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Development and Standardization of Germinated and Fermented Foxtail Millet Flour Incorporated Idli Batter for Enhancing Sports Performance

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Millets are a group of cereal grains that belong to the Poaceae family, commonly known as grass family. They contain many health promoting nutrients. Among the millets, Foxtail Millet (*Setaria italica*) is a highly nutritive, gluten free, easy to digest and non-acid forming millet. Fermentation improves gut health which is an essential part of athletic performance. It improves digestion, enhances absorption of nutrients, strengthens the immune system and improves intense exercise tolerance. In this study, Foxtail millet was soaked for 24 hours and germinated for 96 hours due to high antioxidant of 94% and less antinutritional factors. The germinated millet was subjected to cabinet drying and powdered. Foxtail millet Idly was prepared in various proportions at 10 hours fermentation. The fermented product was subjected to sensory evaluation and the result revealed that 50% foxtail millet flour incorporated idli was highly ranked based on the overall acceptability. Foxtail millet flour incorporated idli batter was prepared with the selected proportion of 3:1 ratio in different fermentation intervals of 6 hours, 8 hours, 10 hours and 12 hours. The comparative analysis of protein and vitamin C showed that when the fermentation period of idli batter increased, protein and vitamin C contents were also increased. Protein plays an important role in building and maintenance of muscles. High protein intake prevents soreness, improves endurance, muscle repair, recovery and reduces muscle damage. Antioxidants like vitamin C is beneficial in assisting with sports recovery and supporting return from injury. Hence, the germination and fermentation processes for millets could be utilized to prepare low cost nutritious food products, to enhance sports performance and to improve the nutritional status of the athletes.

Introduction

Eating is a must, but eating well takes skill. The most important factor in preserving human health and physical well-being is the nutritional value of food. Fermentation is a desirable process of biochemical modification of primary food matrix brought about by microorganisms and their enzymes (Kahajdova and Karovicova, 2007). Fermentation enhances the bioavailability of nutrients from different crops including millets and improves organoleptic properties as well as extending

the shelf life (Hotz and Gibson, 2007). It makes food safe by inhibiting growth of pathogenic bacteria due to anti microbial activity of lactic acid (Li et al., 2007; Sahlin, 1999). Fermentation has been considered as an effective way to reduce the risk of mineral deficiency among populations, especially in developing countries where unrefined cereals and millets are highly consumed (Kumar, Sinha, Makkar and Becker, 2010). Millets play an important role in the traditional diet of people. Fermentation is a traditional method of food processing and is extensively used in Asia to process cereals and millets. These foods constitute part of the daily food intake of the population. Fermented steamed foods are considered to be easily digestible and are particularly recommended for growing children and during convalescence. Nutritional enhancement of millets can be possible through fermentation. Millets are consumed whole or hand-pounded, unlike rice and wheat which are milled and polished. Thus, they contribute significantly not only to carbohydrate and protein intake, but also to the vitamin and fibre intake. Fermented foods have a special significance in the diet of a predominantly vegetarian population as in India. In such diets the major source of vitamin B12 is from lactic acid fermented foods. Other benefits include the antipathogenic effect during fermentative processing (Hesseltine, 1979, 1983). Foxtail millet is one of the minor millets, containing high amounts of proteins and minerals. Simple processing methods like dehulling, soaking, germinating, fermenting and cooking are recommended to result in significant decreases in antinutrients and increased bioavailability of minerals like iron and zinc and also protein digestibility (Suma and Urooj, 2012). Foxtail millet has the potential to be used in functional foods (Yang et al., 2022). Foxtail millet contains crude fibre, which aids digestion and helps to promote bowel movement. Additionally, Foxtail millet has several health advantages, such as cancer and cardiovascular sickness prevention, decreasing coronary heart attack risk, preventing diabetes and decreasing the level of lipids in the blood (Abedin et al., 2022). Nutritional needs of sportspersons are higher than non-athletes. Athletes due to their lack of time and poor availability of nutritious foods during competition seek for foods that to be easily consumed, at the same time provide with all the nutrients required by them (Arazi & Hosseini, 2012; Barzegari, Ebrahimi, Azizi, and Ranjbar, 2011). Nowadays, the demand and desire for a nutritionally balanced breakfast that are palatable, portable, convenient and free from additives are increasing among sportspersons (Burns, Schiller, Mearick, 2007; Banu et al., 2012; Ijarotomi et al., 2006). Sports breakfast prepared from composite mixture of various ingredients assure a mutual complementation of nutrients to supply adequate energy and increase muscular endurance of sportspersons (Roopa, 2011). Fermented millet based products are convenient, low bulk, portable and easy to consume, compact source of energy, protein, vitamins and fibre. Evidence is overwhelmingly indicating that germinated and fermented foods are superior in nutrients compared to their unfermented or ungerminated counterparts due to activation of endogenous enzymes that degrade antinutritional factors. Antioxidant properties of fermented foods are also elevated compared to their unfermented counterparts due to increased vitamin C and ease of release of different health promoting bioactive compounds resulting from weakening of grain matrix. (Smith N khata, Emmanuel Ayua, Elijah Kamau, and Jean Bosco Shingiro, 2018). Since foxtail millet being low in cost, nutritious and locally available indigenous food, various nutritious food products like idli, Dosa, Dhokla, panniyaram, etc can be developed by including the simple processing methods like germination and fermentation foxtail millet batter which helps in improving the nutritional status of the athletes and to enhance sports performance.

Methodology

Collection of Materials

Foxtail millet grains were purchased from local market in Sivakasi. The raw purchased millets were placed in a tray and the damaged grains, stones or pebbles together with all other extraneous matter were removed by hand and washed with water.

Preparation of Germinated Foxtail Millet Flourgerminated at 96 Hours

The research done by Vijayarani and Saravana Prabha (2023) revealed that soaking foxtail millet at 24 hours and germinating at 96 hours showed high antioxidant of 94% and less antinutritional factors. Ingredients were individually soaked in water at 24 hours and the water was drained. They were germinated at 96hours. And the water was sprinkled occasionally to maintain the moisture. After uniform germination, the millets were placed on trays separately under direct sunlight. The millets were dried using cabinet drier and grinded by using milling machine and was stored separately in a container for further analysis.

Developmentof Germinated Foxtail Millet Flour Incorporated Idli Fermented at 10 Hours

The ratio used for preparing foxtail millet flour incorporated idli fermented at 10 hours were selected by following the ratios of 2:1,3:1 and 4:1. The germinated foxtail millet flourwas added into the ratio of 25%, 50% and 75%in all samplesto makeidli flour by using replacement method and the acceptability test was done by 10 panel members. The ingredients used for the preparation of idli are given in table 1.

Table Ingredients used for the Preparation of the Germinated Foxtail Millet Flourincorporated Idli Fermented At 10 Hours

| Ingredients used | Control Sample | Experimental Sample A | Experimental Sample B | Experimental Sample C |
|--------------------------|----------------|-----------------------|-----------------------|-----------------------|
| Foxtail millet flour (g) | - | 25 | 50 | 75 |
| Rice flour (g) | 75 | 50 | 25 | - |
| Urad dal flour (g) | 25 | 25 | 25 | 25 |
| Salt (to taste) | To taste | To taste | To taste | To taste |

Table 1 shows the ingredients used for the preparation of germinated foxtail millet flour incorporated idli fermented at 10 hours

Sensory Evaluation of Germinated Foxtail Millet Flour Incorporated Idli Fermented at 10 Hours

For evaluating the sensory characteristics, the three different formulations of germinated foxtail millet flour idli fermented for 10 hours were assessed by 10 panel members. The panellist was asked to determine the sensory attributes on the basis of 5 point Hedonic scale and they were scored on the basis of sensory qualities such as appearance, colour, taste, texture and odour. The overall acceptability was evaluatedby the mean score of all the attributes.



Figure 1 Prepared Germinated Foxtail Millet Flour Idli Fermented At 10 Hours

Figure 1 shows the prepared germinated foxtail millet flour incorporated idli fermented at 10 hours.

Preparation of Germinated Foxtail Millet Flour Incorporated Idli Batter Fermented at Various Periods

Idli batter was prepared with theselected ratio ofselected germinated foxtail millet flour, rice flour and black gram dhal flour. This selected sample was fermented at various periods of 6 hours, 8 hours,10 hours and 12 hours.

Determination of Protein of the Selected Germinated Foxtail Millet Flour Incorporated Idli Batter Fermented at Various Periods

The protein content of the sample was determined by using “Lowry’s Method”. The amount of protein present was calculated from the nitrogen concentration of the sample. In this study, protein content was determined for germinated foxtail millet flour idli batter fermented at various periods of 6 hours, 8 hours, 10 hours and 12 hours

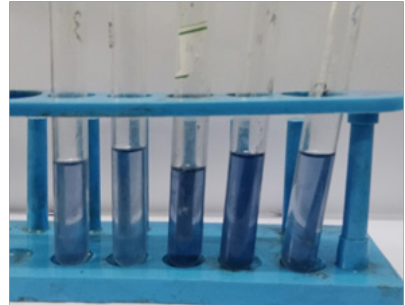


Figure 2 Estimation of Protein

Figure 2 shows the estimation of protein present in germinated foxtail millet flour incorporated idli batter fermented at various periods.

Determination of Vitamin C of the Germinated Foxtail Millet Flour Incorporated Idli Batter Fermented at Various Periods

In this study, ascorbic acid was determined for the germinated foxtail millet flour idly batter fermented at various periods of 6 hours, 8 hours, 10 hours and 12 hours



Figure 3 Estimation of Vitamin C

Figure 3 shows the estimation of vitamin C present in germinated foxtail millet flour incorporated idli batter fermented at various periods.

Development of the Selected Germinated Foxtail Millet flour Incorporated Idli Batter Fermented for 12 Hours

The nutritional values of protein and vitamin C were compared in the developed batter fermented at various periods. The batter which was formed at 12 hours had high protein and vitamin C contents. So it was selected to develop and standardize idli incorporated with foxtail millet. The selected germinated foxtail millet flour was added into the ratio of 25%, 50% and 75% in all samples to make idli by using replacement method and the acceptability test was done by 10 panel members. The ingredients used for the preparation of foxtail millet flour incorporated idli are given in table

Table 2 Ingredients used for the Preparation of Selected Germinated Foxtail Millet Flour Incorporated Idli Batter fermented for 12 Hours

| Ingredients Used | Control Sample | Experimental Sample A | Experimental Sample B | Experimental Sample C |
|-------------------------|----------------|-----------------------|-----------------------|-----------------------|
| Foxtail millet flour(g) | - | 25 | 50 | 75 |
| Rice flour(g) | 75 | 50 | 25 | - |
| Urad dal flour(g) | 25 | 25 | 25 | 25 |
| Salt (to taste) | To taste | To taste | To taste | To taste |

Table 2 shows the ingredients used for the preparation of the selected germinated foxtail millet flour incorporated idli batter fermented at 12 hours

Sensory Evaluation of Germinated Foxtail Millet Flour Incorporated Idli Batter Fermented at 12 Hours

For evaluating the sensory characteristics, the three different formulations of germinated foxtail millet flour idli fermented for 10 hours were assessed by 10 panel members. The panellist was asked to determine the sensory attributes on the basis of 5 point Hedonic scale and they were scored on the basis of sensory qualities such as appearance, colour, taste, texture and odour. The overall acceptability was evaluated by the mean score of all the attributes.



Figure 4 Prepared Germinated Foxtail Millet Flour Incorporated Idli Batter Fermented At 12 Hours

Figure 4 shows the prepared germinated foxtail millet flour incorporated idli batter fermented at 12 hours

Results and Discussion

Selection of the Ratio of the Ingredients used for Preparing Germinated Foxtail Millet Flour Incorporated Idli

According to research done by Debasree Ghosh and Parimal Chattopadhyay et al 2011, It is evident that 10 hours of fermentation of idli batter provided maximum production of all vitamins and the preferred ratio of idli batter was 3:1 which produced considerable amount of B vitamins. Therefore 3:1 ratio fermented at 10 hours was used for preparing the batter.

Sensory Evaluation of the Germinated Foxtail Millet Flour Incorporated Idli Fermented at 10 Hours

The germinated Foxtail millet flour was incorporated in the ratio of 25%, 50%, and 75% to make idli. They were subjected to sensory evaluation by 10 panel members and then the mean scores were obtained and analysed statistically.

Table 3 Mean Scores of the Germinated Foxtail Millet Flour Incorporated Idli Fermented at 10 Hours

| Characteristics | Control | Experimental sample A | Experimental sample B | Experimental sample C |
|-----------------------|----------|-----------------------|-----------------------|-----------------------|
| Flavour | 4.2±0.5 | 3.8±0.3 | 4.6±0.6 | 4.1±0.3 |
| Taste | 4.4±0.37 | 3.6±0.2 | 4.8±0.77 | 4.2±0.74 |
| Colour | 4.5±0.44 | 3.9±0.8 | 4.8±0.24 | 4.4±0.8 |
| Texture | 4.5±0.45 | 3.4±0.5 | 4.9±0.7 | 4.2±0.7 |
| Overall acceptability | 4.5±0.8 | 3.7±0.74 | 4.7±0.8 | 4.2±0.4 |

Table 3 shows the mean score of the germinated foxtail millet flour incorporated idli fermented for 10 hours. Evaluation of organoleptic attributes of the germinated foxtail millet flour idli fermented for 10 hours for colour, texture, flavour, taste and overall acceptability of 50% germinated Foxtail millet flour Idly was excellent with the mean score of 4.7±0.8 than the other two variations. Therefore, 50% foxtail millet flour incorporated idli batter was selected for further analysis.

Comparison of the Protein Present in the Germinated Foxtail Millet Flour Incorporated idli Batter Prepared from the Selected Ratio Fermented at Various Periods

The protein content of the samples were determined by Lowry's method. Protein is essential for muscle development and body building. The protein present in the germinated foxtail millet flour incorporated idli batter fermented at various periods are given below.

Table 4 Comparison of Protein Present in the Germinated Foxtail Millet Flour Incorporated Idli Batter Fermented at Various Periods

| S. No | Fermentation Periods | Protein Value (g) |
|-------|----------------------|-------------------|
| 1 | 6hrs | 11.2 |
| 2 | 8hrs | 12 |
| 3 | 10hrs | 13.4 |
| 4 | 12hrs | 15.2 |

Table 4 shows the protein content of the germinated foxtail millet flour incorporated idli batter prepared from selected ratio fermented at various periods. The result found that the fermentation period of 12 hours had high protein content compared to other periods of fermentation. The result coincides with the research done by Lakshmi et al., (2015) who found that the germinated foxtail millet grains contained more protein content with fermentation.

Comparison of the Vitamin C Present in Germinated Foxtail Millet Flour Incorporated Idli Batter Prepared from the Selected Ratio Fermented at Various Periods

Table 4 Comparison of Vitamin C Present in the Germinated Foxtail Millet Flour Incorporated Idli Batter Fermented at Various Periods

| S. No | Fermentation Periods | Vitamin C Value (mg) |
|-------|----------------------|----------------------|
| 1 | 6 hours | 6.66 |
| 2 | 8 hours | 13.3 |
| 3 | 10 hours | 16.66 |
| 4 | 12hours | 20 |

Table 4 shows the Vitamin C content of the germinated foxtail millet flour incorporated idli batter prepared from the selected ratio fermented at various periods. The result found that the fermentation period of 12 hrs had high Vitamin C content compared to other periods of fermentation. The result coincides with the research done by Mukherjee et al., (1965) who found that the fermented foxtail millet contained more Vitamin C content with fermentation. Hence, it was concluded to develop germinated foxtail millet flour incorporated idli with 12 hours fermentation period.

Sensory Evaluation of the Selected Germinated Foxtail Millet Flour Incorporated Idli Fermented at 12 Hours

The selected germinated foxtail millet flour was incorporated in the ratio of 25%, 50%, and 75% to make idli. They were subjected to sensory evaluation by 10 panel members and then the mean scores were obtained and analysed statistically.

Table 5 Mean Scores of the Selected Germinated Foxtail Millet Flour Incorporated Idli Fermented for 12 Hours

| Characteristics | Control | Experimental sample A | Experimental sample B | Experimental sample C |
|-----------------------|----------|-----------------------|-----------------------|-----------------------|
| Flavour | 4.1±0.6 | 4.2±0.4 | 4.6±0.6 | 4.2±0.3 |
| Taste | 4.2±0.5 | 4.5±0.75 | 4.5±0.77 | 4.1±0.74 |
| Colour | 4.2±0.24 | 3.6±0.8 | 4.8±0.24 | 3.6±0.7 |
| Texture | 4.1±0.2 | 3.5±0.6 | 4.4±0.7 | 3.8±0.5 |
| Overall acceptability | 4.2±0.4 | 4.0±0.6 | 4.5±0.8 | 4±0.3 |

Table 5 shows the mean score of the selected germinated foxtail millet flour incorporated idli fermented for 12 hours. Evaluation of organoleptic attributes of the selected germinated foxtail millet batter incorporated idli for colour, texture, flavour, taste and overall acceptability. 50% germinated foxtail millet flour incorporated idli was excellent with the mean score of 4.5±0.8 than the other two variations.

Conclusion

The study concluded that the implementation of soaking at 24 hours, germination at 96 hours and fermentation at 12 hours of foxtail millet flour incorporated idli batter resulted in bio availability of the nutrients such as protein and vitamin C. So fermented foxtail millet flour food product serves as a low cost nutrient rich food to enhance sports performance and improve nutritional status of athletes. Hence, the sprouting and fermentation methods can be used to develop value added food products. A small step to process the foxtail millet helps in enhancing sports performance for athletes.

References

1. Suma, P.F., & Urooj, A. (2012). Antioxidant activity of extracts from foxtail millet (*Setaria italica*). *Journal of food science and technology*, 49, 500-504.
2. Yang, T., Ma, S., Liu, J., Sun, B., & Wang, X. (2022). Influences of four processing methods on main nutritional components of foxtail millet: A review. *Grain & Oil Science and Technology*.
3. Nkhata, S. G., Ayua, E., Kamau, E. H., & Shingiro, J. B. (2018). Fermentation and germination improve nutritional value of cereals and legumes through activation of endogenous enzymes. *Food science & nutrition*, 6(8), 2446-2458.
4. Kahajdova, Z. , & Karovicova, J. (2007). Fermentation of cereals for specific purpose. *Journal of Food and Nutrition Research*, 46, 51–57.
5. Hotz, C., & Gibson, R.S. (2007). Traditional food processing and preparation practices to enhance the bioavailability of micronutrients in plants-based diets. *Journal of Nutrition*, 137, 1097–1100. 10.1093/jn/137.4.1097
6. Chaves Lopez, C., Serio, A., Grande Tovar, C.D., Cuervo Mulet, R., Delgado Ospina, J., & Paparella, A. (2014). Traditional fermented foods and beverages from a microbiological and nutritional perspective: The Colombian Heritage. *Comprehensive Reviews in Food Science and Food Safety*, 13, 1031–1048. 10.1111/1541-4337.12098
7. Kumar, V., Sinha, A. K., Makkar, H. P. S., & Becker, K. (2010). Dietary roles of phytate and phytase in human nutrition: A review. *Food Chemistry*, 120, 945–959. 10.1016/j.foodchem.2009.11.052
8. Hesseltine, C. W. (1979). Some important foods of Mid-Asia, the Middle East and Africa. *J. Am. Chem. Soc.*, 56, 367-374.
9. Hesseltine, C.W. (1983). The future of fermented foods. *Nutr. Rev.*, 41, 293-301.
10. Arazi H, Hosseini R. A comparison of nutritional knowledge and food habits of collegiate and non-collegiate athletes. *Sport Logia*, 2012; 8(2):100-107.
11. Barzegari A, Ebrahimi M, Azizi M, Ranjbar K. A Study of nutrition knowledge, attitudes and food habits of college students. *World Applied Sciences Journal*. 2011;15(7):1012-1017.
12. Vijayarani D, Saravana Prabha P(2023).Millets- Ensuring Food Security and Sustainable Farming volume 14, issue 04 (July Aug 2023), pp 895-897