for each characteristic are given in Table. 3, Thus indicating a high acceptability. The extruded product developed from foxtail millet showed overall acceptability of 9.

**Table 3:** Sensory analysis of extruded snack

| Sl. No. | Parameters | Extruded |
|---|---|---|
| 1 | Appearance | 8.0 |
| 2 | Colour | 8.0 |
| 3 | Texture | 7.60 |
| 4 | Flavour | 8.30 |
| 5 | Taste | 8.30 |
| 6 | Overall acceptability | 7.85 |
| 7 | Overall Acceptability index | 88.8 |

**Conclusion**

The results of the study revealed that millet flours with peas has a great potential to be used in food industry either for the purpose of formulating new products or for the replacement in food products made from various conventional flour sources. There is also tremendous opportunity to develop functional food from millets.

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