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Studies on development of technology for preparation of millet based extruded snack

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Abstract
In the modern-day world people are preferring more ready to eat extruded snack rather than normal traditional snacks. Most marketable snacks are made of cereal yet, cereal-which is a decent source of carbs but weak in protein and other elements like iron-is the main ingredient in most commercially available snacks. To provide balanced nutrients like protein and minerals, it is therefore necessary to change the raw materials used to produce snacks. By using millets this problem can be solved since millets have least far and rich in protein. So, an effort was made to develop a millet-based snack using millets such as Sorghum, oats and green gram in different combinations and the properties of these millets have been studied respectively.

Keywords: Millets, extruded snack, ready-to-eat, sorghum, oats, green gram

1. Introduction

The desire for convenience foods, such as ready-to-eat extruded snacks, ready-to-cook foods, processed and semi-processed foods, is currently on the rise due to peoples' busy schedules and changing lifestyles. Snacks market size in India is worth Rs. 44,000 crores with snacks contributing 80% of snacks products or snacks brands sold is from India's top 10 snacks companies. Industry sources claimed that snacks have 50% more shelf life compared to other snacks since snacks are packaged and sealed well. Because of the taste, flavour, convenience, and low cost of snack foods, kids tend to consume more of them. However, most marketable snacks are made of cereal, which is a good source of carbohydrates but lacking in protein and essential nutrients like iron. Therefore, altering the raw materials used to prepare snacks is required to give balanced nutrients like protein and minerals. Today's focus is on making inexpensive snacks that combine cereals and pulses to provide a balance of nutrients, such as amino acids, which can help battle malnutrition and satisfy nutritional security to make up for the nutritional shortage in snack meals.

One of the most significant cereal grains is millets. More than one-third of people on the planet eat millets. It is the sixth-largest cereal crop in the world production of agriculture. Jowar (sorghum), Sama (little millet), Ragi (finger millet), Korra (foxtail millet) and Variga are millet varieties (Proso millet). Ragi has the least amount of fat, while Bajra and Sama are both heavy in fat. In rural places, millets are frequently consumed as food. Millets have been farmed for a thousand years and are used all over the world; throughout the middle ages, the Romans and Gaul's preferred eating millets to wheat in their porridge. Most people in the world China, India, Greece, and other nations cultivate commercial millet crops. Africa and Egypt. But some millets are consumed even in rural areas such as finger millet, sorghum, etc., for consumption and the remainder is fed to animals. Millet has incredible values in terms of nutrition. Millets have a big part to play.in many regions' traditional meals. In various Indian states they are each employing a different variety of millets. All of Millets have three to five times more nutritional value. When compared to the nutritional value of rice and other commonly consumed wheat. While millets offer various security benefits, such as food, health, nutrition, livelihood, animal feed, etc., compared to wheat and rice, millets are a source of agricultural security. Millets provide nutritional and physiological benefits, and they aid in the management of conditions including diabetes mellitus, hyperlipidemia, and others (Veena, 2003) [32]. Karnataka is the state that produces the most millets in India. Millets account for more than 58% of global output, but very few Indians are aware of its nutritional worth and health advantages.

Millets do not require pesticides, according to traditional growing techniques and the land used for growing millets is totally pest free. Millets like foxtail millet are pest free and act as anti-pest agents in storage conditions for pulses like green gram. The millets do not need any fumigants. Millets have relatively a lower position in India, among feed crops in agriculture, but they are very important from food security point at regional and farm level, (Stanley Joseph, *et al*., 2013) [30].

Millets can grow in drought conditions and can withstand higher heat regimes. Millets can grow even in non- available Millets can face the low water conditions and can grow. (Millet Network of India, MINI) Considering the nutritional parameters, millets are way ahead of wheat and rice. In terms of mineral content, millets have more fiber when compared to rice and wheat. Each one of the millets has more fiber than rice and wheat. Some millets have more than fifty times of fiber than of rice. Finger millet is having thirty times more Calcium than rice while all other millets have at least double amount of Calcium compared to rice (Amir Gull, *et al*., 2014) [26].

Sorghum and millets crops are called Nutri-cereals or Smart Food because they fulfill the criteria of being good for individuals (nutrition and health), for the planet (environments) and for the farmer (nutrition, health, and income). Smart Food is a global initiative that aims at diversifying staples (Seetha *et al*., 2019) [53]. The focus on nutri-cereals can lead to major climate nutri smart impacts with respect to alleviating malnutrition and ensuring better on farm diversity. India is producing 42.9 million tons of nutri-cereals from an area of 4.81 million hectares (Directorate of Economics and Statistics of India 2019). The average carbohydrate content of millets and sorghum varies from 56.88 to 72.97 g/100 g, protein content from 7.5 to 12.5% and lipid content ranges between 1.3 and 6 g/100 g. They are also rich source crude fiber as well as dietary fiber and rich in vitamins and minerals (Poshadri *et al*., 2020) [46] Sorghum ranks 5th most important cereal in the world after rice, wheat, maize and barley amongst the top important cereal crops in the world with its origin believed to be from Africa, Indian Ocean, Australia, and the Pacific Ocean (FAO/WHO, 2007).

Sorghum (*Sorghum bicolor* (L.) Moench is a gluten free cereal and is rich in dietary fiber, minerals and phenolic compounds (Dlamini *et al*., 2016). Its cultivation, demand and use have, however, been declining over time since there are no alternative uses. Sorghum grain is mainly consumed by households as a jowar roti or coarse porridge in rural India. In recent years the demand for sorghum grits has grown in the beer production industry as adjuncts (Olu Malomo *et al*., 2012) [35]. A variety of ready-to-eat value added snacks have been mainly prepared from wheat, corn, and rice. Use of sorghum in snacks is one area that has not been adequately explored given that it is generally easier for most people to consume snack foods rather than other types of complementary foods.

A traditional crop in both India and Africa, sorghum is one of the oldest varieties of cereal grain. For those who are gluten intolerant or have celiac disease, it is regarded as a safe grain substitute. Molecular proof demonstrates that sorghum grain is completely free of gluten and offers health advantages that make it a beneficial addition to any diet. When grains like wheat, barley and rye are baked into breads or pastas, a protein called gluten, which is frequently present in these grains, gives the finished product a chewy, springy texture. Sorghum is substituted for wheat in breads and pastas. It is also showed that Sorghum or jowar helps in weight loss. Compared to major cereals like rice and wheat, jowar has a high proportion of calcium. It is also packed with iron, protein and fiber. Researchers have found that a typical sorghum wax is rich in policosanols which helps in reducing the levels of cholesterol. Being a gluten-free grain, it is also much preferred by those who can't tolerate wheat- based products (O.S.K. Reddy, 2017) [50].

Cereal grains feed a large population around the world. They constitute a significant part of daily diet of the consumers. Wheat, rice and maize are the leading grains in terms of consumption (Bushuk 2001) [12]. These grains are consumed as whole or in fractionated forms. Oat remains an important cereal crop in the developing world and the most popularly cultivated species is *Avena sativa* L. and is trivially known as common covered white oat (White 1995). Oat requires lesser nutrients (N-Sodium, P-Phosphorus and K-Potassium) to cultivate than that required for wheat or maize. Since oat requires more moisture to produce a given unit of dry matter than all other cereals except rice, it grows well in cool and moist climate (Forsberg and Reeves 1995) [24]. Oat is predominantly grown in American and European countries, mainly Russia, Canada and United States of America. It is used mostly for animal feeding and to some extent as human food. The use of oat as animal feed has declined steadily owing to emerging use and interest in oats as human health food (Ahmad *et al*. 2010) [4].

Whole grain oat contains considerable amount of valuable nutrients such as proteins, starch, unsaturated fatty acids and dietary fiber as soluble and insoluble fractions. Oat also contains micronutrients such as vitamin E, folates, zinc, iron, selenium, copper, manganese, carotenoids, betaine, choline, Sulphur containing amino acids, phytic acid, lignins, lignane and alkyl resorcinol (Flander *et al*. 2007) [23].

Starch constitutes about 60% of oat grain. It is mainly a constituent of endosperm. There is considerable difference observed between the physicochemical properties of oat starch and other cereal starches. Differences in physicochemical properties are also observed in different cultivars of oat. These differences are probably due to differences in the magnitude of interaction between and among starch chains within the amorphous and crystalline regions of the native granules and by the chain length of amylose and amylopectin fractions of oat starch. Oat starch offers untypical properties such as small size of granules, well developed granule surface and high lipid content (Berski *et al.* 2011) [6].

Oat is considered to be a potential source of low cost protein with good nutritional value. Oat has a unique protein composition along with high protein content of 11-15%. Cereal proteins have been classified into four types according to their solubility as follows: albumins (water soluble), globulins (salt water soluble), prolamins (soluble in dilute alcohol solution) and glutelins (soluble in acids or bases). Oat protein not only differs in the structural properties but also differs in distribution of protein fraction in comparison to other cereal grains. Other cereals such as wheat and barley have characteristic protein matrix which lacks in oat. In wheat and some other cereals, the storage protein is insoluble in salt solutions, while in oats, a large portion of salt water soluble globulins also belong to the storage proteins of the endosperm (Klose *et al.* 2009) [14].

Oat is a good source of lipids. It contains much higher levels of lipids than other cereals which are excellent sources of energy and unsaturated fatty acids. The majority of lipids of oats are in the endosperm. The fat content of oat ranges from 5.0 to

9.0% of the total lipid content. The lipid content in an intact kernel of oat stored for 1 year at room temp was found to be stable (Keying *et al*. 2009), due to the protection from endogenous antioxidants such as tocopherols, L-ascorbic acid, thiols, phenolic amino acids and other phenolic compounds.

Oat has been widely shown to provide a vast range of human health benefits such as reduced symptoms of diabetes (Tapola *et al*. 2005) [29] and obesity (Zduńczyk *et al*. 2006) [34]. The primary component of oat responsible for these health benefits is β-glucan, however phenolic compounds of oat and other antioxidant compounds also provide health benefits. Oats possess antioxidant capacity mainly due to presence of tocopherols, tocotrienols, phytic acid, flavonoids and non-flavonoid phenolic compounds such as AVAs.

Pulses hold an important place in human nutrition on account of their rich nutritional contribution to diets, particularly for proteins, essential minerals and vitamins, and dietary fiber. They also form a staple part of diets along with cereals as an essential accompaniment. They are of significance in South East Asian dietaries where people are vegetarians or do not have an access to animal sources of proteins due to economic reasons (Egounlety and Aworh 2003) [19].

Pulses are one of the important groups of crops that plays a vital role in addressing the nutritional security all around the world. Pulses are cultivating throughout the world, and almost half of its production occurs in Asia especially in India. India is the largest producer of pulses and cultivated over 29 million hectares of area and recorded the highest ever production of 25.23Mt during 2017-2018. In the case of mung bean, more than 3Mt of green gram is produced in the world annually (FAOSTAT 2016). India contributes to the major share of mung bean in the world market with a production of 1.9Mt in which Rajasthan with 42% area and 39% production outshined in the total mung bean production in the country. (Ministry of Agriculture and Farmers Welfare, India 2018) which is followed by China (0.98Mt), Myanmar (0.400 Mt), Indonesia (0.300 Mt), Thailand (0.210 Mt) and Pakistan (0.199Mt). China is the largest exporter (Misiak *et al.* 2017) [37], and India is the largest importer of mung beans.

Mung bean (*Vigna radiata* L. Wilczek) popularly known as green gram, believed to be native crop of India. According to the source Ministry of agriculture financial year 2019-20 the leading producer of green gram holding the share of 24.63% followed by, Rajasthan (23.99), Maharashtra (20.21), Uttar Pradesh (7.69).

It is a tiny green bean with a circular shape that is widely cultivated throughout Asia, including South China, Bangladesh, India, Pakistan, Sri Lanka, Thailand, Cambodia, and Vietnam. This short-lived legume can flourish in a variety of environments and later spreads to the USA, Australia, and Africa. Mung beans are a high-quality protein source that can be consumed whole, in dhal, or sprouted form. They are a great addition to rice for a well-balanced diet.

Green gram can be a rich source of protein with higher digestibility and can serve to convalescing babies or malnutrition people. The nutrients are not distributed uniformly in major components such as seed coat, cotyledon and embryo of the mung bean seed. The protein and lipids are found to be high in embryo, whereas the starch and crude fiber are concentrated in cotyledons and seed coats, respectively. The average moisture content present in the whole mung bean seed is 10.6g/100 g of whole green gram with high protein (22.9g), fat (1.2g), total carbohydrate (61.8g), crude fiber (4.4g) and ash (3.5 g) per 100 g of sample (Adsule *et al.* 1986) [1].

As generation changes, changing in lifestyle and limited free time has brought a lot of behavioral changes toward foods. Now a day's consumers do choice for convenient ready to eat and ready to cook food with nutritionally rich and therapeutic benefits. Thus to fulfill the demand of consumer, extrusion technology is used. Extrusion technology has become an important technique in food processing industries as it one of the cost-effective method. Extrusion processing is defined as the process by which moistened, starchy and proteinaceous food materials are plasticized through a die by a combination of moisture, pressure, heat and mechanical shear (Maurya and Said, 2014) [11].

The extrusion process is an effective continuous process in which few unit operations like mixing, shearing, heating, pumping, forming and sizing combines uniquely to from the products (Agarwal and Chauhan, 2019) [2].

Extruders were developed in the 1870s to produce sausage. Single-screw extruder was evolved during the 1930s and was used to mix semolina flour and water to make pasta products. It was also used in the process of making ready-to eat (RTE) cereals to shape hot, precooked dough. In both of these applications, the level of shear rate was low. During the late 1930s and 1940s, directly expanded corn curls were produce using extruders, which were characterized by extremely high shear rates. The first patent on an application of twin-screw extrusion technology was filed in the mid1950s. Since then the application of extrusion technology in food processing has advanced, widened and grown dramatically (Rao and thejaswini, 2015) [48]

The principles of operation in extrusion include raw materials are fed into the extruder barrel and the screw(s) then convey the food along it. Further down the barrel, smaller flights restrict the volume and increase the resistance to movement of the food. As a result, it fills the barrel and the spaces between the screw flights and becomes compressed. As it moves further along the barrel, the screw kneads the material into a semi-solid, plasticized mass. If the food is heated above 100 ºC the process is known as extrusion cooking (or hot extrusion). Here, frictional heat and any additional heating that is used cause the temperature to rise rapidly. The food is then passed to the section of the barrel where pressure and shearing is further increased due to smaller flight. Finally, it is forced through one or more restricted openings (dies) at the discharge end of the barrel as the food emerges under pressure from the die, it expands to the final shape and cools rapidly as moisture is flashed off as steam. A variety of shapes, including tubes, rods, spheres, strips, doughnuts, squirls or shells can be formed. Typical products include a wide variety of low density, expanded snack foods and ready-to-eat (RTE) puffed cereals. Cold extrusion, in which food temperature remains at ambient is used to mix and shape foods such as pasta and meat products. Low pressure extrusion, at temperatures below 100 ºC, is used to produce, for example fish pastes, surimi, liquorice and pet foods (Bordoloi and Ganguly, 2014) [11].

Extrusion brings gelatinization of starch, denaturation of proteins, reduces lipid oxidation and anti-nutritional factors. In addition, it is considered a versatile, low cost and very efficient technology in the food processing (Pansawat *et al*., 2008) [42], to produced wide range of nutritionally rich value-added product. It is one of the contemporary food processing technologies applied for development of variety of snacks, textured and supplementary foods. Extruded products have less moisture content, longer shelf life, nutritionally rich and are microbiologically safe (Pathak and Kochhar, 2018) [44].

Extrusion is a high-temperature short-time process where a set of blended moist ingredients is enforced through a small opening in a die with a design specific to the food. Hot extrusion would be carried out by heating the product above 100 °C and in cold extrusion at ambient condition. It produces high-quality texturized products by modifying our functionality and improves the digestibility and sensory characteristics (Patil and Kaur 2018) [22].

The extrusion study was carried out by blending green gram and rice by Chakraborty and Banerjee (2009) [7]. The expansion ratio of extruded product is decreased by an increase in moisture content; it shows that temperature and moisture content have a significant effect on product expansion ratio. The dough viscosity is decreased by an increase in the speed of screw which results in low-power consumption. Morphological characteristics showed gelatinization of starch and denaturation of protein by forming elongated and parallel air cells in extruded products.

The hardness of cereals increased with moisture content for each extrusion temperature. In general, the hardness of extruded cereal exhibited an inverse relationship with extrudate expansion, as observed in several studies on extruded products where hardness was represented by instrumentally measured mechanical properties such as compression modulus and crushing stress. Hardness is greatly affected by the expansion of the extrudates. Aguilar Palazuelos *et al*., (2006) [2].

Extruder is equipment which is used for extrusion processing. Food extruders may be designed to perform several unit operations concurrently, including mixing or homogenization, shearing, starch gelatinization, protein denaturation, texturization, enzyme inactivation, thermal cooking, pasteurization, dehydration, shaping and size reduction (Akhtar *et al*., 2015) [3].

Extruders are composed of five main parts:

1. The pre-conditioning system.
2. The feeding system.
3. The screw or worm.
4. The barrel.
5. The die and the cutting mechanism.

They can vary with respect to screw, barrel and die configuration. The selection of each of these items will depend on the raw material used and the final product desired (Riaz, 2000) [23].

1.2 Research objectives

1. To study the Physio-chemical properties of oats, green gram and sorghum
2. To study the standardization and formulation of extruded snack.
3. To study the physicochemical and sensory characteristics of extruded snack.
4. To study the Techno-Economic Feasibility of millet-based extruded snack.

2. Review of literature

2.1 To study Physiochemical properties of oats, green gram, and sorghum

2.1.1 Sorghum

Becker and Hanners (1991) [9] has studied that sorghum contains 60-80% starch on a dry weight basis Sorghum starch was reported to be modified by germination and fermentation (Marengo *et al.* 2015; Elkhalifa and Benhardt 2013; Elkhalifa *et al.* 2004) [36, 20, 21], but the effect of a combination of the two treatments on technologically relevant properties of sorghum flour has never been assessed.

Gopalan *et al*., (1996) [25] has tested nutrients content of sorghum are limited to major entities like carbohydrates, protein, fats, fiber, Polyphenols. The factors such as polyphenols add promising antioxidant capacity to sorghum and coupled with fiber content of the cereal indicates its potential as functional food. Sorghum has 11.9 percent of moisture and about 10.4 percent of protein and a lower fat content of 1.9 percent. The fiber and mineral content of grain sorghum is around 2.1 percent and 1.6 percent respectively. It is a good source of energy and provides about 349 K Cal/100 g and gives 72.6 percent of carbohydrates.

Thousand kernel weight (34.4g) and thousand kernel volume (28.3 ml) was observed for sorghum cultivar Maldandi (M35-1). Whereas the lowest weight and volume for the parbhani jyoti was (33.1g) and (23 ml) was observed respectively. This variation may be due to genotypic differences. The weight of thousand kernels is influenced by meteorological factors, methods of farming and genotypic differences.

Results reported on physical properties of sorghum are in close agreement with Shashikumar, G. S. Kumaran *et al.* (2018) [26] Bulk density, true density, porosity, and angle of repose of sorghum were found to be 0.79g/cm3, 1.44 g/cm3, 45.2% and 26.73º, respectively.

2.1.2 Oats

Syed SJ, Gadhe KS and Katke SD (2020) [28]. The analysis of the physical properties of oats showed that the average 1000 Kernel weight was 30.89 gms. Bulk density of oats was found to be 0.419 gm/cm³ whereas true density was 1.19 gm/cm³. Porosity of rolled oats was recorded to be 64.45 percent, whereas Angle of repose was 46.4º for oats.

Syed SJ, Gadhe KS and Katke SD (2020) [28] The grain has been analyzed for the various constituents like moisture, protein, carbohydrates, fat, ash etc. The results of the analysis showed that the content of moisture in the oats was 4.206%, ash content was about 1.97 percent, total carbohydrates ranged about 55.75 percent, the crude protein content was 12.62 percent, crude fat content was 6.91 percent and the total fiber content was around 13.65 percent.

Wani *et al*., 2014 [33] observed that oats is a good source of antioxidant vitamin E, phytic acid, phenolic acid and avenanthramides. Oat is well accepted in human nutrition, and it is an excellent source of different β-glucan, arabinoxylans and cellulose. It contains relatively high levels of protein, lipids (unsaturated fatty acids), vitamins, antioxidants, phenolic compounds, and minerals.

Chandan Solanki 2019 [56] reported that it was found that the true density of oat increased from 1250 to 1809.797 kg/m3 as the moisture content of the oat increased from 6.33% to 21.47% wb. It could be seen from Figure 5 (b) that true density had a linear relationship with moisture content.

2.1.3 Green Gram

Prabhavat, (1990) [47] reported that vitamins in mung bean are thiamine, riboflavin, niacin, pantothenic acid, and nicotinic acid. Vitamin C was reported to range from 0 to 10 mg/100 g dw with an average of 3.1 mg/100 g dw. This variation could be due to experimental variation or genetic differences; the author does not provide an explanation.

Adsule *et al*. (1986) [1] observed that green gram can be a rich source of protein with higher digestibility and can serve to convalescing babies or malnutrition people. The nutrients are not distributed uniformly in major components such as seed coat, cotyledon and embryo of the mung bean seed. The protein and lipids are found to be high in embryo, whereas the starch and crude fiber are concentrated in cotyledons and seed coats, respectively. The average moisture content present in the whole mung bean seed is 10.6 g/100 g of whole green gram with high protein (22.9 g), fat (1.2 g), total carbohydrate (61.8 g), crude fiber (4.4 g), and ash (3.5 g) per 100 g of sample.

Mubarak (2005) [17] proved that the presence of antinutritional factors such as tannins (366.6 mg/100 mg), phytic acid (441.5 mg/100 g), hemagglutinin, trypsin inhibitors, proteinase inhibitors, and polyphenols (462.5 mg/100 g) were reported in mung bean, which affect the digestion and bioavailability of full nutrition.

Liman *et al*., (2012) proved that physical properties of sorghum were studied and it was found that the highest thousand kernel weight (34.4g) and thousand kernel volume (28.3 ml) was observed for sorghum cultivar Maldandi (M35-1). Whereas the lowest weight and volume for the Parbhani jyoti was (33.1g) and (23 ml) was observed respectively. This variation may be due to genotypic differences. The weight of thousand kernels is influenced by meteorological factors, methods of farming and genotypic differences.

Green gram (*Vigna radiata* (L.) Wilczek) is a legume widely grown and consumed in South East Asia. The mung bean is commonly known in Asia as the green gram. It is an excellent source of digestible protein, with a higher lysine content than any other legume and is free from factors that cause flatulence. Mung bean contains 26.4g protein, 0.72g non-protein nitrogen, 4.5g ash, 1.75g fat, 6.15 crude fiber, and 61.2g carbohydrates in 1005 on dry weight basis. The green gram is a source of protein, carbohydrates, amino acids and mineral.

Results reported on physical properties of green gram are in close agreement with Ravi P., Tirupathi V. *et al*. (2017) [49] Bulk density, true density, porosity, and angle of repose of green gram were found to be 0.71 g/cm3, 1.16 g/cm3, 38.8% and 33.25º, respectively).

To study the standardization and formulation of extruded snack Sharmila. B and Athmaselvi. K.A (2017) [25] Horse gram (*Macrotyloma uniflorum*), Chick pea (*Cicer arietinum*), Kodo millet (*Paspatum serobiculatum*) were purchased from supermarkets (Rogers, Urapakkam, Tamil Nadu). Kodo millet and chick pea were cleaned and milled into flour from local flour mill. Horse gram was subjected to different treatments such as soaking, sprouting and preconditioning before milling into flour. The assortment of samples with different treatments of horse gram. All the samples were kept at room temperature until use. After many experimental trial runs, the composition of flour blend was kept constant (Horse gram-36%; Kodo millet-52%; Chickpea-12%).

Mary Omwamba, Symon M. Mahungu (2014) [18] Took rice and sorghum flour were obtained from a local miller.

Defatted soy flour (45% protein) was from Chemicals and Solvents (E.A.) Ltd. A mixture of 65% rice, 20% sorghum and 15% defatted soy flour was mixed for 5 min in a ribbon blender ready for extrusion processing. All the reagents used for analysis were of analytical grade.

P. Vijaya Deepthi (2016) [19] prepared samples were from process parameters including three different blends of sorghum, broken rice and green gram in the ratios of (7:2:1, 6:3:1, 5:4:1) at feed moisture content (12%) and operational parameters of the extruder like barrel temperature (110, 120 and 140 °C) and screw speed (150, 200 and 250 rpm). All the flours were weighed, and the moisture was adjusted by sprinkling water in the flours and mixed to prepare a homogeneous mix. After mixing the samples were stored in polyethylene bags at room temperatures for 12- 24 hrs. The samples were sieved and poured in to feed hopper and extruded using die diameter of 3 mm and product was collected at the die end.

Tiwari and Jha (2016) [30] developed pearl millet based ready to eat snacks using twin screw extruder by response surface methodology from pearl millet (60%), maize (30%) and green gram (10%) and observed that desirable expanded product, characterized by high expansion ratio and low hardness as well as maximum reduction of anti-nutritional factors were obtained at feed moisture (13%), screw speed (470 rpm) and barrel temperature (128 °C).

To study the physicochemical and sensory characteristics of extruded snack P. Vijaya Deepthi (2016) [19] studied that bulk density of the sorghum based extruded products the bulk density of the samples ranged from 0.45 g/cm3 to 0.90 g/cm3. The bulk density decreases with increase in barrel temperature which may be attributed due to higher starch gelatinization at higher temperature resulting in greater expansion. The bulk density increases with the increase in moisture content at higher temperatures only, which may be due to change in the molecular structure of extrudates. Similar reduction of rice extrudates density caused by increased barrel temperature has been reported by (Ilo *et al*., 1999) [13].

P. Vijaya Deepthi (2016) [19] studied the effect of on moisture content of the sorghum based extruded products is that the sorghum based extruded products with high expansion ratio and low bulk density initially the products had moisture content ranging from 6.9 to 7.6% (w. b).

P. Vijaya Deepthi (2016) [19] studied the effect of parameters on carbohydrate content of the sorghum based extruded products is that the carbohydrate content of the samples ranged from 44.85 to 49.95g.

The sample S6 has the highest carbohydrate content. The extrudates prepared from 3rd blend showed high carbohydrate content as there was decrease in sorghum percentage.

P. Vijaya Deepthi (2016) [19] studied the protein content of the samples ranged from 4.37 to1.75 g. Among the samples S5 has the highest protein content. Proteins influences expansion through their ability to affect water distribution in the matrix and through their macromolecular structure and confirmation, which affects the extensional properties of the extruded melts (Moraru and Kokini, 2003) [16].

3. Materials and Methods

3.1 Materials: Raw materials such as Oats flour, Sorghum flour and green gram flour will be purchased from the local market/Departmental stores of Phagwara or Jalandhar depending on the availability.

3.2 Packaging materials: Polyethylene bags.

3.3 Equipment: Kent noodle and pasta maker, sieve shaker, oven, frying pan, tray dryer.

3.4 Methodology

Take oats, green gram, and sorghum flour
↓
Add water (according to need)
↓
Knead it and prepare a dough
↓
Put the dough in Kent noodle and pasta maker
↓
Cut the extruded product in desired length

Fig 1: Preparation of extruded snack

3.5 Estimation of moisture content

Moisture content of the samples was determined by using hot air oven method for every 15 days. A sample of 5gm was accurately measured into a clean and dry moisture box of known weight and dried in a hot air oven at 105 °C for 12-15 hrs, cooled in a desiccators and weighed (AOAC, 1990) [5].

$$\text{Moisture content} = \frac{\text{Intial weight-final weight}}{\text{Sample weight}} \times 100$$

3.6 Fat Content

Five gm ground demoisturised sample was weighed accurately in thimble and defatted with petroleum ether in Soxhlet apparatus for 6-8 hrs at 60 °C. The resultant ether extract was evaporated, and lipid content was calculated method using Soxhlet apparatus was used to determined crude fat content of the samples. The percent of crude fat was expressed as follows (AOAC, 2005) [7].

3.6.1 Outline of procedure

5g of samples of different ratios is placed inside a thimble made from thick filter paper, which is loaded into the main chamber of the Soxhlet extractor. The Soxhlet extractor is placed onto a flask containing the extraction solvent. The Soxhlet is then equipped with a condenser. The solvent is heated to reflux. The solvent vapour travels up a distillation arm, and floods into the chamber housing the thimble of solid. The condenser ensures that any solvent vapour cools, and drips back down into the chamber housing the solid material. The chamber containing the sample slowly fills with warm solvent. Some of the desired compound will then dissolve in the warm solvent. When the Soxhlet chamber is almost full, the chamber is automatically emptied by a siphon sidearm, with the solvent running back down to the distillation flask. This cycle may be allowed to repeat many times, over hours or days. During each cycle, a portion of the non-volatile compound dissolves in the solvent. After many cycles the desired compound is concentrated in the distillation flask. The advantage of this system is that instead of many portions of warm solvent being passed through the sample, just one batch of solvent is recycled. After extraction the solvent is removed, typically by means of a rotary evaporator, yielding the extracted compound. The non-soluble portion of the extracted solid remains in the thimble and is usually discarded.

3.7 Ash Content

Five gm sample was weighed into silica crucible and heated at low flame till all the material was completely charred and cooled. Then it was kept in muffle furnace for about 4 hr at 550 °C. It was again cooled in desiccator and weighed and repeated until two consecutive weights were constant. The percent ash was calculated by knowing the difference between the initial and final weight (AOAC, 2005) [7]. The percent ash was calculated using following formula.

3.8 Protein

Estimation of protein using Lowry's method

The –CO-NH- bond (peptide) in the polypeptide chain reacts with copper sulfate in an alkaline medium to give a blue-colored complex. In addition, tyrosine and tryptophan residues of protein cause a reduction of the phosphomolybdate and phosphotungstate components of the Folin-Ciocalteau reagent to give bluish products which contribute towards enhancing the sensitivity of this method.

3.8.1 Reagents Required

1. **Reagent A:** 2% sodium carbonate in 0.1 N sodium hydroxide.
2. **Reagent B:** 0.5% copper sulphate (CuSO4.5H2O) in 1% potassium sodium tartarate. Prepare fresh by mixing stock solutions.
3. **Alkaline copper solution (Reagent C):** Mix 50mL of reagent A and 1 mL of reagent B prior to use.
4. **Diluted Folin's reagent (Reagent D):** Dilute Folin-Ciocalteau reagent with an equal volume of 0.1 N NaOH
5. **Standard:** Dissolve 50mg BSA in 50mL of distilled water in a volumetric flask. Take 10mL of this stock standard and dilute to 50 mL in another flask for working standard solution. One mL of this solution contains 200 µg protein.

3.8.2 Outline of the procedure

1. Pipette out 0.2, 0.4, 0.6, 0.8 and 1 ml of working standard into the series of labeled test tubes
2. Pipette out 1 mL of the sample in another test-tube.
3. Make up the volume to 1 mL in all the test tubes. A tube with 1 mL of distilled water serves as the blank.
4. Now add 5 mL of reagent C to all the test tubes including the test tubes labeled 'blank' and 'unknown'.
5. Mix the contents of the tubes by vertexing/shaking the tubes and allow to stand for 10 min.
6. Then add 0.5 mL of reagent D rapidly with immediate mixing well and incubate at room temperature in the dark for 30 min.
7. Now record the absorbance at 660 nm against blank. Then plot the standard curve by taking concentration of protein along X- axis and absorbance at 660 nm along Y-axis.
8. Then from this standard curve calculate the concentration of protein in the given sample.
9. Protein content was determined using (A.O.A.C, 2005) [7] method using Lowry method.

3.9 Crude fibre

About five gm of the sample was weighed into a 600ml long beaker. 200ml of hot 1.25% H2SO4 was added. Beaker was placed on digestion apparatus with preheated plates, boiled, refluxed for 30mins, and filtered through Whiteman GF/A paper by gravity. The beaker was rinsed with distilled water. The residue was washed on the paper with distilled water until the filtrate was neutral. The residue was transferred from the paper back to the beaker containing 200 ml of hot, 1.25%

NaOH. Steps 4 and 5 were repeated. The paper with residue was transferred into a crucible, dried at 100 °C overnight, cooled in a desiccator and reweighed (weight A). The sample was put in furnace at 600 °C for 6 hrs, cooled in a desiccator and reweighed (weight B). The loss in weight during incineration represents the weight of crude fiber (AOAC, 2005) [7].

$$\% \text{ Crude fiber} = \frac{(\text{Weight A}) - (\text{weight B}) \times 100}{\text{Sample weight}}$$

3.10 Carbohydrates

Carbohydrates content was calculated by difference method AOAC (1995) on dry basis using following formula:

Total carbohydrates = 100 – (moisture + crude fat + crude protein + ash)

3.11 Preparation of Ready to Eat Extruded Snacks

The process standardization is an important aspect for the development of any food product. The process was standardized for the preparation of extruded snack by using oat, green gram and sorghum flour mixed in various proportions, to obtain the good quality value added extruded snack. Following proportions of oat: sorghum: green gram flour was utilized to prepared value added snack.

Table 1: Formulation and standardization of sorghum, oats, green gram flour for extruded snack

Products	Sorghum: oats: green gram
P1	40:40:20
P2	45:45:10
P3	40:50:10
P4	35:35:30
P5	35:45:20

3.11.1 Procedure

The process for preparation of ready to eat extrudates Selection of oat, sorghum and green gram flour.

Combination of oat, sorghum and green gram flour
↓
Passing the flour through Kent extruder
↓
Cutting of extruded collets by manual cutting
↓
Frying of extruded product (at 90 °C)
↓
Packing in suitable packaging material
↓
Extruded snack product

4. Result and Discussion

Table 2: Sensory characteristics of ready to eat extruded snacks prepared by using Sorghum, oats, green gram

Sr. No.	Formulation (sorghum: oats: green gram	Color and appearance	Taste	Flavour	Texture	Overall acceptability
1.	P1	9.0	8.0	9.0	8.0	8.5
2.	P2	9.0	9.0	9.0	9.0	9.0
3.	P3	8.0	8.0	8.0	8.0	8.0
4.	P4	9.0	8.0	8.0	9.0	8.5
5.	P5	6.0	6.0	6.0	6.0	6.0

*Each value represents average of ten determinations. Hedonic scale 1 to 9 point

From the results of sensory evaluation, it was found the sample containing 45% sorghum flour and 45% oats flour and 10% of green gram flour variety of extruded snack was having highest value of taste, texture, flavour and overall acceptability (except control sample), which was evaluated by semi trained panel with 9 point hedonic scale Hence, the sample of extruded snack made from in combination of 45:45:10 (sorghum flour: oats flour: Green gram)) was used for further investigation.

4.1 Proximity analysis of the extruded snack made up of (Sorghum, Oats, Green gram) in the ratio of (45:45:10)

The extruded products were analyzed for moisture, crude protein, total fat and ash content using AOAC (2005) standard methods. Carbohydrate content was determined by difference 100-(% moisture + % protein + % fat + % ash) while dietary fiber was by AOAC (2005) [7] standard method.

Table 3: Proximity analysis of the extruded snack made up of (Sorghum, Oats, Green gram) in the ratio

Extruded snacks	Moisture (g)	Fat (g)	Protein (g)	Ash (g)	Carbohydrates (g)	Fibre (g)
Sample	4.8	30.06	2.4	5.8	56.94	1.2

After doing the proximate analysis of the extruded snack made from sorghum, oats and green gram with the ratio of 45:45:10 we have observed after doing all the analysis is that the moisture of our product came to 4.8g fat had come a value of 30.06 and ash has a value of 5.8g, Proteins value was found to be 2.4g, Carbohydrate was observed to be 56.94g P. Vijaya Deepthi (2016) [19] said that The sorghum based extruded products with high expansion ratio and low bulk density Initially the products had moisture content ranging from 6.9 to 7.6% and The carbohydrate content of the samples ranged from 44.85 to 49.95g and The protein content of the samples ranged from 4.37 to1.75 g so comparing it with out results they are very near to the value that were found out by our tea.

4.2 To study the Techno-Economic

Feasibility of millet-based extruded snack. The techno-economic feasibility of preparation of ready to eat extruded snack from the best blend raw materials (sorghum, oats, and green gram) with the blend ratio of 45:45:10 was estimated in this study. Were to be analysed. For the success of any kind of food product, the product should have minimum selling price and maximum quality. In the present investigation, the techno economic feasibility of ready to eat extruded snack was studied. The cost of oat flour and sorghum flour was 200/kg and 130/kg, rupees. The processing cost includes 30% of total production cost. Finally, the total cost of ready to eat extruded snacks was 28.59 rupees for 100 g (Table 4). The cost of ready to eat extruded snacks available in market is nearly about 28.59 Rs for 100 g. As the products were bought in a very small quantity and made from already packaged flours the price is very high but if we can get this at an wholesale rate and can make the product for a huge quantity can reduce the price of the product. From the cost of ready to eat extruded snack, it can be concluded that, the product is techno economically feasible and will be enable produce on large scale.

Table 4: Techno-economic feasibility of Millet based extruded snack

Sr. No.	Particular	Quantity	Price per Unit(Rs.)	Cost (Its.)
1.	Oat flour	45 g	200/kg	9/-
2.	Sorghum flour	45 g	130/kg	5.85/-
3.	Green grain flour	10 g	214/kg	2.14/-
4.	Packaging material	5 bags	1/bag	5/-
5.	Total raw material cost			21.99/-
6.	Processing cost @ 30 % of raw material cost			6.6/-
7.	Production cost for 100 g ready to eat extruded snacks			28.59/-
8.	Production cost of ready to eat extruded snacks			28.59/-

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