



## Research Article

# A Study on Functional and Nutritional Characteristics of Barnyard Millet and Foxtail Millet

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### Abstract

The chemical analysis of both foxtail and barnyard millets showed excellent sources nutrients and phytochemicals. The total phenolic content value of foxtail millet was 0.60 compared to barnyard millet 0.227 mg of Gallic Acid Equivalent (GAE) / g of sample. Foxtail millet showed the highest total flavonoid content 28.94 mg when compared to barnyard millet 7.61 mg of Quercetin/ g of sample. Regarding tannin content Foxtail millet showed the highest tannin value 12.97 when compared to barnyard millet 6.67 mg of Tannic acid equivalent / g of sample. Both foxtail and barnyard millets exhibited very good cooking performance in cooking quality of rice, fermentation performance with regard to preparation of idli and dosa and excellent performance in development of bakery products. Hence these millets offer great opportunities for diversified utilization and value addition in various food products.

**Keywords:** Baked Millet Products; Cooking Quality; Foxtail Millet Barnyard Millet; Fermented Millet Products; Nutrients; Phytochemicals

### Introduction

Despite their exceptional nutritional profile, food use of millets is still confined only to traditional consumers and economically deprived sections of the society. Diversification of food resources by incorporating less popular millets is essential for achieving the nutritional security and combat with emerging climatic vagaries and life-threatening diseases. The gluten-free nature of protein, bioactive compounds with medicinal value, and high micronutrient density makes them an ideal candidate for developing several functional and value-added food products. Several value-added products of millets like biscuits, cakes, pasta, and infant foods are available in the market and gaining the attention of economically rich and health concerned masses of the society [1].

Small Millets have immense health benefits. They are good sources of protein, dietary fiber, energy and minerals when compared to rice. The high protein content provides several nutritional and physiological benefits. The tiny “grain” is gluten-free and packed with vitamins and minerals. Small Millets are rich sources of nutrients which our body needs, such as magnesium,

calcium, manganese, phosphorus, iron and antioxidants. They are also valued for natural antioxidants and are gaining importance as complete nutrient source. Small Millets can be used for the preparation of traditional recipes, pasta products, puffed foods, bakery products and instant food mixes [2].

**Baked Products** By virtue of their longer shelf life, easy marketing, and handsome packaging baked products are popular among all age groups of people across the world [3]. However, the baking industry is mainly occupied by the different value added products of wheat. Due to high proportion of gluten, these products are not preferred by people suffering from celiac disease especially in developed countries. Millet-based bakery products will not only be superior in terms of nutrition but will also fetch the higher price in the market [4]. Flour of foxtail millet and finger millet is preferred for making biscuits and muffins, while barnyard millet is preferred for making cakes.

**Fermented Products** In general, millets are a good source of protein but the protein quality in terms of essential amino acid profile is low [5]. Interestingly, probiotic fermentation and germination of millets are known to enhance the protein digestibility and content of lysine, thiamine, niacin, sugars, protein fractions, soluble fibers, and in vitro availability of micronutrients [6]. Fermented food products such as idli and dosa are the popular and common breakfast in many parts of India [7,8].

## Foxtail Millet

Foxtail millet (*Setaria italica* (L.) P. Beauvois) is regarded as a native of China, it is one of the world's oldest cultivated crops. Foxtail millet ranks second in the total world production of millets. The foxtail millet is also known as Italian millet. It is one of the world's oldest cultivated crops. In the northern area of China it has been widely used as a nourishing gruel or soup for pregnant and nursing women and has been applied to food therapy. It has been recorded that millet has many nutritious and medical functions [9].

## Barnyard Millet

Barnyard millet (*Echinochloa crusgalli* (L.) P. Beauvois) is a multi-purpose crop which is cultivated for food and fodder. It is also called by several other names viz., Japanese barnyard millet, ooda, oodalu, sawan, sanwa and sanwank. Nutritionally too, it is a good source of protein, which is highly digestible and is an excellent source of dietary fiber with good amount of soluble and insoluble fractions. The carbohydrate content of barnyard millet is low and slowly digestible, which makes the barnyard millet a nature's gift for the modern mankind who is engaged in sedentary activities. In barnyard millet the major fatty acid is linoleic acid followed by palmitic and oleic acid. It also shows a high degree of retrogradation of amylase, which facilitates the formation of higher amounts of resistant starches [9].

## Purpose of the study

Millets are high energy nutritious foods equivalent to other common cereals and some of them are even better with regard to protein and mineral content. These are particularly low in phytic acid and rich in dietary fiber, iron, calcium and B- vitamins, thus they can act as a shield against nutritional deficiency disorders and provide nutrition security. Antioxidative properties of millets are determined by their phytochemicals like phenolics, tannins, and phytates [10].

Millets have considerable potential for use as an ingredient in foods and beverages. As they are gluten-free they are suitable for celiacs. The major categories of traditional foods where millets can be effectively used are fermented and unfermented flat breads, fermented and unfermented thin & thick porridges, steamed and boiled products, snack foods, alcoholic and non-alcoholic beverages (Schober et al, 2005). Keeping in view the above mentioned facts the aim of this study is to investigate the following.

## Objectives

1. To determine the nutrition composition of barnyard and foxtail millet flour
2. To determine the phytochemicals present in barnyard and foxtail millet flour

3. To study the cooking quality of millet grain rice with different soaking time
4. To study the characteristics of fermented millet products
5. To study the characteristics of baked millet products

## Materials and Methods

### Selection of samples for the study

Millets are small- grained, annual, warm-weather cereals belonging to the grass family. Millets are highly tolerant of drought and other extreme weather conditions and have a similar nutrient to other major cereals. They are gluten-free and contain high protein, fiber, and antioxidant contents.

### Selection of type of millets for the study

Millets are divided into two categories- Major and Minor millets

Major millets include Pearl millet, foxtail millet, proso millet, and finger millet. Minor millets include kodo millet, barnyard millet, little millet, guinea, browntop, fonio and adlay.

I have selected major millet foxtail millet and minor millet barnyard millet for study based on their popularity and analyzed for their nutritional characteristics and other specific characters.

### Procurement of the millets

The foxtail, barnyard millets were purchased in a local market at Tirupati, Chittoor district, Andhra Pradesh.

### Storage of the procured samples

Procured grains were cleaned to remove shriveled, immature, damaged grains and impurities. The cleaned grains were stored in air tight container under refrigerated conditions for further analysis.

### Processing of millets

Both barnyard millet and foxtail millet grains are moistened by adding about 10% water which facilitates not only the removal of the fibrous bran from the endosperm. Moistening the grain before pounding produces slightly moist flour (Perten, 1983). Then dry the grain and stored.

### Storage of the processed samples

Samples were packed in LDPE bags (75  $\mu$ ) and stored at ambient conditions (15-35 °C, 45-85 % RH) for further usage.

### Chemical analysis of the processed millets

Proximate composition of the barnyard millet and foxtail millet grains were done by as per the procedures A.O.A.C, 1985; and phytochemical analysis done according to total phenols [11]; total tannins [12] and total flavonoids [13].

## Functional properties of the samples

### Cooking quality of barnyard and foxtail millets

**Raw materials:** Foxtail millet, barnyard millet and water

**Procedure:** A known quantity of millets (50 g) was soaked in different soaking timings like 3, 6, 12 hours and were subjected to boiling temperature in predetermined constant amount of water (3.5 times) in a steel vessel and was cooked till the desired consistency of cooked grain is obtained (Table 1).

Millets	Weight of millets (g)	Soaking time (hrs)	Cooking time (mins)
Foxtail millet	50	12	19
		6	22
		3	25
Barnyard millet	50	12	16
		6	11
		3	8

**Table 1:** Soaking and cooking time of Foxtail millet, barnyard millet.

### Evaluation of Cooking characteristics and sensory attributes of foxtail and barnyard millet rice

After soaking the rice grains was cooked as per proportions of water and cooked rice quality was evaluated using parameters like cooking time textural characteristics of cooked rice, gelatinization temperature, taste quality and color was evaluated.

### Fermentation capacity of barnyard and foxtail millets

#### Preparation of Fermented products

**Raw materials:**

The raw materials namely Barnyard and foxtail millet were obtained from the local market of Tirupati, Andhra Pradesh, India and decorticated black gram was purchased from a local market.

#### Preparation of batter:

The decorticated barnyard and foxtail millets and decorticated black gram was soaked in excess water for 10h at room temperature (28±1°C), separately. The soaked grains was subjected

to wet grinding to yield a coarse particle size for barnyard and foxtail millet and plastic-like or glutinous consistency for black gram. The wet ground mass was blended in 2:1 ratio with water and salt was allowed to ferment for overnight.

#### Preparation of idli and dosa

Fermented batter was ready for preparing idli and dosa, idli was prepared using steam cook method and dosa was prepared by spreading fermented batter like a crepe on a hot griddle or tawa (Table 2,3).

Ingredients	Quantity
Decorticated barnyard millet	2 parts
Black gram	1 part
Salt	As required
Water	As required

**Table 2:** Ingredients for barnyard millet idli/ dosa batter.

Ingredients	Quantity
Decorticated foxtail millet	2 parts
Black gram	1 part
Salt	As required
Water	As required

**Table 3:** Ingredients for foxtail millet idli/ dosa batter.

### Fermented products evaluation

The idli/dosa prepared using foxtail and barnyard millets was evaluated for following characteristics like consistency of the fermented batter, spread ability of the batter, textural quality of the products, fermentation flavor of the products, bitter taste of the products, product outcome, eating properties.

### Baking performance of barnyard and foxtail millet

#### Formulation of cup cakes using barnyard and foxtail millets

**Raw materials:**

Millet flours such as barnyard and foxtail millet flours, wheat flour, jaggery powder, butter, milk, baking powder, baking soda, vanilla essence were purchased from local market in Tirupati (Table 4,5).

S.no	Ingredients	Variation-1	Variation-2	Variation-3	Variation-4
1.	Barnyard millet flour	75 g	150 g	75 g	-
2.	Wheat flour	75 g	75 g	150 g	150 g
3.	Jaggery powder	180 g	180 g	180 g	180 g
4.	Butter	60 g	60 g	60 g	60 g
5.	Milk	125 ml	125 ml	125 ml	125 ml
6.	Baking powder	5 g	5 g	5 g	5 g
7.	Baking soda	2 g	2 g	2 g	2 g
8.	Vanilla essence	2 ml	2 ml	2 ml	2 ml

**Table 4:** Formulation of cup cakes using barnyard millet.

S.no	Ingredients	Variation-1	Variation-2	Variation-3	Variation-4
1.	Foxtail millet flour	75 g	150 g	75 g	-
2.	Wheat flour	75 g	75 g	150 g	150 g
3.	Jaggery powder	180 g	180 g	180 g	180 g
4.	Butter	60 g	60 g	60 g	60 g
5.	Milk	125 ml	125 ml	125 ml	125 ml
6.	Baking powder	5 g	5 g	5 g	5 g
7.	Baking soda	2 g	2 g	2 g	2 g
8.	Vanilla essence	2 ml	2 ml	2 ml	2 ml

**Table 5:** Formulation of cup cakes using foxtail millet.

#### Procedure for preparation of millet cup cakes

- Sieve flours, baking powder and soda together
- Mix butter, milk and jaggery powder well
- Mix both dry and wet ingredients together by cut and fold method
- Add vanilla essence and add milk if necessary
- Grease cup cake moulds and fill the moulds 3/4<sup>th</sup> with cake batter.
- Preheat oven and place the moulds, set for 25-30 minutes at 180 °C
- After baking completed, let the moulds cool down and unmold the cup cakes
- Can be stored for 3-4 days at room temperature, one week at refrigerator

#### Sensory evaluation of the cup cakes prepared by barn yard and foxtail millets

A numerical score card was prepared using the quality parameters such as appearance, color, taste, crumb and crust texture, and flavor cooking and eating properties and overall acceptability was evaluated by panel members (Kemp, S.E et al (2009). Scorecard was the test where judges express their evaluation scores according to the scores given for each sensory attributes on the score card provided.

## Barnyard and foxtail millet cookies

### Raw materials:

Millet flour- barnyard and foxtail millet flours, wheat flour, brown sugar, butter, milk, baking powder, baking soda, vanilla essence were purchased from local market in Tirupati (Table 6,7).

S.no	Ingredients	Variation-1	Variation-2	Variation-3	Variation-4
1.	Barnyard millet flour	75 g	110 g	40 g	-
2.	Wheat flour	75 g	40 g	110 g	150 g
3.	Brown sugar	75 g	75 g	75 g	75 g
4.	Butter	40 g	40 g	40 g	40 g
5.	Milk (if necessary)	5 ml	5 ml	5 ml	5 ml
6.	Baking soda	3 g	3 g	3 g	3 g
7.	Vanilla essence	2 ml	2 ml	2 ml	2 ml

**Table 6:** formulation of barnyard millet cookies.

S.no	Ingredients	Variation-1	Variation-2	Variation-3	Variation-4
1.	foxtail millet flour	75 g	110 g	40 g	-
2.	Wheat flour	75 g	40 g	110 g	150 g
3.	Brown sugar	75 g	75 g	75 g	75 g
4.	Butter	40 g	40 g	40 g	40 g
5.	Milk (if necessary)	5 ml	5 ml	5 ml	5 ml
6.	Baking soda	3 g	3 g	3 g	3 g
7.	Vanilla essence	2 ml	2 ml	2 ml	2 ml

**Table 7:** formulation of foxtail millet cookies.

### Procedure for preparation of millet cookies

- In a bowl, sieve flours and baking soda.
- In another bowl, add sugar, butter and vanilla essence. Mix it together until sugar is dissolved.
- Add the wet mixture to the dry mixture. Mix well until the mixture comes together in form of dough. If necessary milk can be added and allow the dough sit for 5-10 min.
- Then make small balls and can be shaped into desired shapes using cookie cutters or by hands.
- Once all the cookies have been shaped, arrange them in a lined baking tray.
- Bake in a preheated oven at 200 °C for 10-12 min until the bottoms are golden brown. Remove them from the oven.
- After cookies cool down, can be stored in an air tight container for longer shelf life.

### Sensory evaluation of the cookies prepared by barn yard and foxtail millets

A numerical score card was prepared using the quality parameters such as appearance, taste, crisp texture, breaking strength, cooking and eating properties and overall acceptability was evaluated by 7 panel members (Kemp, S.E et al (2009)). Scorecard was the test where judges express their evaluation scores according to the scores given for each sensory attributes on the score card provided.

### Statistical Analysis

The data is subjected to statistical analysis, mean, standard deviation; Analysis of variance (ANOVA) tests was carried out on millet Products (Table 8-11).

S.no	Test parameters	Results	Unit
1	Moisture	11.16	%
2.	Ash	1.45	%
3.	Crude fiber	0.51	%
4.	Fats	5.32	%
5.	Proteins	10.68	%
6.	Carbohydrates	72.39	%
7.	Energy	380	Kcal

**Table 8:** Nutrient analysis of foxtail millet.

S.no	Test parameters	Results	Unit
1	Moisture	11.02	%
2	Ash	0.4	%
3	Crude fiber	0.33	%
4	Fats	5.07	%
5	Proteins	10.14	%
6	Carbohydrates	73.38	%
7	Energy	383	Kcal

**Table 9:** Nutrient analysis of barnyard millet.

S.no.	Test parameters	Results	Unit	Test method
1	Total phenolic content	0.60	mg of Gallic acid equivalent(GAE) / g of sample	Folin-Ciocalteu's method [11],
2	Total flavonoid content	28.94	mg of Quercetin / g of sample	Aluminium Chloride calorimetric assay [13],
3	Total tannin content	12.97	mg of Tannic acid equivalent / g of sample	Folin-Ciocalteu's method

**Table 10:** Phytochemical analysis of foxtail millet.

S no.	Test parameters	Results	Unit	Test method
1	Total phenolic content	0.227	mg of Gallic Acid Equivalent (GAE) / g of sample	Folin-Ciocalteu's method [11],
2	Total flavonoid content	7.61	mg of Quercetin / g of sample	Aluminium Chloride calorimetric assay [13],
3	Total tannin content	6.67	mg of Tannic acid equivalent / g of sample	Folin-Ciocalteu's method

**Table 11:** Phytochemical analysis of barnyard millet.

### Nutrient analysis of foxtail and barnyard millets

Millet grains are abundant source of nutrients and health-beneficial phenolic compounds, making it suitable as food. The moisture content in both millets was at 11 per cent level, ash level 1.45 to 0.40 per cent, crude fiber ranges 0.51 to 0.33 per cent, fat at 5.32 to 5.0 per cent level, proteins 10.6 to 10.1 per cent, carbohydrates 73 per cent level and the energy levels are the same for both millets 380kcal.

#### Total phenolic content of foxtail and barn yard millets

The phenolic properties found in millets compromise phenolic acids, flavonoids, and tannins, which are beneficial to human health. The total phenolics present in foxtail millet is 0.60 compared to barnyard millet 0.227 mg of Gallic Acid Equivalent (GAE) / g of sample. In agreement with the previous studies, TPC of hulls were higher compared to those of dehulled and whole grains of studied millet samples [1,15]. Disna Kumari, et al. (2017) [16] also studied on comparison of phenolic content and antioxidant activities of millet varieties like finger millet, foxtail, and proso millets and results found that the highest phenolic content and antioxidant activities were reported for millet samples.

#### Total flavonoid content

The results showed that Foxtail millet showed the highest total flavonoid content 28.94 mg when compared to barnyard millet 7.61 mg of Quercetin/ g of sample. Flavonoid content was significantly influenced by the variety and cultivated locations of millets [17].

Flavonoids are polyphenolic compounds comprising of 15 carbons, with two aromatic rings connected by a 3 - carbon bridge. According to the modifications of the central C - ring, they can be divided into different structural classes such as flavonols, flavones, flavan - 3 - ols, flavanones, isoflavones, and anthocyanidins. Determination of total flavonoid content is based on the chelating ability of flavonoids with aluminum (III). Flavonoids form a pink - colored complex with aluminum (III) through the 4 - keto and neighboring hydroxyl groups or through adjacent hydroxyl groups in the B ring [18].

#### Total tannin content

The results showed that Foxtail millet showed the highest total tannin content 12.97 when compared to barnyard millet 6.67 mg of Tannic acid equivalent / g of sample, which is about double fold higher. Previous studies showed that in finger millet tannin content ranged from 0.04 to 3.47 % by Ramachandra, et al. (1977) [19]. Tannin content was also estimated in hilly region varieties and found to be less compared to base region varieties [20].

Florence Suma Pushparaj, et al. (2014) [21] study results indicated that the bran rich fraction showed high antioxidant activity (RPA) owing to high tannin, phytic acid and flavonoid levels.

#### Cooking quality of millet rice

This study examines the cooking characteristics and sensory attributes of baryard and foxtail millets rice soaked at different timings. The cooking qualities of millet, namely cooking time, softness of the grain and pasting profile were studied (Table 12).



Soaking time	Cooking time	texture of rice	Gelatinization temperature <sup>0</sup> C	Taste-Bitter/less bitter/bland	color
<b>Foxtail millet</b>					
12 hrs	19min	Cohesiveness	86 °C	Less bitter	Slight yellowish
6hrs	22min	Soft textured grains	80 °C	Less bitter	
3hrs	25min	Hard to soft	75 °C	Bland	
<b>Barnyard millet</b>					
12 hrs	8min	Adhesiveness	85 °C	Less bitter	Cream to white color
6hrs	11min	Soft textured grains	81 °C	Less bitter	
3hrs	16min	Soft to hard grains	77 °C	Bland	

**Table 12:** Cooking characteristics and sensory attributes of foxtail millet rice.

The results from table 12 shows that the cooking time of foxtail millet ranges from 19 min to 25 min, on the other hand for barnyard millet it ranges from 8min to 16min . As the soaking time increases from 3 hrs to 12 hrs the cooking time was reduced. The texture of cooked grains appeared that the softness character at 3hrs soaking time was increased to gumminess/cohesiveness at 12 hrs of soaking, as it corresponds to gelatinization temperature which ranges from 75 °C -86 °C. The taste quality was ranges between less bitter to bland taste may be due to with increase in soaking time the fermentative bacteria attracted to grains. The color of the rice was slight yellow incase of foxtail millet, where as for barnyard millet the rice appeared to be cream to white color.

### Fermentation capacity of millets dosa and Idli

Evaluation of fermented products prepared with foxtail and barnyard millets (Table 13).

Fermented products	Consistency of the fermented batter	spread ability of the batter	Cooking quality	textural quality of the products	Taste/flavor of the products	Visual appearance of products
Idli	Thick consistency	Ability to pour on idli plates	Soft idlys formed	Very soft and no adhesive properties	Slightly bitter to bland	Well cooked and very good appearance
Dosa	Thin consistency	Able to spread the batter on the pan	Very thin dosa's formed	Soft textured dosa's formed	Slightly bitter to bland	Well cooked and very appealing

**Table 13:** Fermented characteristics and sensory attributes of idli and dosa.

Table 13 shows that the idli and dosa prepared out of two millets came out well. The fermented batter was able to pour as well as able to spread easily on the pans. Very soft textured products were developed, but taste and flavor quality was slight bitter to bland and visual appearance of the products showed well cooked appearance and soft products.

### Baking performance of barnyard and foxtail millets cup cakes

#### Evaluation of Bakery products prepared with foxtail and barnyard millets

Numerical score card was developed using appropriate attributes and 7 panel members evaluated products (Table 14,15).

Quality description	Numerical score	outcome of product/ mean scores	Crust and crumb texture/ mean scores	Taste/flavor/mean scores
Excellent	90			
Good	80	84.2857	82.8571	81.4285



Fair	70			
Poor	60			

**Table 14:** evaluation of cup cake using numerical score card.

Quality description	Numerical score	outcome of product/ mean scores	Crisp texture/ mean scores	Breaking strength/easy to break or not/mean scores	Taste/flavor/mean scores
Excellent	90				
Good	80	81.4285	81.4285	80.0	84.2857
Fair	70				
Poor	60				

**Table 15:** Evaluation of cookies using numerical score card.

The results of numerical score test of cup cake reveals the outcome of the product, crust and crumb structure and taste/flavor characteristics scored the scores between 81% to 84%, similar results were obtained for cookies the score ranges between 81% to 84%.

It has been suggested that the total flour volume in a baked good can contain as much as 30 percent millet flour; however, other research suggests increased concentrations of millet flours in cake and bread doughs decreased their baking performance. (Whole Grains Council, (2018) [22] the McGill University, for example, investigated the characteristics of little, foxtail, and barnyard millets, which are grown in India, as a wheat flour replacement in bread and cake production. This included scientific evaluation of dough rheological behaviors, baking performance, sensory attributes, and other aspects of the final products made with these millet flours [23].

Recently, millets are gaining importance because they can offer several nutraceuticals, and also being rich in protein, minerals and vitamins. Its protein has a beneficial influence on the metabolism of cholesterol. Cereal or millet cookie is made from a fine flour of millet with leavening and shortenings. There exists, however considerable potential for large scale manufacture and marketing of shelf-stable product utilizing underutilized grains like proso or foxtail millet as the demand for ready-to-eat convenience food products has been steadily increasing, consequent to industrialization and convenience in using. The product can be consumed during tea time or in between the meal (central food technological research institute, mysore).

## Conclusions

Both foxtail and barnyard millets exhibited very good cooking performance, fermentation performance and bakery performance in their products development and evaluation. The chemical analysis showed excellent sources nutrients and phytochemicals. Hence these millets offer great opportunities for diversified utilization and value addition. Small Millets are thus an amazing grain offering great opportunities for diversified utilization and value addition. These Small Millets have diversified uses and high food value but the consumption of these Small Millets has declined for want of standardized processing techniques to compete with fine cereals. Hence utilization of small Millets in popular foods would find ready acceptability with the tag of ‘health foods’.

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