

# EFFECT OF HEAT TREATMENT PARAMETERS ON SHELF LIFE, NUTRITIONAL VALUE AND ANTINUTRITIONAL FACTORS OF BARNYARD MILLET

## Abstract

Barnyard millet has been used as food since ages and it is the vital source of highly nutritious macronutrients, micronutrients and nutraceutical constituents. It is important to reinstate the missing interest in millets that desperately need recognition due to its nutritional qualities and substantial health benefits in management of diabetes mellitus, obesity and hyperlipidemia. A number of nations have long grown and utilized barnyard millet as a viable food source. It has been a neglected crop up until now despite the important nutrients and their improved bioaccessibility with different processing procedures. In this study, we employed roasting to extend shelf life, increase in nutrient content, and decrease antinutritional components. To extend the shelf life and increase the bioavailability of vital nutrients, barnyard millet has been roasted at a range of temperatures (between 100°C and 130°C) for a range of times (5, 10, and 15 minutes). Total polyphenols showed bioaccessibility of 8.2%, 9.1% and 9.4% for raw, 105°C for 15 minutes and 130°C for 15 minutes roasted at 0 month. Preferably, 130°C for 15 minutes roasted sample showed enhanced shelf life (6 months) and better bioaccessibility of total polyphenols (670 mg/100 g) while nutrient retention is almost similar in all roasted samples.

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**Key words:** Barnyard millet, heat treatment, shelf life, polyphenols, nutritional value and antinutritional factors.

## INTRODUCTION

Developing countries such as India, China and a few African countries have been currently focusing on droughtresistant grains due to the water shortage and swiftly enhancing population. Additionally, allocation of morefunds to the scientific research on millets for their use as food source has been increased. Millets show pest anddisease resistance, short growing season and productivity during dearth conditions when compared to mostimportant cereals [Saleh *et al.*, 2013; Anju and Sarita, 2010].Diet plays a potential role in overcomingthese diseases [Surekha *et al.*, 2013]. Therefore, there has been an increasing demand for the functional andhealth foods comprising high antioxidants, minerals and fiber [Goswami *et al.*, 2015].Barnyard millet (BM) has been used as food since ages [Surekha *et al.*, 2013]. It is the vital source of highly nutritiousmacronutrients, micronutrients and nutraceutical constituents [Surekha *et al.*, 2013]. It is vital minor millet dueto its high quantity of protein (12%) that shows appropriate digestibility (81.13%) together with lowcarbohydrate level (58.56%) of slow digestibility (25.88%) [Surekha *et al.*, 2013]. It is also abundant in dietaryfiber (13 g/100g) with fair amounts of soluble (4.66 g/100g) and insoluble (8.18 g/100g) fractions and bettersource of digestible protein (81.13 g/100g digestibility) [Goswami *et al.*, 2015]. BM lacks gluten, hence plays anessential role in the preparation of gluten free foods for gluten intolerant population. In addition, it can easily beblended with other food grains [Goswami *et al.*, 2015]. BM is most commonly used as food by poor farmingfamilies and also at times brewed for beer and used as a feed for birds. It has extensively been used in bakeryproducts such as cookies [Surekha *et al.*, 2013] and biscuits [Anju and Sarita, 2010] recently. It is important toreinstate the missing interest in millets that desperately need recognition due to its nutritional qualities andsubstantial health benefits in management of diabetes mellitus,

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obesity and hyperlipidemia [Kumari andThayumanavan 1997, Takhellambamet *al.*, 2015]. Therefore, we have used roasting process to enhancebioaccessibilityof nutrients.

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## MATERIALS AND METHODS

Barnyard milletwas procured from Regional agricultural research station (RARS, Tirupati). All the chemicals were ofanalytical grade and purchased from Himedia, Tirupati, India.Antioxidant activity (DPPH) has been evaluated in raw and roasted (100° and 130° C) BM samples by using AOACmethod at 0, 1, 2, 3, 4, 5 and 6 months.Tyrosine has been studied in raw and roasted (100° and 130°C) BM by using AOAC method at 0, 1, 2, 3, 4, 5and 6 months. The tyrosine content was estimated with progressive storage as a measure of proteolysis insample by using the method of Strange *et al.* [Strange *et al.*, 1977].Tannins have been evaluated in raw and roasted (100° and 130°C) BM samples by using modified vanillin–HClmethod [Price *et al.*, 1978] at 0, 1, 2, 3, 4, 5 and 6 months.Phytate has been estimated in raw and roasted (100° and 130°C) BM samples by using the method of Haug andLantzsch [1983], at 0, 1, 2, 3, 4, 5 and 6 months.Polyphenols of raw and processed BM samples were extracted by refluxing the sample powders (2 g) inacidified methanol (20 mL) for 2 h at 60±5° C [Chetan and Malleshi, 2007]. Thereafter, samples were filtered toestimate the quantity of TPP and tannins.Total Polyphenols have been studied in raw and roasted (100° and 130°C) BM by using Folin-Ciocalteumethod at 0, 1, 2, 3, 4,5 and 6 months, with some alterations.Bioaccessibility of raw and roasted BM samples was analyzed by using an *in vitro* method described by Lutenet *al.* [1996] which involves gastrointestinal digestion with suitable alterations.All the experiments were done in triplicates. p values < 0.05 were considered significant. Analysis of variance(ANOVA) was used to test the differences between raw and roasted groups of BM flours. The data shown intables are an average of triplicate observations.

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## RESULTS AND DISCUSSION

Dehulled and heat-treated BM has been found to improve type 2 diabetics in which low glycemic index fordehulled millet (50.0) and heat-treated (41.7) was observed [Ugareet *al.*, 2011]. Numerous processingtechniques are employed to improve the nutrients, bioaccessibility and decrease antinutritional factors amongwhich roasting plays an essential role. Studies have shown that roasting process significantly increases theamount of iron which may be because of the influx of leached iron from the roasting pan into the sample atelevated temperature. However, a reduction in protein, fat, crude fiber was noticed due to the extinction of a fewamino acids and breakdown of fat [Obadinaet *al.*, 2016].

### DPPH (2,2-diphenyl-1-picrylhydrazyl)

Antioxidant activity of raw BM at 0 month was 125±2 µg/mL but after 6 month storage it was 117±1 µg/mL.Antioxidant activity of raw BM reduced remarkably by 6.4% with time showing maximum at 6 month storage.Although roasting process showed 13% reduction in antioxidant activity *yet all* roasted samples exhibitedremarkably less reduction (4-8%) in antioxidant activity with 6 month storage duration emphasizing that the roasting process substantially retained the antioxidant potential of BM (Table 1). Roasting process did not affectantioxidant activity of BM, therefore, it is recommended to follow this process for improving shelf life. Severalstudies have demonstrated that thermal treatments probably decrease or increase the phenolic compounds andantioxidant activities based on the severity of heat treatment and duration of treatment and the type of cerealstudied [Hegde and Chandra, 2005]. Numerous studies have suggested that outer layers of millets have a

high amount of phenolic compounds and antioxidant activity [Liyana-pathirana and Shahidi, 2007]. In addition, the amount of antioxidants in millets and antioxidant activities vary depending on the factors like species, cultivar and environmental conditions [Bonoliet *et al.*, 2004]. Processing methods such as soaking and roasting have been noticed to influence the amount of total phenolic, flavonoid and antioxidant activity of a few dry beans. Roasting or boiling of kodo millet and finger millet reduced the antioxidant activity [Hegde and Chandra, 2005, Pushparaj and Urooj, 2014].

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### Tannins

Tannins of raw BM showed 25% increase at 6 month storage compared to 0 month. At 0 month the tannins of BM was  $1.5 \pm 0.5\%$  and at 6 month storage also their level was  $2.2 \pm 0.2\%$ . Similarly, all the roasted samples also showed an enhancement (24%) with the highest amount of tannins at  $130^\circ\text{C}$  15 minutes treated BM sample (Table 2). Conversely, earlier studies have shown higher TPP in roasted finger millet sample which was specifically because of increased tannin quantity as noticed in little millet [Pradeep and Guha 2011]. Tannins exert numerous health benefits like anti-inflammatory, anti-ulcer, neuroprotective effect. Another study showed

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that roasting reduces anti-nutrients of foxtail millet like tannins and phytic acid from 221.1 to 92.4 mg CAE/100g and 306 to 180.5 mg/100 g but it was assumed to be due to milling of roasted samples [Khapreet *et al.*, 2021]. Ramachandra *et al.*, [1977] showed that white grains had lower phenolic content compared to brown grain foxtail millet (FM) variety and dehulling remarkably enhances *in vitro* protein digestibility (IVPD) [Pawar and Machewad, 2005]. Dehulled and roasted BM sample in this study may show an increased IVPD. Tannins being natural polyphenols reduce protein digestibility by attaching with proteins and inhibiting enzymes [Aganga *et al.*, 2001].

### Phytates

The amount of phytates in BM showed a decrease of 10% from 0 month to 6 month storage period. In the same way, the amount of phytates in roasted ( $100^\circ\text{C}$  for 5, 10 and 15 minutes and  $130^\circ\text{C}$  for 5, 10 and 15 minutes) BM also showed 15-25% increase 6 months of storage. Phytates, phenols and tannins present in cereals are abundant antioxidants which play an essential role in health, aging and metabolic diseases [Kringset *et al.*, 2000]. Phytic acid available in the grains exhibits antioxidant activity by making chelates with pro-oxidant transition metals. Though phytic acid is an antinutrient due to its mineral binding ability, it has been observed to reduce the risk of colon and breast cancer in animals [Pushparaj and Urooj, 2014].

### Total Polyphenols

TPP of raw BM enhanced remarkably (22%) with time showing maximum at 6 month storage. At 0 month the TPP of BM was  $11 \pm 0.5\%$  whereas at 6 month storage it was increased to  $14 \pm 2\%$ . All the roasted samples also demonstrated remarkable enhancement (24-37%) with the maximum TPP at  $130^\circ\text{C}$  15 minutes (Table 2). In accordance with our studies, earlier studies also showed that roasting process increases TPP remarkably in finger millet and pearl millet [Hithamani and Srinivasan, 2014]. In another study, roasting of proso millet for 10 mins at  $110^\circ\text{C}$  has shown significantly increased the total phenolic content from 295 to 670 mg/100 g (ferulic acid equivalent). It was explained that roasting aids the hydrolysis of C-glycosylflavones and release of successive phenolic compounds [Azad *et al.*, 2019]. On the other hand, in another study, the roasting of pearl millet has significantly reduced the phenolic

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content from 169.85 to 90.60 mg/ 100 g [Obadina *et al.*, 2016, Yousuf *et al.*, 2021]. Phenolics of BM and several other millets have also exhibited their potential as reducing agents, singlet oxygen scavengers and metal chelators [Chandrasekara and Shahidi, 2010].

### Bioaccessibility

BM comprises a few phytochemicals with strong antinutrient effects [Saleh *et al.*, 2013] which can extraordinarily reduce nutrient bioavailability and quality [Devisetti *et al.*, 2014]. The analysis of bioavailable polyphenols is important to evaluate the antioxidative efficacy of the compounds [Hithamani and Srinivasan, 2014]. In our study, TPP showed bioaccessibility of 8.2%, 9.1% and 9.4% for raw, 105°C for 15 minutes and 130°C for 15 minutes roasted BM samples respectively at 0 month. Similarly, TPP showed bioaccessibility of 11%, 13.3% and 15.6% for raw, 105°C for 15 minutes and 130°C for 15 minutes roasted BM samples respectively at 6 months. However, 6 months stored samples did not show significant difference in bioaccessibility. TPP, showed 10-13% enhancement in bioaccessibility for 105°C for 15 minutes and 130°C for 15 minutes roasted samples compared to raw samples [Fig 1]. In accordance with this, earlier studies also demonstrated increased bioaccessibility of TPP in finger millet and pearl millet [Hithamani and Srinivasan, 2014]. Hence, roasting process shows a profound importance both in increasing the shelf life of BM and bioaccessibility of its TPP. It has been shown that the rats fed with a diet of native and treated starch from BM had the lowest blood glucose, serum cholesterol and triglycerides when compared with rice and other minor millets [Kumari and Thayumanavan 1997]. Roasting can improve protein digestibility from 22.3 to 60.1% most likely due to vulnerability of protein to hydrolysis [Yousuf *et al.*, 2021]. A few studies have shown that processing initiates injury to cell structures and facilitate the release of bioactive compounds from the matrix, therefore, enhancing the extractability of bound phenolics in the materials [Zeng *et al.*, 2016]. It has been shown that rats fed with a diet of native and treated starch from BM had the lowest blood glucose, serum cholesterol and triglycerides than rice and other minor millets [Kumari and Thayumanavan 1997].

### CONCLUSION

Although millets show potential health benefits, there is no much research and novelty on millet grains/flours when compared to conventional cereal grains like maize, sorghum, rice and wheat [Abah *et al.*, 2020]. In addition, the nutritional value of BM and its ability to be incorporated in novel foods is interesting but its utilization is inadequate until now. Our study has shown that roasting at 100° and 130°C temperatures did not decrease nutrients significantly and improved shelf life significantly. Preferably, 130°C for 15 minutes roasted sample showed enhanced shelf life and better bioaccessibility of TPP while nutrient retention is almost similar in all roasted samples.

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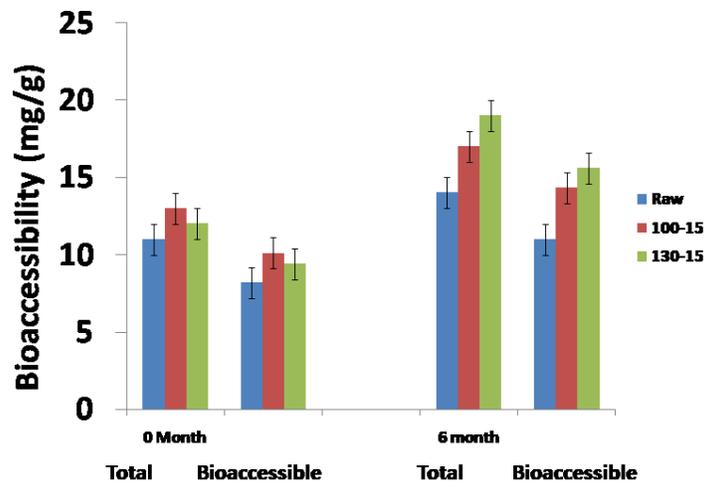
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**Table 1. Effect of roasting on nutritional quality of barnyard millet**

Anti-Nutritional Compounds	Treatment	Time of Storage in Months						
		0	1	2	3	4	5	6
<b>DPPH</b> (Antioxidant Activity) µg/mL	Raw	125±2	126±4	123±3	121±3	119±4	118±3	117±1
	100□-5'	116±3	114±2	114±1	114±4	116±3	112±4	109±3
	100□-10'	115±5	113±5	113±5	112±3	115±1	110±3	110±1
	100□-15'	116±3	112±4	114±2	112±1	114±1	107±1	106±2
	130□-5'	117±3	114±3	112±3	115±3	113±2	108±2	106±1
	130□-10'	110±5	109±4	109±4	110±5	108±5	107±1	105±2
	130□-15'	109±4	111±4	108±3	107±5	109±3	105±5	104±3
<b>Total Polyphenols</b> mg/g	Raw	11±0.5	12±0.5	11±0.7	11±1	12±1	13±3	14±2
	100□-5'	13±1	14±0.3	13±0.5	12±0.3	15±0.2	16±1	17±2
	100□-10'	12±1	13±1	14±1	13±0.4	15±0.6	14±0.5	16±0.5
	100□-15'	13±1	14±0.7	14±0.1	12±0.3	14±0.3	15±0.5	17±1
	130□-5'	13±0.4	13±0.8	13±0.4	13±0.5	15±0.4	16±0.4	18±0.7
	130□-10'	12±0.6	13±0.4	14±1	12±1	16±0.8	15±1	18±1
	130□-15'	12±0.9	13±1	13±0.8	11±0.8	16±0.4	16±0.2	19±2
<b>Tannins</b>	Raw	1.5±0.5	1.7±0.7	1.8±0.3	1.6±0.2	1.9±0.1	2±0.3	2±0.2
	100□-5'	2.8±0.4	2.8±0.3	3±0.4	2.9±0.3	3±0.1	3.1±0.1	3.3±0.3
	100□-10'	3±0.8	3.1±0.2	2.9±0.8	3.3±0.5	3.8±0.2	3.6±0.2	3.5±0.1
	100□-15'	3.2±1	3.3±0.1	3.2±0.3	3.1±0.6	3.5±0.4	3.5±0.4	3.6±0.4
	130□-5'	2.9±0.8	3±0.3	2.5±0.4	3±0.7	3.6±0.7	3.8±0.4	3.8±1
	130□-10'	3.2±0.2	3.2±0.5	3.6±0.2	3.2±0.8	3.8±0.8	3.7±0.6	3.9±0.6
	130□-15'	3±0.4	3.2±0.3	3.2±0.4	3.4±0.4	3.9±0.3	3.7±0.2	3.9±0.5
<b>Phytates</b> g/100g	Raw	1±0.1	0.9±0.3	0.8±0.3	0.8±0.1	0.9±0.2	1±0.1	0.9±0.1
	100□-5'	0.9±0.3	0.8±0.1	0.7±0.1	0.7±0.2	0.8±0.1	0.9±0.2	0.8±0.2
	100□-10'	0.8±0.5	0.7±0.2	0.6±0.3	0.6±0.1	0.7±0.3	0.8±0.4	0.7±0.1
	100□-15'	0.7±0.4	0.6±0.2	0.5±0.1	0.5±0.1	0.6±0.2	0.7±0.1	0.6±0.1
	130□-5'	0.6±0.1	0.5±0.2	0.4±0.1	0.4±0.2	0.5±0.1	0.6±0.1	0.5±0.2
	130□-10'	0.5±0.3	0.4±0.1	0.3±0.1	0.4±0.1	0.4±0.2	0.5±0.2	0.4±0.1
	130□-15'	0.4±0.1	0.4±0.1	0.4±0.1	0.3±0.1	0.3±0.1	0.3±0.1	0.3±0.1

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**Fig. 1** Bioaccessibility of total polyphenols roasted barnyard millets at zero and six months storage

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