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Accelerated Shelf Life of Processed Little Millet (*Panicum sumatrense)*

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Abstract

Millet without shells has a short shelf life. Dehulled millets develop autoxidation and become plagued by insects, causing them to turn rancid early due to their high fat content. Thus, a variety of processing techniques, such as dry heating, boiling, roasting, and so on, were used on all of the grains to reduce the amount of antinutrients, enhance digestibility, and lengthen the grain's shelf life. As a way to determine the grain's shelf-life assessment using the method of the Accelerated Shelf-Life Test, the focus of this article is to describe significant processing procedures and their impact on the shelf-life of little millet. Microwave-treated little millet grains, as compared to all other treatments, have a minimum shelf life of about 10 months under ideal storage conditions because the treated grain does not oxidize. This study demonstrates that, for all power levels of 720, 810, and 900 W and exposure times of 3, 6, and 9 minutes, little millet grain treated with electromagnetic radiation has a longer shelf life.

Keywords: Little millet, microwave treatment, hydrothermal treatment, roasting, Accelerated shelf life.

Introduction

Millets are a great complement to a regular diet since they have several health advantages. The majority of civilized people are unaware of millets, much less their nutritional advantages. Still, millet is one of the best-kept secrets of our ancestors. Since its introduction in China, millet has been used in many different countries and over the course of millennia V & Ambati, (2019). it is consumed in little amounts, little millet, like all other millets, is superior than cereals nutritionally. Little millet is also rich in nutrients, such as resistant starch, phytates, phenolic, sterols, lignans, and gamma-aminobutyric acid, Guha et al., (2015).Shelf-life studies may give product makers valuable information that helps them make sure consumers will see a high-quality product for a long time after production. Long shelf-life studies, of course, fail to satisfy the speed requirements; as a result, accelerated studies have been created as an innovative approach. Of the fatty acids, polyunsaturated are the least stable and have up to six double bonds, whereas monounsaturated fatty acids only have one. Enzymes, oxygen, and hydrogen may readily attack these double bonds, which are the most reactive locations on the fatty acid chain. These attackers each yield various results, this induction period, which can extend for a while with high stability oils, is characterized by little change in the peroxide value readings (which are frequently too tiny to quantify). The rate of peroxide breakdown in relation to production rises as oxidation continues. Due to the fact that formation proceeds more slowly than breakdown, the peroxide levels will eventually start to fall. When it comes to determining rancidity, the peroxide value is useless since many foods have ingredients like metal ions or enzymes that speed up the breakdown of peroxides. The best way to use the peroxide value test is to assess the quality of fresh oils, which should have a peroxide of one or below. When manufacturing mix products, shortening with a peroxide value of at least five need to be avoided as it would drastically shorten the product's shelf life, Sewald & Devries, (2003).

Materials and Methods

Materials

Little millets source:

The grain of the small millet variety ATL-1, which was released and registered in 2019, is nutrient-rich, drought-resistant, and ideal for mechanized harvesting. It originated from a neighboring farmer in Pollachi, Tamil Nadu. When the samples were first brought to the lab in packaging, their moisture level was 10.79 ± 0.08%. Following cleaning, each small millet sample was graded using an aspirator and grader before being placed in room-temperature polyethylene terephthalate containers for additional examination.

Sample preparation for analyses

Microwave treatment

As mentioned by Yadav, Anand, et al., (2012b) distilled water (300 ml, respectively) was added to a 1 kg sample of little millet that was placed in a stainless-steel tray. The sample's moisture content was initially 10.79 ± 0.08%; however, by the time it tumbled, it increased to 20% (wb). After ten minutes of spinning, the wet grains had 19–21% moisture. For a duration of 30 minutes, the humidity within the stainless-steel plate was maintained at 25°C ± 1.04°C. To guarantee that the moisture was distributed evenly, the basin was shaking on a regular basis. Using an infrared moisture sensor, the initial moisture content of the grain was found.

After being split, the cured sample was put in 100 gramme petri dishes that had a thickness of 1 ± 0.321 cm. The samples were then microwaved for 3, 6, and 9 minutes at power levels of 720 W, 810 W, and 900 W. After treating the grains and spreading them out on aluminum trays to cool, some millet samples were placed in 75 µm LDPE (low density polyethylene) bags with the least amount of headspace, and they were maintained at 4 ° C until the analysis was finished.

Roasting

Before dehulling and milling, the soaking grains reduce phytates, according to (Sarkar et al., 2015). After being soaked in water (3% w/v) for 2, 4, or 6 hours in the dark, around 300 g of whole millet seeds were roasted in a roaster for 10 minutes at 80, 100, or 120º C. After being roasted and allowed to cool to room temperature, the seeds were crushed in a mill and stored at 4°C for further testing Azad et al., (2019).

Hydrothermal treatment

After weighing clean millet samples (whole grains), the samples were soaked in water at a 1:3 (w/v) ratio for 2, 4, and 6 hours to produce steam-soaked grains. Maintain a temperature of 100°C for the full 15-minute cooking period. Following more testing at 4°C, the grains were dried for four hours at 60°C,Sahoo et al., (2020).

Methods

Milling characteristics of little millet

DE husker's mode of operation

Grain husks were removed by hulling. Bark is removed by abrasive DE huskers using grinding stones covered in carborundum that revolve at a steady speed. The rollers are closed by shells spaced at certain intervals. The sample is fed into the grinding stone through a hopper, and the shell is removed by cutting or polishing it. The dehulled grains that remain above the screen are suctioned, and the husks are blasted through a pipe and collected at a side exit. The powder is separated by a sieve beneath the stones and exits via the lowest level outlet. Grain residue that has been dehulled is gathered at the front outlet. What constitutes a performance,Nithyashree & Vijayalaxmi, (2023).

$$\text{Dehusking Efficiency \%} = \left(\frac{\text{Weight of the millet grain(g)}}{\text{Weight of the grains fed into a machine (g)}}\right) \times 100$$

$$\text{Head Grain Yield \%} = \left(\frac{\text{Weight of the head grains(g)}}{\text{Weight of the milled grain (g)}}\right) \times 100$$

$$\text{Broken \%} = \left(\frac{\text{Weight of the broken(g)}}{\text{Weight of the milled grains (g)}}\right) \times 100$$

$$M\text{illing Efficiency \%} = \text{Dehusking efficiency x Head rice yield x 100.}$$

Accelerated shelf life of little millet:

We assessed the storage stability of the chosen treated millet samples and the control group. Samples were placed in 75-gram polypropylene cover bags and kept in both ambient (28–34°C) and accelerated (55°C) storage settings. Ten days later, the samples were analyzed using (Association of Official Analytical Chemists (AOAC), 2019) procedures to determine any changes in the free fatty acid content and peroxide value.

Estimation of peroxide valve:

Chemical preparation must Pour 90 milliliters of concentrated acetic acid into a reagent flask after measuring it. Pour 60 ml of chloroform into the same reagent flask and stir to mix. To combine the chemicals, give the flask a shake. The acetic acid and chloroform combination at a ratio of 3:1 is now ready for use and for making 1% starch solution Pour 50 ml of distilled water into a 100 ml beaker, set the beaker on a hot skillet, and bring the water to a boil. Consider pour the 0.5g of weighed starch solution into the water that is boiling. To dissolve the starch in the water, now stir the mixture using a clean glass rod while it is boiling. Boil and stir until a clear solution is achieved. Immediately use filter paper to filter the solution once the starch has been dissolved. The 1% starch solution is now ready for use after 30 minutes of filtering the solution and transferring it to an appropriate container. The manufacture of 0.01N Sodium Thiosulfate is required. Mix thoroughly by shaking after dissolving 0.25g of sodium thiosulfate in 80ml of distilled water and adding 0.02g of sodium carbonate. If needed, heat the mixture to thoroughly dissolve the sodium thiosulfate, and then allow it cool to room temperature. To get the final volume of 100ml, add enough distilled water. Add potassium dichromate to the prepared solution to standardize it. The process of making saturated potassium iodide (KI) solution was Pour 2 milliliters of distilled water into the test tube, then gradually add KI until the bottom of the test tube is filled with undissolved KI. Saturated KI is prepared for usage. Preparing the samples was taking around 0.5–2 milliliters of the oil sample that was extracted from millet and records its weight in an Erlenmeyer flask. 30 milliliters of the acetic acid-chloroform combination should be measured, added to the flask, and shaken to combine the mixture with the sample. After adding one milliliter of saturated potassium solution, shake for a minute. To ensure a thorough mixing, add 30 milliliters of distilled water to the container and mix for a minute. Titration: Place 0.01N sodium thiosulfate in a burette and record the burette's first reading. As an indication, add 0.5 milliliter of 1% starch solution. After mixing by shaking and rotating the flask, begin the titration. Titration until the entire black hue is gone. Once the solution turns white, stop titrating. The last burette reading should be noted. To get the peroxide valve in meq/kg, utilize the equation below (Association of Official Analytical Chemists (AOAC), 2019).

$$Peroxide\ valve\ \left(\frac{meq}{kg}\right) = \frac{(Titre\ Valve\ x\ Normality\ of\ acid\ usedx100)}{\text{weight of the sample}}.$$

Oil extracted from the stored little millet grain for estimation of peroxide valve and free fatty acid.

Estimation of free fatty acid

In a 250 ml conical flask, 1–10 g of oil or melted fat will dissolve in 50 ml of the neutral solvent (neutral solvent: combine 47.5 ml of alcohol with 2.5 ml of distilled water). Add a few drops of phenolphthalein. Titration of the contents is performed against 0.1 N potassium hydroxide. Shake vigorously until a fifteen-second-long pink hue is achieved. Using the equation of oleic acid this free fatty acid (mg KOH/g) was computed (Association of Official Analytical Chemists (AOAC), 2019).

$$Acid\ value\ \left(mg\,\frac{KOH}{g}\right) = Titre\ value\ \times\ Normality\ of\ KOH\ \times (\frac{56.1}{Weightof\ sample\ (g)}).$$

Results and Discussion

Accelerated shelf life of control little millet

Any raw millet flour has a limited shelf life of 5 to 7 days, and for pearl millet it is considerably shorter due to the presence of unseen fats and sugars that quickly oxidize after milling. If millets are treated using food processing procedures such as parboiling, irradiation, and germination, they can increase their shelf-life, nutritional content, and possible health advantages to 6–12 months, Poshadri et al., (2023). Before these grains can be used for food, they need to be dehulled or ground into flour. Enzymes, bacteria, and other environmental elements like moisture and gasses can assault seeds when the cell wall is broken and the seed structure is destroyed during milling. The whole grain the flour of millet has greater fat content, such pearl millet, has been shown in several tests to begin to deteriorate after from ten to fifteen days of storage at room temperature, Tiwari et al., (2014));Yadav, Kaur, et al., (2012).Compared to other grains, there have been less scientific investigations on the storage of sorghum and other millets. This may be largely due to the remarkable results of the farmers' long-standing methods of storing millets, which have superior storage qualities when kept as whole grains Mobolade et al., (2019).

Table 3.1. Accelerated shelf life of control little millet.

Time of interval in days	Room temperature (32°C)		Accelerated temperature (55°C)	
L	Peroxide value	FFA value	Peroxide value	FFA value
0	1.01±0.15	18.86±0.08	1.01±0.15	18.86±0.08
10	2.27±0.26	18.41±0.35	2.41±0.2	32.37±0.28
20	3.05±0.06	18.86±0.07	3.26±0.15	32.59±0.3
30	3.76±0.27	20.54±0.25	6.69±0.03	33.82±0.17
40	5.04±0.07	23.55±0.4	7.21±0.21	34.65±0.07
50	5.67±0.3	26.1±0.1	25.62±0.37	42.53±0.44
60	6.76±0.5	26.32±0.18	37.39±0.18	46.51±0.21

Free fatty acid and peroxide readings at the beginning of the experiment revealed that there was 18.86±0.08 mg KOH/100g and 1.01±0.15 meq per 1000 grams, respectively. The results of the study demonstrated that free fatty acid and peroxide values rise with the length of storage (0, 10, 20, 30,40,50, and 60 days of storage). Using KOH as a metric, the percentage free fatty acid concentration in control millet varied from 18.86±0.08 to 60.34±0.21 and was within an acceptable range.

After being stored for 60 days, the free fat acidity of the untreated sample rise from 18.86 to 46.51 mg KOH/100g accelerated storage, respectively. Additionally, the untreated sample showed the highest rate of rise in free fat acidity. With regard to this, it was discovered that, at any given storage time, the FFA was lower under controlled conditions than under ambient ones. The samples' free fat acidity increased as the storage time lengthened. The research of Nantanga et al., (2008) lipolysis caused an increase in desterilized fatty acids, which was demonstrated by the rise in free fat acidity during storage in our study that on the 40th storage day, the rise in FFA was observed in an accelerated state, exceeding the ambient level of FFA.

The peroxide value in products containing oil should be between 20 and 40 meq/kg fat, according Kirk & Sawyer, (1991),and this study's results were within their limits. The increasing trends in free fatty acid (FFA) levels and peroxide value were identical.

Based on study of this shelf life got that the control little millet flour was rising the peroxide valve of 1.01±0.15 meq per 1000 grams to 25.62±0.37 meq per 1000 grams its indicated that the flour was rising peroxide value towards the spoilage in the accelerated storage environment, the oxidation of the unsaturated fatty acids in the mix may be the cause of the rise in the peroxide value. An indication of the development of rancidity during storage is the peroxide value. The concentration of peroxide was below 10 meq O_2/kg, indicating that the high fiber mix is stable. According to a study by Geetha et al., (2019),control little millet flour began to oxidize on the 40th day of storage in an accelerated storage environment. As a result, when no treatment is done, control little millet flour has an accelerated shelf life of 195 days. One detects a rotten flavor whenever the peroxide concentration value ranges from 30 and 40 meq/kg Chakrabarty, (2003).

When millet flour was kept, its peroxide value increased along with its moisture level. This phenomenon was explained by moisture-triggered hydrolytic rancidity. FFA content is a fundamental measure of food rancidity and directly influences the development of bad tastes and smells in flour during storage. FFA concentration is a fundamental measure of food rancidity and directly influences the development of bad tastes and smells in flour during storage. Applying different processing techniques to the grain or flour can improve its durability in millet flours. These methods seek to either mechanically eliminate the anatomical regions that produce lipids or inactivate the enzymes lipase and LOX through various processing procedures. Over the course of ten days of storage, Kaced et al.,(1984) observed a steady rise in the free fat acidity of pearl millet, from 20 to 60 mg/100g KOH, suggesting both oxidative and hydrolytic breakdown.

Accelerated shelf life of microwave treated little millet

Inactive lipase in cereal grains has been somewhat inhibited and shelf life extended by the use of microwave heating. The exact mechanism responsible for the microwave deactivation of enzymes remains unclear; there is disagreement over due to a thermal effect or an electromagnetic field effect**.** The authors (Arora et al., 2002) reported that applying a dry heat treatment (100 ± 2°C for 120 min) to pearl millet grains prior to milling significantly extended the shelf life of pearl millet flour (PMF) without compromising its acceptability. A potential sign of pearl millet flour degradation during storage, increased fat acidity, was confirmed by the study. In a 28-day storage investigation, the fatty acid acidity levels of the heat-treated flour increased from 30.3–123.7 mg KOH per 100 g and 28–50.5 mg KOH per 100 g, respectively.

Table 3.2. Accelerated shelf life of microwave treated little millet at 720W for 3 min.

Time of interval in days	Room temperature (32°C)		Accelerated temperature (55°C)	
7R	Peroxide valve	FFA valve	Peroxide valve	FFA valve
0	1.82±0.01	28.7±0.12	1.25±0.01	26.54±0.17
10	1.97±0.04	33.6±0.36	2±0.1	28.46±0.42
20	2.54±0.36	50.12±0.1	5.17±0.1	30.57±0.3
30	2.96±0.03	50.7±0.07	6.34±0.14	33.6±0.36
40	3.33±0.48	52.09±0.19	6.65±0.23	34.67±0.18
50	4.12±0.06	54.44±0.25	7.46±0.39	35.33±0.36
60	4.48±0.34	57.05±0.04	8.58±0.08	38.89±0.05

Table 3.3. Accelerated shelf life of microwave treated little millet at 720W for 6 min.

Time of interval in days	Room temperature (32°C)		Accelerated temperature (55°C)	
7S	Peroxide valve	FFA valve	Peroxide valve	FFA valve
0	1.58±0.36	9.7±0.19	1.58±0.36	9.7±0.19
10	2.19±0.01	14.17±0.28	2.28±0.01	19.62±0.08
20	3.33±0.16	14.41±0.49	4.76±0.06	23.39±0.25
30	3.68±0.19	16.36±0.16	5.1±0.1	23.75±0.19
40	7.85±0.16	16.48±0.26	5.46±0.01	27.28±0.14
50	8.37±0.26	18.44±0.1	8.44±0.32	28.7±0.12
60	8.44±0.32	20.36±0.55	9.23±0.37	29.35±0.51

Table 3.4. Accelerated shelf life of microwave treated little millet at 720W for 9 min.

Time of interval in days	Room temperature (32°C)		Accelerated temperature (55°C)	
7T	Peroxide valve	FFA valve	Peroxide valve	FFA valve
0	0.47±0.01	12.41±0.04	0.46±0.02	12.41±0.04
10	1.7±0.15	12.41±0.04	0.79±0.14	17.15±0.17
20	2.47±0.08	20.85±0.06	1.94±0.07	17.48±0.26
30	2.89±0.03	21.79±0.1	6.55±0.34	20.8±0.22
40	4.73±0.03	22.96±0.03	6.95±0.01	23.61±0.11
50	7.76±0.24	23.62±0.16	8.22±0.1	37.21±0.12
60	9.42±0.41	27.62±0.07	8.57±0.13	38.57±0.29

Table 3.5. Accelerated shelf life of microwave treated little millet at 810W for 3 min.

Time of interval in days	Room temperature (32°C)		Accelerated temperature (55°C)	
8R	Peroxide valve	FFA valve	Peroxide valve	FFA valve
0	1.06±0.09	20.33±0.3	0.89±0.09	18.79±0.36
10	1.68±0.25	24.77±0.14	1.02±0.01	20.33±0.3
20	1.89±0.16	26.78±0.15	1.04±0.02	21.21±0.02
30	2.7±0.06	32.12±0.15	1.12±0.01	24.77±0.14
40	2.82±0.09	34.44±0.04	1.69±0.33	26.26±0.18
50	3.22±0.1	49.52±0.23	1.89±0.03	27.38±0.23
60	7.7±0.16	55.48±0.5	1.96±0.03	30.37±0.54

Table 3.6. Accelerated shelf life of microwave treated little millet at 810W for 6 min.

Time of interval in days	Room temperature (32°C)		Accelerated temperature (55°C)	
8S	Peroxide valve	FFA valve	Peroxide valve	FFA valve
0	1.74±0.31	17.61±0.31	2.51±0.01	12.65±0.33
10	2.08±0.08	17.61±0.31	2.8±0.07	15.33±0.1
20	2.35±0.09	20.38±0.08	3.1±0.02	15.62±0.21
30	2.66±0.05	22.29±0.37	3.4±0.14	17.36±0.31
40	3.37±0.37	26.5±0.03	7.79±0.29	20.46±0.12
50	5.71±0.26	30.69±0.18	15.62±0.1	20.7±0.1
60	7.79±0.29	59.25±0.24	22.53±0.2	24.41±0.21

Table 3.7. Accelerated shelf life of microwave treated little millet at 810W for 9 min.

Time of interval in days	Room temperature (32°C)		Accelerated temperature (55°C)	
8T	Peroxide valve	FFA valve	Peroxide valve	FFA valve
0	1.16±0.03	9.09±0.04	3.27±0.18	9.09±0.04
10	1.96±0.01	16.44±0.3	3.34±0.2	11.56±0.24
20	2.41±0.26	20.64±0.28	4.13±0.12	18.45±0.25
30	2.79±0.09	28.46±0.42	4.37±0.04	21.68±0.16
40	3.34±0.2	29.21±0.03	4.54±0.23	40.17±0.22
50	8.16±0.02	31.46±0.46	6.64±0.02	40.75±0.14
60	9.35±0.02	38.33±0.02	7.2±0.09	47.58±0.41

Table 3.8. Accelerated shelf life of microwave treated little millet at 900W for 3 min.

Time of interval in days	Room temperature (32°C)		Accelerated temperature (55°C)	
9R	Peroxide valve	FFA valve	Peroxide valve	FFA valve
0	2.21±0.02	21.18±0.12	1.12±0.03	16.25±0.08
10	2.77±0.03	25.7±0.13	1.6±0.41	17.43±0.18
20	5.46±0.19	27.48±0.15	1.81±0.28	17.83±0.05
30	5.82±0.13	29.42±0.12	5.29±0.5	21.18±0.12
40	7.55±0.27	30.08±0.06	7.08±0.13	22.37±0.31
50	7.8±0.29	30.1±0.02	7.8±0.29	22.62±0.3
60	8.67±0.27	30.29±0.19	8.09±0.07	28.57±0.29

Table 3.9. Accelerated shelf life of microwave treated little millet at 900W for 6 min.

Time of interval in days	Room temperature (32°C)		Accelerated temperature (55°C)	
9S	Peroxide valve	FFA valve	Peroxide valve	FFA valve
0	5.86±0.12	10.45±0.44	0.77±0.04	10.32±0.2
10	6.45±0.3	16.57±0.22	1.89±0.03	13.52±0.36
20	7.24±0.28	17.2±0.2	6.22±0.16	13.87±0.08
30	8.39±0.19	18.2±0.06	6.49±0.14	16.62±0.12
40	8.87±0.18	18.76±0.3	7.24±0.28	17.61±0.31
50	9.65±0.03	19.47±0.44	10.15±0.25	20.64±0.28
60	9.88±0.04	22.65±0.11	11.2±0.04	22.57±0.02

Table 3.10. Accelerated shelf life of microwave treated little millet at 900W for 9 min.

Time of interval in days	Room temperature (32°C)		Accelerated temperature (55°C)	
9T	Peroxide value	FFA value	Peroxide value	FFA value
0	1.72±0.12	9.71±0.16	1.31±0.1	7.34±0.51
10	2.54±0.04	13.16±0.24	1.78±0.02	9.64±0.1
20	3.32±0.16	15.74±0.08	2.35±0.38	9.82±0.03
30	7.17±0.28	16.52±0.31	2.7±0.21	11.93±0.05
40	7.58±0.06	16.65±0.29	5.86±0.12	15.64±0.3
50	7.84±0.11	20.13±0.02	6.77±0.4	17.15±0.17
60	8.18±0.11	21.79±0.07	7.57±0.22	19.54±0.34

When the microwave power was kept at 900 W for 100 seconds in a study to assess the efficacy of microwave therapy for inactivating lipase in the pearl millet grain and the grain moisture content was 18%, there was a 92.9% reduction in the flour's lipase activity Yadav, Anand, et al., (2012a). With longer microwave treatment times, lipase was shown to inactivate more quickly; the maximum inactivation was reached at 90 seconds. After 30 days in storage, the FFA showed a similar tendency. The primary cause of inactivation of enzymes can be considered to be the thermal impact of microwave irradiation.

When all power levels of 720W, 810W, and 900W were used, along with exposure times of 3 minutes, 6 minutes, and 9 minutes, the impact of the microwave treatment on little millet grain was observed to enhance its shelf life, resulting in an accelerated shelf life of up to 300 days for all power levels of treatment. This also showed good results in reducing lipases activity. According to the study conducted by Geetha et al., (2019), there was no oxidation developed in the small millet grain that underwent microwave treatment, as demonstrated by the data that showed that the peroxide level was under 10 meq O_2/kg at all power levels, we funded this study to determine that all microwave-treated little millet grains have a minimum 300-day shelf life under ideal storage conditions. Additionally, there are no high increments in the FFA valve in either the ambient or accelerated storage condition, indicating that there is no a quiche degree of hydrolytic the decomposition and all products in the acceptable range. This conclusion also supported the research of microwave heating (18% moisture level, 80 s) of pearl millet grains significantly ($P < 0.05$) lowered lipase activity, as stated by Yadav, Anand, et al., (2012b).This may have been caused by the sample's high temperature (107.6 ºC) during the conversion of microwave energy into thermal energy. Furthermore, after 30 days of storage (15–35 ºC), microwave-treated flour was still considered acceptable, but control flour had a shelf life of just 10 days. After doing review Rani et al., (2018) came to the conclusion that heat treatments will be used to make food items based on pearl millet that have a longer shelf life and less anti-nutritional content on a commercial basis. Since there is less chance of rancidity, the low-fat content of the millet flour will have a lower energy value but a longer shelf life.

Accelerated shelf life of hydrothermal treated little millet

Its shelf life was shortened when rancidity and bitterness issues with pearl millet flour emerged during storage. Due to the degradation of glycerides and subsequent rise in the free fatty acid profile, these issues were brought on by the function of lipase enzymes Arora et al., (2002).

As reported by Rai et al., (2008);Singh et al., (2012), pearl millet flour's fat acidity, free fatty acid, and lipase activity were decreased when acid treatment (18 hours) and dry heat (120 minutes) were combined over the course of a 28-day storage period. The flour's longer shelf life than the control sample added to these outcomes.

Table 3.11. Accelerated shelf life of hydrothermal treated little millet -2hr soaked.

Time of interval in days	Room temperature (32°C)		Accelerated temperature (55°C)	
2hl	**Peroxide valve**	**FFA valve**	**Peroxide valve**	**FFA valve**
0	1.68±0.02	29.42±0.12	2.14±0.13	15.31±0.19
10	2.61±0.38	35.8±0.22	2.32±0.2	22.62±0.31
20	6.41±0.2	40.44±0.06	2.5±0.32	29.42±0.12
30	8.51±0.43	49.39±0.01	2.79±0.06	31.46±0.46
40	10.78±0.16	58.71±0.04	3.81±0.16	32.37±0.18
50	11.67±0.17	88.63±0.47	6.45±0.08	37.31±0.13
60	14.28±0.21	95.31±0.1	8.32±0.28	56.59±0.25

Table 3.12. Accelerated shelf life of hydrothermal treated little millet -4hrs soaked.

Time of interval in days	Room temperature (32°C)		Accelerated temperature (55°C)	
4hl	**Peroxide valve**	**FFA valve**	**Peroxide valve**	**FFA valve**
0	3.67±0.44	25.7±0.13	2.46±0.24	19.74±0.38
10	4.11±0.04	32.36±0.06	4.21±0.15	21.42±0.1
20	4.41±0.35	34.67±0.18	5.29±0.04	23.76±0.34
30	8.36±0.28	35.8±0.22	6.82±0.01	25.57±0.15
40	11.47±0.02	42.69±0.26	16.5±0.3	25.7±0.13
50	27.17±0.15	43.36±0.44	28.42±0.43	26.89±0.06
60	52.57±0.25	63.19±0.05	72.74±0.15	28.46±0.42

Table 3.13. Accelerated shelf life of hydrothermal treated little millet -6hrs soaked.

Time of interval in days	Room temperature (32°C)		Accelerated temperature (55°C)	
6hl	**Peroxide valve**	**FFA valve**	**Peroxide valve**	**FFA valve**
0	2.57±0.42	12.25±0.1	2.2±0.1	13.53±0.18
10	3.26±0.44	13.5±0.23	2.87±0.1	21.26±0.17
20	5.37±0.13	15.64±0.26	3.55±0.38	24.77±0.14
30	6.16±0.23	26.85±0.16	4.34±0.3	25.36±0.24
40	6.65±0.13	28.37±0.11	4.89±0.07	25.85±0.11
50	7.2±0.08	38.57±0.29	7.76±0.15	30.38±0.38
60	7.88±0.17	81.79±0.09	8.33±0.52	33.74±0.06

In contrast to the hydrothermally treated sample, the untreated and roasted samples showed a higher rate of rise in fat acidity during storage, suggesting that the hydrothermal treatment is more effective at inhibiting lipase. According to

Kashaninejad, (2019) research, millet grains were subjected to a heat-moisture treatments at varying temperatures and moisture levels to assess its impact on its shelf life.

The little millet grain that was subjected to hydrothermal treatment showed that after 2 hours of soaking and steaming for 15 mints, the grain's shelf life was significantly shorter than that of the control sample. This was due to the grain's increased oxidation during the 2-hour soaking period, which showed that the peroxide valve of the grain had increased to more than 10 meq O_2/kg within 40 days of storage in ambient conditions. Additionally, the FFA value had increased significantly when compared to the accelerated storage conditions. As a result, the grain's shelf life after 2 hours of soaking and hydrothermally treated gains was only 30 days in ambient temperature. It was found that little millet can be kept in better shape under controlled conditions than it can under ambient conditions. Furthermore, after soaking for four hours, the grains were hydrothermally treated, and the results showed that the peroxide value was greater than 10 meq O_2/kg within 40 days of storage at room temperature and 55 ºC of increased temperature. The fatty acid acidity levels of the hydrothermally treated grain increased from 25.7–63.19 mg KOH per 100 g to 19–28 mg KOH per 100 g at room temperature and accelerated temperature, respectively. The results of these modifications revealed that samples that had been hydrothermally treated and soaked for four hours had a shelf life of just 147 days. Despite the other treatment, the samples of small millet grains that were soaked for 6 hours and then steamed for 15 minutes had a much longer shelf life than the samples that were soaked for 2 hours and 4 hours, which had less of an impact on the millet grains' peroxide valve. However, there was a slight increase in the FFA valve and the peroxided valve of the small millet on the 60th day of storage. Based on these results, we were able to determine that the hydrothermally treated millet had a 300-day shelf life, while the 6-hour soaking method showed good results.

Hydrothermal treatment processing (steaming at 1.05 kg per m^2) stopped the lipase activity prior to (20 min) as well as after (15 min), according to Yadav, Kaur, et al., (2012) It was discovered that treated flour samples held at room temperature (15–35°C) for up to 50 days remained in acceptable condition when kept in 75 µm polyethylene pouches.

Accelerated shelf life of roasted little millet

According to research by Nantanga et al., (2008), roasting the pearl millet at 120°C for 16 mints was more effective than boiling it at 100°C for 15 minutes. During three months of storage, there was an increase in the fat acidity of the flour samples that were untreated (0.11 to 3.73 g per kg), roasted (0.01 to 0.68 g per kg), and steaming (0.00 to 0.04 g per kg).

Table 3.14. Accelerated shelf life of roasted little millet -2hrs soaked& 80ºC roasted.

Time of interval in days	Room temperature (32°C)		Accelerated temperature (55°C)	
2h8r	Peroxide valve	FFA valve	Peroxide valve	FFA valve
0	2.53±0.33	48.74±0.24	3.51±0.43	36.84±0.23
10	2.6±0.28	64.23±0.28	4.72±0.24	38.46±0.28
20	3.09±0.04	74.74±0.21	5.37±0.41	40.34±0.24
30	3.57±0.04	77.47±0.01	6.32±0.39	42.32±0.5
40	4.72±0.24	77.75±0.05	7.25±0.04	48.74±0.24
50	7.54±0.2	82.42±0.2	10.33±0.21	50.32±0.13
60	10.29±0.49	84.32±0.2	15.4±0.31	67.41±0.03

Table 3.15. Accelerated shelf life of roasted little millet -2hrs soaked& 100ºC roasted.

Time of interval in days	Room temperature (32°C)		Accelerated temperature (55°C)	
2h1r	Peroxide valve	FFA valve	Peroxide valve	FFA valve
0	1.13±0.13	16.57±0.22	2.36±0.22	16.77±0.14
10	4.23±0.16	37.29±0.44	2.67±0.25	20.59±0.02
20	5.36±0.1	40.25±0.42	3.48±0.35	45.28±0.47
30	5.78±0.2	51.47±0.28	4.23±0.16	66.68±0.16
40	8.27±0.12	51.51±0.35	4.76±0.06	71.66±0.31
50	8.45±0.21	53.45±0.31	8.43±0.42	76.71±0.46
60	9.77±0.14	96.68±0.14	11.48±0.2	88.56±0.23

Table 3.16. Accelerated shelf life of roasted little millet -2hrs soaked& 120ºC roasted.

Time of interval in days	Room temperature (32°C)		Accelerated temperature (55°C)	
2h2r	Peroxide valve	FFA valve	Peroxide valve	FFA valve
0	7.06±0.06	38.46±0.17	7.1±0.14	38.46±0.17
10	7.74±0.42	60.53±0.45	7.43±0.11	67.34±0.2
20	8.46±0.17	72.41±0.25	7.76±0.2	71.17±0.1

30	9.58±0.11	74.25±0.3	8.33±0.22	71.55±0.25
40	9.81±0.05	90.56±0.21	10.46±0.06	75.83±0.27
50	12.8±0.24	91.57±0.17	11.67±0.3	79.15±0.23
60	13.37±0.37	94.43±0.08	13.45±0.44	94.43±0.08

The profile of free fatty acids and fat acidity were significantly reduced in pearl millet flour when it was heat treated for 60 seconds at 110 °C, based on Tiwari et al., (2014). Additionally, heat-treated pearl millet flour can be kept at room temperature for up to six days. The millet grain was subjected to a 2-hour soaking period and an 80ºC roasting temperature. The millet was then dehusked and stored at two different storage temperatures: ambient temperature and accelerated temperature. The results of the peroxide valve at the 50th storage day showed that it had increased to more than 10 mg equivalent/kg in an accelerated condition, and the FFA valve had also increased. Based on these changes, we were able to determine that the millet grain's shelf life after two hours of soaking and roasting was 195 days, the same results were observed with little millet grains that were soaked for two hours and then roasted at 120 º C. The millet grains rancid at the 40-day storage point, resulting in a very short shelf life of 147 days for the treated samples when compared to the control samples. Afterwards, the process of accelerating hydrolytic and oxidative breakdown was started. In the meantime, the little millet grain's peroxide valve was more than 10 mg equivalent/kg during the 60-day storage period, and the FFA valve was also rising at that time, resulting in a 250-day shelf life for the 100ºC roasting process and 2-hour soaking duration of same millet grains.

Table 3.17. Accelerated shelf life of roasted little millet -4hrs soaked& 80ºC roasted.

Time of interval in days	**Room temperature (32°C)**		**Accelerated temperature (55°C)**	
4h8r	**Peroxide valve**	**FFA valve**	**Peroxide valve**	**FFA valve**
0	3.24±0.01	37.21±0.12	4.35±0.24	37.21±0.12
10	4.72±0.24	61.82±0.15	4.6±0.09	40.66±0.55
20	4.83±0.18	70.1±0.14	4.94±0.02	45.57±0.05
30	5.29±0.04	71.15±0.22	5.2±0.35	55.56±0.3
40	6.64±0.32	87.27±0.07	5.55±0.16	62.58±0.33
50	8.9±0.01	92.38±0.04	6.07±0.03	64.23±0.28
60	12.49±0.34	96.32±0.21	11.86±0.18	65.6±0.44

Table 3.18. Accelerated shelf life of roasted little millet -4hrs soaked& 100ºC roasted.

Time of interval in days	**Room temperature (32°C)**		**Accelerated temperature (55°C)**	
4h1r	**Peroxide valve**	**FFA valve**	**Peroxide valve**	**FFA valve**
0	5.16±0.16	48.74±0.24	5.2±0.13	61.07±0.05
10	6.18±0.14	57.51±0.05	5.34±0.13	61.37±0.02
20	7.11±0.11	61.69±0.18	5.57±0.21	70.32±0.15
30	7.61±0.33	76.24±0.16	7.36±0.31	72.56±0.28
40	8.91±0.14	83.21±0.07	8.88±0.12	77.65±0.45
50	9.37±0.48	87.65±0.26	9.57±0.16	80.57±0.42
60	12.33±0.15	94.55±0.09	11.62±0.19	83.36±0.32

Table 3.19. Accelerated shelf life of roasted little millet -4hrs soaked& 120ºC roasted.

Time of interval in days	**Room temperature (32°C)**		**Accelerated temperature (55°C)**	
4h2r	**Peroxide valve**	**FFA valve**	**Peroxide valve**	**FFA valve**
0	2.34±0.29	48.74±0.24	5.56±0.15	48.82±0.11
10	3.36±0.04	74.76±0.18	7.16±0.03	57.51±0.05
20	5.54±0.18	80.12±0.07	7.45±0.23	62.39±0.01
30	5.73±0.28	85.19±0.05	8.37±0.26	67.29±0.11
40	8.66±0.08	90.52±0.28	8.76±0.04	69.4±0.51
50	8.66±0.08	90.69±0.03	9.28±0.12	79.15±0.23
60	12.2±0.01	98.77±0.01	12.35±0.02	89.12±0.16

After soaking and steaming the millet grains for four hours, they were roasted at three different temperatures: 80ºC, 100ºC, and 120ºC. After the samples were dehusked, they were all studied for the duration of their shelf lives at ambient and accelerated temperatures. All three samples showed similar results, obtaining more than 10 mg of equ /kg within 60 days of storage, meaning that all three samples had a shelf life of 250 days.

Table 3.20. Accelerated shelf life of roasted little millet -6hrs soaked& 80ºC roasted.

Time of interval in days	Room temperature (32°C)		Accelerated temperature (55°C)	
6h8r	Peroxide valve	FFA valve	Peroxide valve	FFA valve
0	2.82±0.08	24.77±0.14	3.71±0.31	22.58±0.2
10	3.71±0.31	46.12±0.04	7.55±0.36	24.53±0.29
20	5.64±0.28	69.76±0.08	8.67±0.27	28.39±0.05
30	6.36±0.09	85.76±0.23	9.61±0.51	37.31±0.13
40	7.2±0.09	88.63±0.47	13.37±0.18	70.61±0.17
50	12.58±0.27	94.43±0.08	14.67±0.07	93.7±0.22
60	14.67±0.07	96.53±0.3	18.9±0.01	97.65±0.17

Table 3.21. Accelerated shelf life of roasted little millet -6hrs soaked& 100ºC roasted.

Time of interval in days	Room temperature (32°C)		Accelerated temperature (55°C)	
6h1r	Peroxide valve	FFA valve	Peroxide valve	FFA valve
0	5.72±0.42	40.59±0.26	5.72±0.42	40.17±0.22
10	8.33±0.08	57.48±0.11	6.82±0.04	40.79±0.1
20	8.5±0.18	80.58±0.42	7.2±0.09	51.29±0.44
30	10.71±0.12	83.21±0.07	10.37±0.33	66.31±0.26
40	11.22±0.23	90.71±0.21	10.49±0.37	83.21±0.07
50	11.92±0.03	92.23±0.08	16.13±0.09	91.63±0.24
60	14.79±0.16	94.55±0.09	22.23±0.01	92.48±0.34

Table 3.22. Accelerated shelf life of roasted little millet -6hrs soaked& 120ºC roasted.

Time of interval in days	Room temperature (32°C)		Accelerated temperature (55°C)	
6h2r	Peroxide valve	FFA valve	Peroxide valve	FFA valve
0	5.43±0.41	46.62±0.24	5.42±0.4	48.84±0.08
10	6.75±0.04	48.74±0.24	7.77±0.14	57.48±0.11
20	7.38±0.23	59.38±0.2	10.49±0.2	74.47±0.18
30	10.44±0.16	65.74±0.2	14.07±0.08	80.87±0.11
40	11.27±0.15	85.76±0.23	14.34±0.14	83.21±0.07
50	12.71±0.39	94.57±0.16	18.77±0.13	87.65±0.26
60	18.13±0.1	96.53±0.3	36.68±0.02	94.55±0.09

The little millet grain had a shelf life of only 147 days due to high levels of hydrolytic and oxidative breakdown, which began on the 40th day of storage in treated millet samples that had been soaked for a maximum of 6 hours and roasted at 80°C. At the same time, samples that had been soaked for 6 hours and then roasted at 100°C showed similar results of increasing the peroxide valve of more than 10 mg equ/kg on the 30th storage day. Therefore, we discovered that the 100 ºC roasted grains had a shelf life of only roughly 96 six days when stored as a grain. When millet is roasted at 120 degrees Celsius, the same amount of millet only lasts for 55 days in storage, making it extremely difficult to store for later use. Therefore, when millet is soaked for 6 hours and then roasted at a different temperature, its shelf life is compared to that of the control samples, indicating that 6 hours of soaking and roasting is not recommended for millet grain storage.

Conclusion

A key measure of food rancidity that directly influences the development of bad tastes and odor's during storage is the concentration of free fatty acid and peroxide valve. Therefore, in millet, the grain's endurance may be increased by applying various processing methods. This study proving that, in comparison to all other treatments, microwave-treated tiny millet grains have a minimum 300-day shelf life under perfect storage circumstances because no oxidation formed in the treated grain. When soaking for less than six hours, the little millet grain that underwent hydrothermal treatment had a much lower shelf life than the control sample; however, the six-hour soaking approach produced good results for the little millet grain's shelf life. The results of the roasting treatment shown that samples that were soaked for four hours, soaked for two hours, and then roasted had an average shelf life of more than 250 days. In contrast, samples that were soaked for six hours and then roasted showed degradation with a minimum of 55 days in storage days. Thus, our study demonstrates that tiny millet grain treated with electromagnetic radiation has a longer shelf life across all power levels and exposure durations.

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