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Impact of Glycemic Index and Antioxidant Activity on Human Health of Barnyard Millet-based Designer Vermicelli

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ABSTRACT

Background: A nutrient-rich staple food throughout Asia and Africa, millet is a hardy and drought-resistant crop. Antioxidant-rich bioactive compounds can be found in abundance in millet. Consuming functional ingredients rich in antioxidants through diet is necessary to enhance human health. In this study, four beneficial ingredients (fenugreek seeds, garden cress seeds, Brahmi leaves and Ekanayakam root bark) were added to barnyard millet which contains several bioactive principles that were utilised to prepare designer vermicelli.

Methods: The present study is to formulate the designer vermicelli with a combination of barnyard millet at 40 per cent, functional ingredients of fenugreek seed flour, garden cress seed flour, ekanayakam root bark at 2 per cent and brahmi leave powder at 0.5 per cent. This study aims to determine the antioxidant activity and glycaemic index for the developed barnyard millet vermicelli incorporated with the functional ingredient.

Result: The antioxidant activity measured using DPPH scavenging activity shows that the barnyard millet vermicelli has a high antioxidant activity of 23.28 to 27.18 per cent initially which decreased to 22.94 to 26.74 per cent during the fourth month of storage. The glycemic index of the designer vermicelli varied from 48.25 to 57.91 which was lower than in the control (74.89).

Key words: Antioxidant activity, Barnyard millet, Designer vermicelli, Functional ingredient, Glycemic index, Millet.

INTRODUCTION

Millets are considered “Nutri cereals” because of their abundance of B vitamins, calcium, iron, potassium, magnesium, zinc, dietary fibre and antioxidants. The wonder grains, which are thought to be superior to cereals helps to reduce malnutrition and serious mineral deficiencies (Saini *et al.,* 2021). Antioxidants are bioactive substances that contain the phenolic compounds like tannins, flavonoids and phenolic acids, Carotenoids, ascorbic acid, alkaloids, chlorophyll derivatives, amino acids and amines act as nitrogen compounds, Butylated hydroxyanisole (BHA) and butylated hydroxytoluene (Divya and Garg, 2024). The intake of antioxidant-rich foods helps to regulate blood pressure, diabetes, heart disease and other health conditions. Millet can serve as a therapeutic food with miraculous health advantages (Amadou, 2022).

Barnyard millet (*Echinochloa frumentacea*) is the fastest growing of all the millets and under favourable moisture and temperature conditions Barnyard millet is one of the hardiest millets, which is otherwise known as Japanese barnyard millet, *Sanwan, Kuthiravaali* and *Kavadapullu Ooda, Oadalu* and *Sanwank.* Barnyard millet, a nutritious grain contains a protein of 12 per cent with high digestibility (81.13 per cent) coupled with carbohydrate of 58.56 per cent with slow digestibility (25.88 per cent). Barnyard millet is a minor millet that contains various good sources of micronutrients and phytochemicals like alkaloids, phenols, flavonoids, tannins, terpenoids and saponins (Renganathan *et al.,* 2020).

Barnyard millet, which has excellent nutritional, antioxidant, antimicrobial and medicinal benefits, can be used to create novel products that will be more appealing to consumers (Chandraprabha *et al.,* 2017). Consuming barnyard millet-based value-added products helps to address several health issues, including diabetes, obesity, cardiovascular disease, hypertension, ageing and celiac disease. It is possible to think about barnyard millet as a nutritious food that promotes good health.

Consumer’s interest towards functional food has increased and nowadays people are more interested in foods fortified with functional ingredients (Day *et al.,* 2009). The functional ingredients like fenugreek (*Trigonella foenum - graecum*) seeds, garden cress (*Lepidium sativum*) seeds, Brahmi (*Bacopa monnieri*) leaves and Ekanayakam (*Salacia reticulata*) root bark with antioxidant

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properties, antidiabetic, anticarcinogenic, antibacterial, hypocholesterolemic and hypoglycemic properties were used to develop a convenient product (Wani and Kumar, 2015b; Yadav, 2014; Yoshino *et al.,* 2009).

Designer vermicelli made from barnyard millet and a range of functional ingredients can be utilized as a potential vehicle to deliver nutraceutical qualities (Goel *et al.,*, 2021; Kaur *et al.,* 2024). This research aims to examine the antioxidant and glycemic index of prepared barnyard vermicelli supplemented with beneficial additives for human health.

MATERIALS AND METHODS

Barnyard millet-based designer vermicelli was formulated by using germinated barnyard millet flour, whole wheat flour and functional ingredients (fenugreek seeds flour, garden cress seed flour, Brahmi leaves powder and Ekanayakam root bark) to evaluate its acceptability and health qualities.

Preparation of barnyard millet flour and functional ingredients

Barnyard millet was cleaned, washed and soaked in water for 10 hours, with a water change every 2 hours. The surplus water was drained and the seeds germinated for 24 hours under a damp cloth. The seeds were dried in a hot air oven at 65 degrees Celsius. Devegetated seeds were pulverized and sieved through a 40 mesh sieve.

Fenugreek seeds were cleaned, washed and steeped in water for 12 hours, with six-hour water changes. The seeds were dried at 65 degrees Celsius, pulverized and sieved through a 40-mesh sieve after 24 hours of germination to achieve uniform flour. Garden cress seed and Ekanayakam root bark were dried at 65 degrees Celsius, powdered and sieved through a 40-mesh sieve to form fine flour. Brahmi leaves were dried at 65 degrees Celsius to a moisture level of less than 10 per cent, pulverized and sieved through a 40 mesh size to obtain a uniform powder.

Preparation of barnyard millet vermicelli incorporated with functional ingredients

Millet based vermicelli was prepared by adapting the standard procedure of Ranganna *et al.* (2014). The treatment T_0 was vermicelli prepared using refined wheat flour, served as control. Treatments T_1 to T_4 were prepared using germinated barnyard millet flour incorporated with different proportions of ingredients used as given Table 1. Brahmi (*Bacopa monnerei*) incorporation at the level of 0.5 g was shown to be superior in terms of sensorial quality (Zaker *et al.,* 2014).

Organoleptic analysis

The acceptability evaluation of the prepared barnyard millet vermicelli and uppuma recipe was carried out by a well-trained panel of 15 judges. The quality parameters like appearance, colour, flavour, texture, taste and overall acceptability were analysed by a panel of judges.

Health studies

Total antioxidant activity

Antioxidant capacity of the barnyard millet based functional ingredient vermicelli extract was measured using DPPH (1’1- diphenyl-1-picryl hydrazine) spectrometric assay as suggested by research of Blois (1958). The Methanolic solution containing DPPH radicals (0.1 mM) was added to the sample at varied concentrations and the mixture was violently agitated. The reaction mixture was left in the dark for 30 minutes. In a spectrophotometer, the absorbance was measured at 517 nm. Using the following formula, the percentage of antioxidant activity was calculated.

% Inhibition of free radical=

$$\frac{\text{Absorbance of control - Absorbance of sample}}{\text{absorbance of the control}} \times 100$$

The graph of the percentage of radical scavenging activity against sample concentration was used to determine the sample concentration that would inhibit an enzyme by 50% (inhibitory concentration - IC_{50}).

Glycemic index

A glucose tolerance test is a glucose loading test to understand the function of islet beta cells and the body’s ability to regulate glucose**.** The five healthy people were given the barnyard millet-based designer vermicelli and control food to test its glycemic reaction and the glycemic index was calculated using a formula suggested by Srilakshmi (2011). Glucometers are used to carry out this test. Initially, a glucose tolerance test was performed to identify the healthy patients. The respondents were instructed to stop taking all medications at least three days before to the test and to keep an eight-hour fast. A measurement of the fasting blood glucose was made. By giving barnyard millet-based *uppuma* recipe to each subject and comparing the results to the control, the postprandial glucose level for each subject was determined. A similar amount of the test food was consumed alongside 75 g of glucose. At specified time intervals of 30 minutes up to 2 hours after the food load, the blood glucose levels were measured. The glycemic index of the barnyard millet *uppuma* were computed from the observation recorded with the formula as follows.

Glycemic index =

$$\frac{\text{Incremental area under the 2 hours plasma glucose curve after eating 75 g of CHO from test food}}{\text{Incremental area under the 2 hours plasma glucose curve after eating 75 g of CHO from glucose}}$$

Quality evaluation

Health studies like antioxidant activity and glycemic index for barnyard millet-based vermicelli were done initially, second and fourth months after storage.

RESULTS AND DISCUSSION

Table 2 and 3 display the test results for the taste and flavour of barnyard millet vermicelli and uppuma with functional ingredients added. According to the findings of the study, barnyard millet vermicelli (T_1) prepared with 40 per cent barnyard millet, 58 per cent whole wheat flour and 2 per cent fenugreek seed flour was highly acceptable in terms of appearance, flavour, texture and taste; treatment T_4 prepared with 40 per cent barnyard millet, 58 per cent whole wheat flour and 2 per cent Ekanayakam root barks was highly acceptable in terms of colour. The fenugreek seed-infused barnyard millet-based designer vermicelli received a mean acceptance score of 7.77, while the garden cress received a score of 7.88. In Treatment T_1, the lowest colour values decrease the overall acceptability of the product.

The barnyard millet *uppuma* fortified with functional ingredients treatment T_1 prepared with a proportion of 40 per cent barnyard millet, 58 per cent whole wheat flour and 2 per cent fenugreek seed flour was highly acceptable in terms of flavour and texture. The treatment T_2 barnyard millet based *uppuma* fortified with garden cress seed flour in combination of 40 per cent barnyard millet, 58 per cent whole wheat flour and 2 per cent garden cress seed flour was highly acceptable, with a mean score in terms of appearance (8.40), colour (8.24), taste (8.06) and overall acceptability (8.31).

The antioxidant activity of barnyard millet-based vermicelli incorporated with functional ingredients was higher than the control, as represented in initially, the antioxidant activity of vermicelli made from barnyard millet ranged from 23.28 to 27.18 per cent, with T_1 (fenugreek-based vermicelli) having the highest antioxidant activity and T_4 (Ekanayakam-based vermicelli) having the lowest antioxidant activity (Table 4). The antioxidant activity of the vermicelli gradually decreased during the second month of storage, we observed that T_1 had the highest antioxidant activity (26.98 per cent) and T_4 had the lowest antioxidant activity (23.09 per cent). During the fourth month of storage, the antioxidant activity of the vermicelli ranged from 22.94 per cent (T_2) to 26.74 per cent (T_1). Control (T_0) had the lowest antioxidant activity of all the vermicelli, starting at 13.68 per cent and falling to 13.37 per cent by the end of storage. Over the entire storage period, a significant difference was observed in all treatments. According to Devi and Nazni (2016), barnyard millet flour exhibited a greater level of antioxidant activity compared to other millets. In addition, they developed chapatti made from barnyard millet, which exhibited an antioxidant activity ranging from 47 to 53 per cent. Dar *et al.* (2016) found that after 6 months of storage, the antioxidant activity of bran-enriched extruded snacks decreased from an initial value of 38.99 per cent to 32.15 per cent. Wani and Kumar (2016) and Sharma and Riar (2020) observed a similar trend of antioxidant decreases in storage.

The five non-diabetic responders were given the equivalent of 75 g of carbohydrate-rich test food carbohydrates. The glycaemic index of barnyard millet-based vermicelli incorporated with functional ingredients

Table 1: Treatments for the preparation of functional ingredient incorporated barnyard vermicelli.

Treatment	Combination
T_0	Control (100% Refined wheat flour)
T_1	40% BM + 58% WWF + 2% F
T_2	40% BM + 58% WWF + 2% G
T_3	40% BM + 59.5% WWF + 0.5% B
T_4	40% BM + 58% WWF + 2% E

(BM- Barnyard millet flour, WWF- Whole wheat flour, F- Germinated fenugreek seed flour, G- Garden cress seeds flour, B- Brahmi leaves powder and E- Ekanayakam root bark powder).

Table 2: Mean score for organoleptic evaluation barnyard millet-based vermicelli fortified with functional ingredient.

Treatments	Sensory attributes					
	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability
T_0	8.84	8.86	8.71	8.84	8.77	8.82
T_1	8.44	7.77	8.20	8.00	8.40	7.77
T_2	8.06	7.80	7.60	7.78	7.68	7.88
T_3	8.04	7.90	7.81	7.70	7.80	7.85
T_4	7.77	7.91	7.80	7.73	7.81	7.75

Table 3: Mean score for organoleptic evaluation barnyard millet based *uppuma* fortified with functional ingredient.

Treatments	Sensory attributes					
	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability
T_0	8.22	8.86	8.71	8.82	8.77	8.22
T_1	8.04	7.80	8.22	8.46	7.55	7.88
T_2	8.40	8.24	8.04	7.91	8.06	8.31
T_3	7.95	7.85	7.77	7.84	8.03	7.88
T_4	7.71	7.84	7.67	7.71	7.06	7.73

Table 4: Total antioxidant activity of barnyard millet based designer vermicelli on storage.

Treatments	Total antioxidant activity (%)		
	Initial	2nd month	4th month
T_0	13.68[e]	13.52[e] (1.14)	13.37[e] (1.10)
T_1	27.18[a]	26.98[a] (0.72)	26.74[a] (0.88)
T_2	24.73[b]	24.63[b] (0.55)	24.56[b] (0.32)
T_3	23.47[c]	23.32[c] (0.65)	23.21[c] (0.47)
T_4	23.28[d]	23.09[d] (0.80)	22.94[d] (0.64)
C.D (0.05)	0.045*	0.087*	0.049*
Significance	S	S	S

Figure in parenthesis indicates per cent relative change over the previous month.
Values with same alphabet for different treatments represented in each column form a homogenous group.

Table 5: Glycemic index of the selected vermicelli.

Treatments	Quantity (g) (equivalent to 75 g of CHO)	Glycemic index
T_0	96.03	74.89[a]
T_1	148.42	55.65[c]
T_2	140.84	56.40[c]
T_3	146.34	48.25[d]
T_4	148.60	57.51[b]
C.D (0.05)		0.991*
Significance		S

Figure in parenthesis indicates per cent relative change over the previous month Values with same alphabet for different treatments represented in each column form a homogenous group.

was given in Table 5. The control had the highest glycaemic index when compared to other barnyard millet-based vermicelli. The Treatment T_3 (Brahmi leave based barnyard vermicelli) had the lowest glycemic index of 48.25, followed by T_1 (55.65), T_2 (56.40) and T_4 (57.51). The glycemic index varied significantly across each treatment; however, T_1 was comparable to T_2. According to a study conducted by Ugare *et al.,* 2014 revealed that intake of dehusked and heat-treated barnyard millet has a beneficial effect in reduction of blood glucose level. The antioxidant activity of brahmi (bacoside A and bacoside B) greatly influence the stability of the glycemic index (Charoenphon *et al.,* 2015; Shankar *et al.,* 2018).

CONCLUSION

The present study revealed that barnyard millet is an underutilized grain that can be effectively used in the development of millet-based designer vermicelli incorporated with functional ingredients (2 per cent germinated fenugreek seed flour/garden cress seed flour/ Ekanayakam root barks powder and 0.5 per cent Brahmi leave powder). The barnyard millet-based vermicelli prepared with the addition of functional ingredients showed high antioxidant activity and low glycemic index in comparison with control. The designer vermicelli was observed to have good sensory, nutritional and health qualities.

Conflict of interest

No conflict of interest amongst the authors associated with this work.

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