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Development and analysis of high fibrous protein rich food (Paniyaram) from barnyard millets (*Echinochloa esculenta*)

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Abstract
Barnyard millet is a non-acid creating, high protein, high fiber, and simple-to-digest to digest meal. Using barnyard millet, an effort was made to create the fermented product Paniyaram, which has added value. The staple Paniyaram recipe was altered by substituting a percentage of rice with barnyard millet. A total of three different ratios of samples were formulated by substituting rice with barnyard millet. The ratio of barnyard millet to rice was taken as 4:1, 3:2, and 2:3. Rest of the components were taken equally, only the ratio of rice was changed. All the three samples were fermented for 8 hours. Sensory attributes such as colour, taste, flavour was recorded. Various tests such as protein estimation, fat estimation, Mineral estimation and fibre estimation was performed. Among the three samples it was revealed that the ratio 3:2 was more acceptable than other ratio variations. Therefore, it can be concluded that the ratio 3:2 is best suited for making Paniyaram using barnyard millet.

Keywords: Paniyaram, fiber, millet, fat

Introduction
Barnyard millet is a minor millet and is the fourth largest in the scale of production. and provides many starving mouths with food security all around the world. Barnyard millet is cultivated throughout the globe. It is grown in many countries such as China Japan Pakistan Africa and Nepal (Patil J.V 2017) [2]. India is the world's largest producer of barnyard millet in terms of area (0.146 m ha) and output (0.147 mt), with an average productivity of 1034 kg/ha over the previous years (IIMR, 2018) [12]. In India Barnyard Millet is majorly grown in the hilly regions of Uttarakhand and in the southern states of India such as Kerala and Tamilnadu (Kumar *et al*., 2007; Joshi, 2013) Although it is also fed to animals, most barnyard millet is grown for human use. Two of the most well-known cultivars and wild species of barnyard millet are Echinochloa frumentacea (Indian barnyard millet) and Echinochloa esculenta (Japanese barnyard millet) (Sood *et al*., 2015) [11].

Besides wheat, maize, and rice, millet is one of the major cereals that can be substituted. Barnyard millet is also a good protein, carbs, and fiber source. Barnyard Millet contains approximately 66% starch, 15% protein and 7 % lipid content (Cao, Th *et al*. 2017) [4]. Barnyard millet has a lot of fiber and is also known as Kuthiravali in Tamil, odalu in Telugu, Jhangora in Hindi, and Kavadapullu in Malayalam. This millet has the lowest calorie and carbohydrate contents of any millet. Vitamin b is important in millet bran strands (Bernard, R.W. 1996) [3].

Barnyard millet is mainly incorporated as a substitute for rice in the diet. When compared to rice and other cereals, Barnyard millet have considerably high concentrations of protein, dietary fibre, Vitamin B1 and Vitamin B2 (Watanabe, Mitsuru 1999) [5]. Barnyard millet is also a rich source of macronutrients such as iron (Fe) and Zinc (Zn) which poses numerous health benefits (Renganathan *et al*. 2020) [6]. These millet's dietary fiber level helps keep the body feeling full. As a result, the desire to eat as much food decreases, which ultimately results in the body receiving more energy. Those who are looking for the best millet for weight loss might incorporate it into their diet. Barnyard millets also contain a lot of antioxidants, which help treat a variety of illnesses and health issues.

Barnyard millet has a lot of easily absorbed protein and makes you feel good and energized after eating it. Barnyard millet is a high-fiber grain with a superb balance of soluble or insoluble fragments; it is not only a fasting millet; it is nutrition packed enough to incorporate

in everyone's daily diet, regardless of age. Dietary fiber in food aids in the prevention of incontinence, excess gas, constipation, and unnecessary stomach cramps. (Parveen Kumari *et al*. 2017) [13]

The high level of enzyme delignification in millets' carbohydrates helps to produce more starch. Patients with diabetes and heart disease may therefore benefit from it. As a result, it might be advised for diabetics and people who have had cardiovascular incidents. Barnyard millet helps diabetics become more sensitive to carbohydrates and lowers blood sugar. (Kimeera Ambati *et al*. 2020) [14].

The technique of abstractly merging carbohydrates, proteins, lipids, and other components in food through the action of enzymes and microorganisms is called fermentation. The process of fermentation improves the food's flavor and aroma, making it more appealing. It also helps increase the nutritive value of food and also makes it easily digestible (Deepa M. Madalageri: 2012) [7]. The purpose of making biscuits from foxtail millet and barnyard millet is to compare them to biscuits made from refined wheat flour in order to assess their sensory quality and acceptability, nutritional value, and glycemic index. biscuits made with 45% millet flour and 55% refined wheat flour were combined to make millet. A trained panel and diabetic participants considered all three types of biscuits to be acceptable. (Anju, *et al*. 2010) [15]. Banyard millet consists of antioxidant substances,a derivative of serotonin,Anti-inflammatory properties Tumor-preventive flavonoid-luteolin and tricin (Dr. Usha Dharmaraj *et al*. 2021) [16].

Due to its widespread distribution across the continent and excellent nutritional profile, millet is essential in this capacity.Millet has been transformed into a variety of products using fermentation and malting. Thus, this analysis evaluates and provides a summary of both traditional and contemporary fermented and malted items. Although millet has been used in a variety of goods, its main food applications are still limited to traditional customers, and it is still completely underutilized. Given the potential contained in this grain, it is crucial to investigate this crop by using the proper contemporary fermentation and malting technology. As a result, ready-to-eat (RTE) and ready-to-use (RTU) food products will be available and, to a significant part, Africa's ongoing food security issues will be resolved. (Adebiyi JA *et al*. 2018) [17].

The purpose of the study was to evaluate the nutritional profile, glycemic index, and health advantages of eating barnyard millet in type II diabetes. The millet included 398 kcal/100 g of calories, 10.5% protein, 3.6% fat, and 68.8% carbohydrate. The total amount of dietary fibre was considerable (12.6%). fractions that are soluble (4.2%) and insoluble (8.4%) (Ugare R, Naik R *et al*. 2014) [18].

Flat bread, porridge, roasted, and alcoholic and non-alcoholic beverages are all made from millet grains or flour. They are used to create a variety of baked goods, including weaning food and cookies, biscuits, bread, and muffins. Chappati, puti, and murukul, additional foods for feeding babies or infants, are made from composite flour. The traditional foods burfi, baddis, halwa, and papad are made from millets. (Shonisani Eugenia Ramashia *et al*. 2021) [19].

The use of millets in bakery products will not only be superior in terms of fibre content, micronutrients but also create a good potential for millets to enter in the bakery world for series of value added products. These are mostly prepared from the wheat flour but efforts are being made to replace few portion of it with millets in order to provide an alternative and reduce over dependence on wheat and make gluten free bread (Saraswathi R *et al*. 2018) [20].

Fermentation is a process that is associated with probiotics also known as good bacteria. Because they have a favorable effect on the balance of the intestinal microflora, preventing the growth of harmful bacteria, promoting healthy digestion, improving the immune system, and boosting resistance to infection. These good bacteria are often referred to as probiotics. (Helland *et al*., 2004) [9].

Millets assist in reducing the unfavourable fermentation of raw food components in the gut and the binding of toxins that causes them to pass through colon as faeces. Colon cancer, constipation, and gastro-intestinal issues are decreased as a result. As according reports, heart disease, duodenal ulcers, and glucose are rare in individuals who regularly eat millet (Viyalakshmi *et al*., 2006) [21].

An inoculum size of 3%, a temperature of 37°C, and a pH of 6.5 were the ideal conditions for fermentation. Under these conditions, the fermentation process was able to improve the amino acid profile, raise the protein content, and lower the amounts of antinutrients in the barnyard millet to increase its nutritional value (Bhat *et al*. 2014) [22].

Paniyaram is a traditional cuisine made from fermented batter, which becomes crisp and golden after being prepared. It has a spongy, soft texture since it’s made from a leavened fermented batter. Then it is shallow fried in a paniyaram pan, a distinctive hollow pan. It is prepared from a batter of fermented rice grains which may or may not comprise fenugreek seeds. This study is carried out by incorporating paniyaram with barnyard millet by replacing the ratio of traditional rice components in the batter. Rice and assorted pulses are traditionally combined in a 4:1 ratio to prepare paniyaram

Materials and Methods

The barnyard millet required for the preparation was obtained from a supermarket situated in Phagwara, Punjab. Other ingredients such as black gram dal, pulses, and rice were also procured from local markets. We had to sieve and wash all the raw materials before soaking.

Fig 1: A view of the raw material used into Paniyaram

Moulderused for making paniyaram: The following moulder was used for the moulding paniyaram (Fig.2).

Fig 2: A view of the moulder used for making Paniyaram

The "paniyaram pan," often referred to as the "appe pan" or the "aebleskiver pan," is an unique cooking vessel widely used in South Indian and several other Asian cuisines to prepare the well-known snack. Small, spherical, and fluffy paniyarams are produced from fermented rice and lentil batter and are often seasoned with spices, peppers, onions, and sometimes vegetables.

Recipe Formulation

We changed the tradition way of preparing by substituting barnyard millet with a percentage of rice. A total of three different ratios of samples were formulated by substituting rice with barnyard millet. The ratio of barnyard millet to rice was taken as 4:1, 3:2, and 2:3. Rest of the components were taken equally, only the ratio of rice was changed.

Table 1: Ratio of the various ingredients used into the paniyarm preparation.

80:20	Barnyard millet	210 g
	Rice	52 g
	Urad dhal	43.75 g
	Chana	2.94 g
60:40	Barnyard millet	157.5 g
	Rice	105g
	Urad dhal	43.75g
	chana	2.94g
	Barnyard millet	52.5g
20:80	Rice	210g
	Urad dhal	43.75g
	Chana	2.94g

Method of Preparation

For 6 hr. the millet, rice and urad dhal are kept for soaking. We grind it into a paste after draining the water from it. Then they are kept for 8hrs. Do this same procedure for 3 different batters.

Result and Discussion

Fig 3: Image of Paniyaram prepared from different concentrations.

Sensory characteristics of the product

A group of trained panelists determined the sensory properties of the 3 products (3 samples prepared from different ratios) is shown in Table 2.

Table 2: Sensory scores for Paniyaram prepared from different ratios

Sample (Millet: rice)	Color	Texture	Flavor	Taste	Overall acceptability
60:40	8.2	8.3	8	8.2	8.175
20:80	6.5	6.6	6.1	6.3	6.375
80:20	5	5.2	5.2	5.1	5.125

Upon observations, we found that due to the larger content of rice in the 20:80 ratio, the paniyaram was very soft in texture meanwhile in the 80:20 ratio the paniyaram was found to be quite firmer and harder in texture. From the results, it was found that the paniyaram prepared from the 60:40 millet to rice ratio was the most acceptable meanwhile the paniyaram prepared from the 80:20 millet to rice ratio was the least acceptable.

Methods for analysis

1. Estimation of protein

Estimation of protein using Lowry's method

In the polypeptide chain the –CO-NH- bond (peptide) reacts in an alkaline medium with copper sulfate to give a bluish colour. The sensitivity of this method is improved by the reduction of the phosphomolybdate and phosphotungstate components of the Folin-Ciocalteau reagent caused by the tyrosine and tryptophan residues of protein.

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. The stock solutions are mixed to prepare fresh.
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.

Outline of the procedure

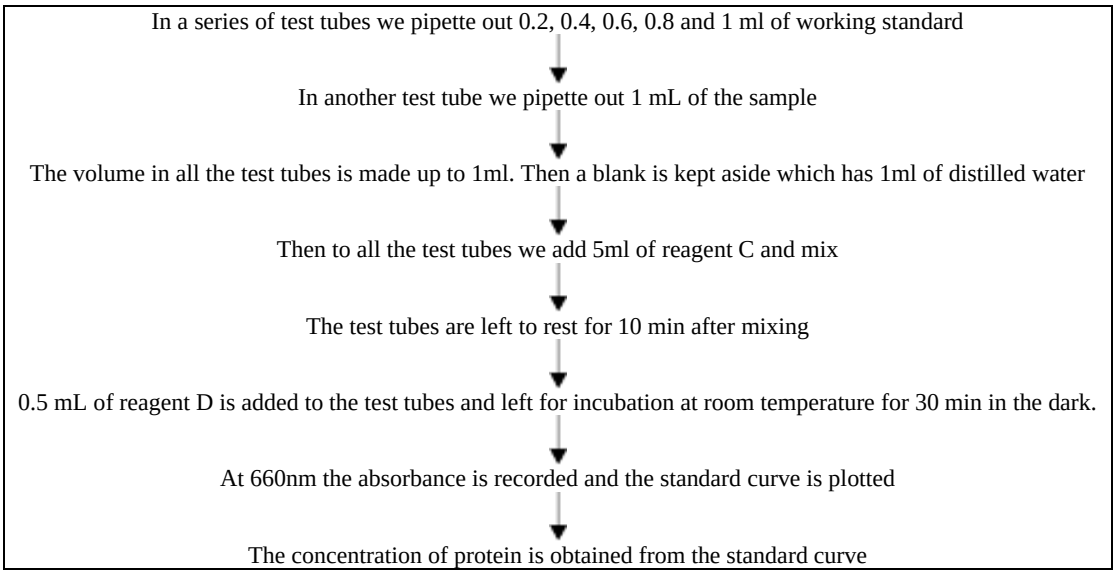

Fig 5: A flow chart of the Paniyaram preparation.

Table 3: Protein estimation from prepared Paniyaram.

Volume of standard BSA (ml)	Volume of distilled water (ml)	Volume of reagent C (ml)		Volume of reagent D (ml)		A 660
0.0	1.0	5	Incubate at room temperature for 30 min	0.5	Incubate at room temperature in the dark for 10 min	0
0.2	0.8	5		0.5		0.115
0.4	0.6	5		0.5		0.187
0.6	0.4	5		0.5		0.268
0.8	0.2	5		0.5		0.314
1.0	0.0	5		0.5		0.387

Table 4: Vitamin C estimation from prepared Paniyaram.

Sample solution (millet: rice)	Volume of reagent C (ml)		Volume of reagent D (ml)		A 660
20:60	5	Incubate at room temperature for 30 min	0.5	Incubate at room temperature in the dark for 10 min	0.241
60:40	5		0.5		0.268
80:20	5		0.5		0.390

As we can see from the table that the as millets have higher protein content the sample prepared from the 80:20, millet to rice ratio has the highest protein content whereas in the 20:60, millet to rice ratio sample has the least protein content available.

Standard curve for Protein by Lowry's method

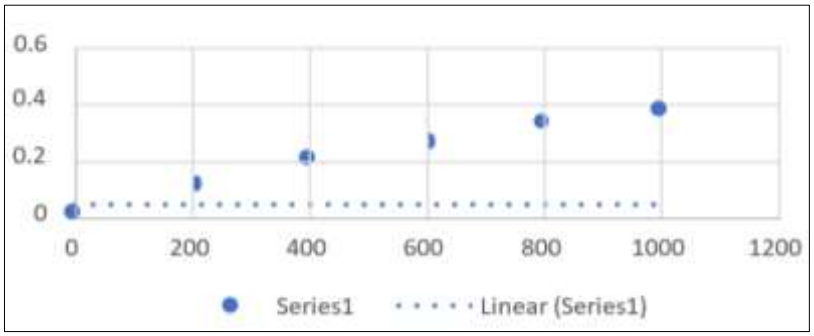

Fig 6: A view of the collected sample a) and operational performance of the protein estimation.

Estimation of mineral content

Mineral content estimation using the ash test. The weight of the fat loss in the sample serves as a proxy for fat content. A semi-continuous solvent extraction technique is the Soxhlet method.

In this process, the sample is totally soaked in a solvent for 5–10 min before being drained back into the boiling flask.

$Ash\% = (W_2 - W_1)/ W_s * 100$

W_1 – the weight of the empty crucible
W_2 - the weight of the crucible with ash
W_s – the weight of the sample

Outline of the procedure

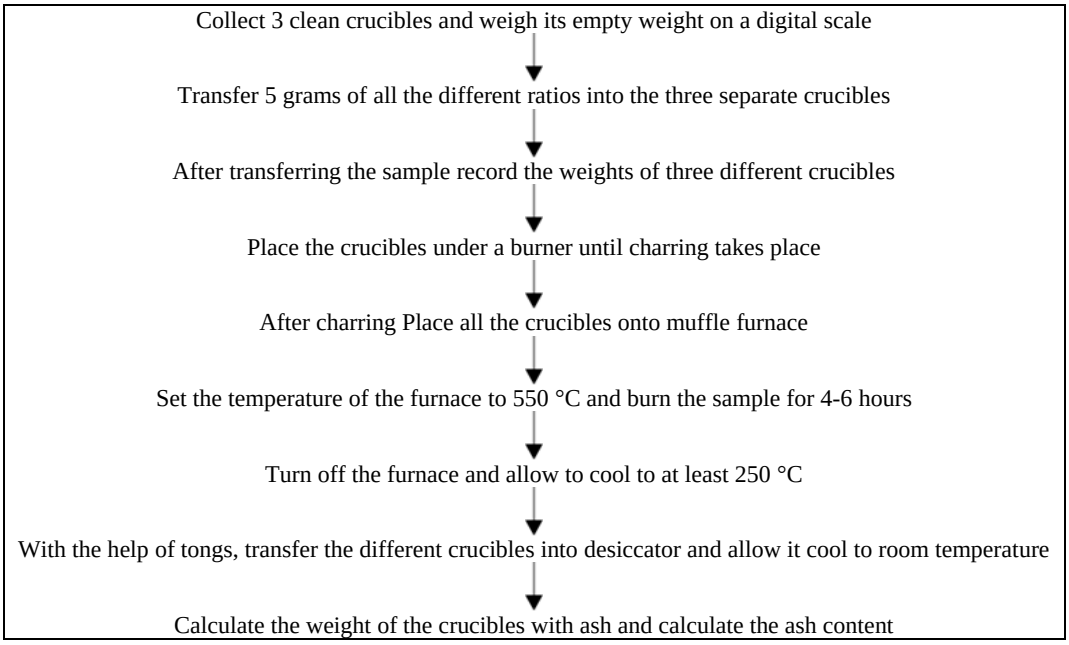

Fig 7: A flow chart for the mineral estimation from the Paniyaram.

Table 5: Observations from the ash test

Sample (millet: rice)	W_1 (g)	W_2 (g)	W_s (g)	Ash%
60:40	22.5	22.63	3	4.33
80:20	21.7	21.79	3	3
20:80	20.7	21.83	3	37

The amount of ash refers to the amount of mineral content, higher the ash content greater the mineral content. From table 5, we can see that the mineral content in the Paniyaram prepared from the ratio of 20:80 millet to rice ratio is the highest meanwhile the least mineral content is present in the 80:20 millet to rice ratio.

Fig 8: A view of the muffle furnace

Estimation of Fat content

Estimation of fat content using the Soxhlet method

Fat content is measured by the weight of the fat loss in the sample. The Soxhlet method is a semi-continuous solvent extraction approach. In this procedure, the sample is soaked completely for 5–10 min in a solvent and then siphoned back into the boiling flask.

$$\text{Fat \%} = (W_1 - W_2) / W_s * 100$$

Where

W_1 – the weight of the flask with fat W_2 – the weight of the empty flask W_s – the weight of the sample

Outline of the procedure

Samples of different ratios were covered in a thimble made of thick filter, and was then put inside into the main chamber of Soxhlet extractor. A glassware which has extraction solvent is kept onto Soxhlet extractor Condenser is then used in adjacent with the Soxhlet.

↓

As the solvent is heated, its vapors will rise towards the distillation arm and it will submerge the chamber housing thimble containing sample. Vapor will cool down as a result of condenser and falls back into the chamber containing the solid material

↓

Sample containing chamber is being slowly filled with the warm solvent. The warm solvent ensures the dissolution of the desired components. If the Soxhlet chamber is on the verge of being full, it will automatically get removed by a siphon sidearm, with the solvent going back to the distillation flask. Repeated cycles of this process can take place over days or hours.

↓

As each cycle takes place a part of the non volatile compound gets dissolved in the solvent.
As many repeated cycles takes places the desired compound will get concentrated on the distillation flask

↓

Rotary evaporators are typically used to remove solvent after extraction yielding the extract compound. The non solid part of the extracted solid is usually removed and not used again

Fig 9: Flow chart for the fat content determination.

Table 6: Fat determination from the Paniyaram

Sample (Millet: rice)	W_1	W_2	W_s	Fat%
60:40	120.37	119.38	3	33%
80:20	119.4	118.5	3	30%
20:80	121.83	120.56	3	42.3%

From table 6 we can observe that the highest fat content is found in the sample prepared from the 20:80 ratio meanwhile the least fat content is found in the sample prepared from the 80:20 ratio. This coincides with the fact that rice is higher in fat content compared to that of millets.

Fig.10: Fat determination from the Paniyaram**.**

Estimation of the fiber content

Estimation of fiber content using crude fiber method

The body is unable to digest fiber, which is a form of carbohydrate. Fiber cannot be converted into glucose, the sugar that results from the breakdown of most carbs; instead, it goes through the body undigested.

fiber crude method (%) = (A-B) / C * 100 Where,

A = weight of crucible with dry residue B = weight of crucible with ash

C = weight of the sample

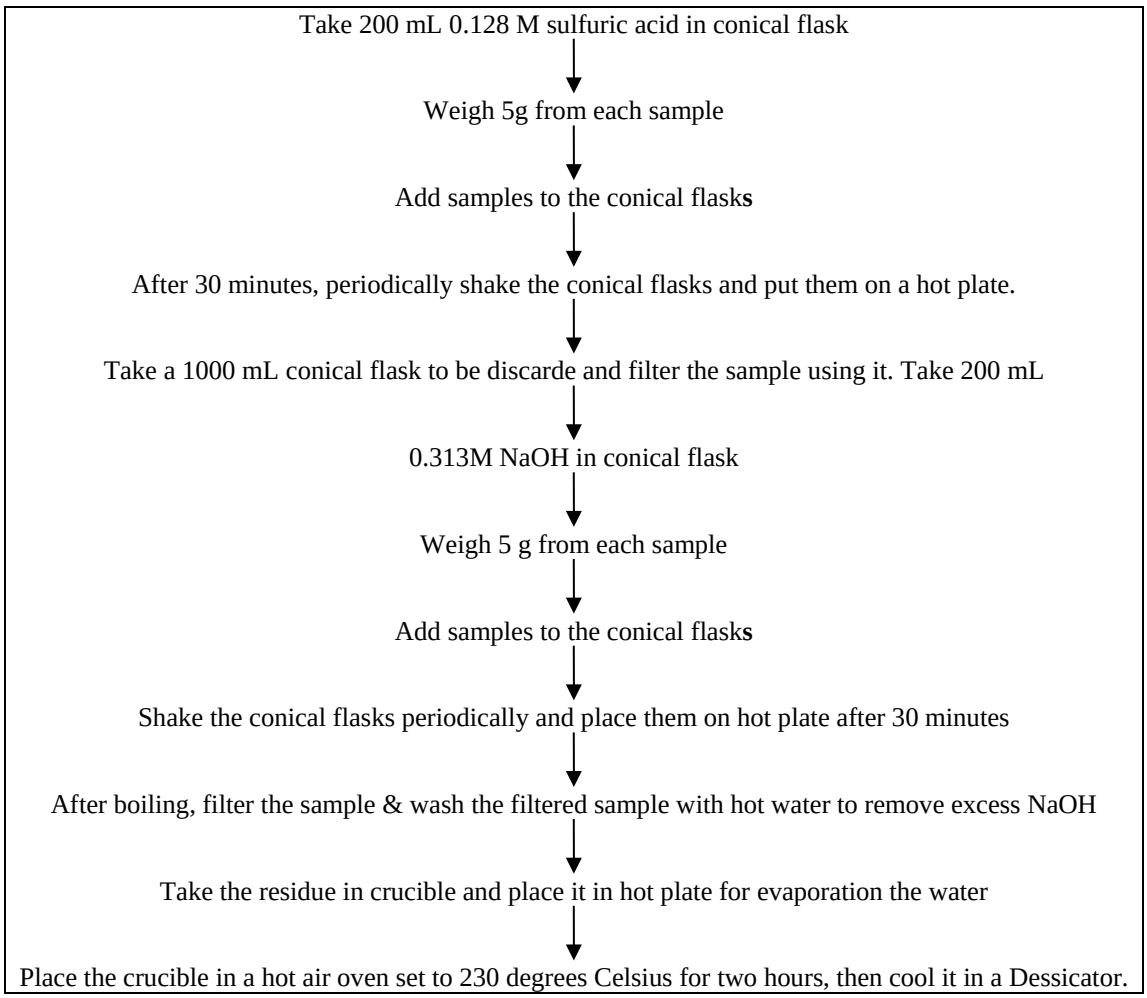

Fig 11: Flow chart for the fiber content determination

Take the weight of the crucible & put it in a muffle furnace at 550 ℃ for 2 hour

Table 7: observations of ash test

Sample (millet : rice)	A (g)	B (g)	C (g)	Fiber %
20:80	17.66	17.65	6	0.166
60:40	19.38	19.36	6	0.333
80:20	21.23	21.15	6	1.333

From the result we can see that the highest fiber content is found in the paniyaram prepared from the 80:20 ratio of millet to rice and the least fiber content is in the 20:80 millet to rice ratio. This coincides with the fact that millets are rich in fiber.

Fig 12: A view of the chemical preparation

Conclusion

The goal of the current study was to create a paniyaram with added value by combining traditional rice with barnyard millet in the batter. The fermentation process improves the softness of the batter and helps to retain a significant amount of carbon dioxide, which increases the volume of the batter and gives the finished product an appropriate soft, spongy feel. Barnyard millet was incorporated with rice to obtain 3 different ratios of batter. Only the ratio of rice and barnyard millet was changed, rest all the components were taken as constant. Three different ratios of barnyard millet to rice were 4:1, 3:2 and 2:3. Out of these three ratios, it was found that the paniyaram prepared from the 60:40 millet to rice ratio was the most acceptable meanwhile the paniyaram prepared from the 20:80 rice to millet ratio was the least acceptable. From this we can conclude that higher incorporation of barnyard millet was responsible for decreased sensory scores.

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