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Nutritional and sensory quality of millet fortified energy bar

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Abstract

Micronutrient deficiencies, particularly nutritional anaemia, iodine deficiency illnesses, and vitamin A insufficiency, have been a problem in developing countries. In order to tackle malnutrition and hidden hunger in developing nations, micronutrient fortification is the most effective method. Micronutrients viz. vitamins, minerals (including trace minerals) are intentionally added to the food for increasing their nutritional content, improving the nutritional quality of food, and providing a public health with minimal risk to health.The present study was undertaken on the formulation of fortified food products using blends of foxtail and barnyard millet flour. Standardization of the fortified food products were on the basis of quality parameters. In the present study, four different types of food products were prepared using blends of foxtail and barnyard millet flour. The developed fortified food products were fortified energy bar respectively. The nutritional characteristics viz. proximate composition, and minerals content of fortified food products were analysed. Consumer acceptability of the fortified food products were also assessed. Fortified food products viz. energy bar were found liked very much as comparison to the control (non-fortified) food samples of the products. The nutritional content of the fortified food products was also higher than the control (non-fortified) food samples.

It can be interpreted from the current study that fortification of the foxtail and barnyard millet flour in food products (energy bar) increased their nutritional value. Blend s of foxtail millet and barnyard millet flour enhance the iron, and zinc content in the fortified food products (energy bar). Food products (energy bar) fortified with foxtail and barnyard millet flour was more nutritious than control (non-fortified) food samples prepared from maket value.

Keywords: Fortification; Malnutrition; Millets; Barnyard millet; Foxtail millet

1 Introduction

In the world's arid and semi-arid regions, millets are a staple diet. Millets are effective energy providers. They offer dietary fibre, polyphenols, fatty acids, minerals, vitamins, and protein.The typical millet protein is rich in important amino acids, particularly methionine and cysteine, which contain sulphur. Milling millet removes the fibrous and phytochemical-rich bran and germ layers, resulting in a considerable loss. Antioxidants including phenolic acids and glycated flavonoids are found in millets.Foods made from millet are regarded as potential prebiotics because they can improve the viability or functionality of probiotics, which has major positive effects on health.Due to millets' nutritional importance, it is necessary to investigate the nutritional traits and practical qualities of various millet cultivars as well as create value-added millet products **(**Palanisamy et al., 2011).

In Asia, particularly in India, China, Japan, and Korea, barnyard millet (*Echinochloa* species) is a common millet crop that has been grown for centuries in warm and temperate climates. It is the fourth-most widely grown small millet, ensuring food security for a large number of hungry people worldwide. With an average productivity of 1034 kg/ha over the past three years, India has emerged as the world's largest producer of barnyard millet in terms of both area

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(0.146 m ha-1) and production (0.147 mt) (Agrawal, 1990). The majority of barnyard millet is grown for human consumption, though it is also fed to animals. Two of the most often used varieties of barnyard millet are *Echinochloa*frumentacea (Indian barnyard millet) and *Echinochloaesculenta* (Japanese barnyard millet), which are both cultivated and wild species. Barnyard millet is a short-lived crop that can tolerate a variety of biotic and abiotic stresses and grow in unfavourable environmental circumstances with essentially little input. The grains are prized for their excellent nutritional value and reduced cost in comparison to major cereals like rice, wheat, and maize, in addition to these agronomic benefits. It is a good source of protein, fibre, carbs, and micronutrients like iron (Fe) and zinc (Zn), which are especially important.(Rai et al., 2011)

Foxtail millet *(Setaria italica*) comes under 'Poaceae family' and 'Panicoideae subfamily' In India, the another name of foxtail millet iskaon, kang, kakun kangni navane, thena rala kangam, kanghau, kangani, korra, and thinai in India. In other countries, Foxtail millet is also called as German millet, Italian millet, and Hungarian millet.

Foxtail millet (*Setaria italica*), which originated in China and is now grown all over the world, is one of the most significant food crops of the semi-arid tropics. It is the second-most prevalent millet species.These tiny seeds have a diameter of around 2 mm (less than 1/8 inch), and they are covered in a thin, papery hull that may be easily removed during threshing. Between types, there are big differences in seed colour. Nutritionally speaking, foxtail millet is a fair source of protein, with 10–12% of it, 351 Kcal of energy per 100 g, 2.29–2.78% of lysine, 0.598% of thiamine, 4-5% of fat, and 17.62% of dietary fibre Ranhotra and Gelroth, 1986; Damaris, 2007; Jeeyup, 2010; Ayo et al., 2010, Kamaljit et al., 2010).

Fortification is the "practise of intentionally increasing the content of an essential micronutrient, i.e. vitamins and minerals (including trace elements) in a food, to improve the nutritional quality of the food supply and to provide a public health benefit with minimal risk to improve the nutritional quality of the food supply and to provide a public health benefit with minimal risk to health," according to the World Health Organisation (WHO) and the Food and Agricultural Organisation of the United Nations (FAO), while enrichment is defined as "synonymous with fortification" (Lee et al., 2010).

Two separate methods of fortification adding back and addition are used in common food items. Grains are prepared in such a way that flour loses nutritious value; Enriched Niacin, riboflavin, thiamine, folic acid, and iron are re-added to flour. The micronutrients that are added to other fortified foods, on the other hand, are not found in those foods naturally. Orange juice is a prime example of this, as it is frequently sold with calcium supplements.

According to the level of addition, food fortification can also be divided into two categories:

- Fortification of food products used in commerce and industry (cooking oils, cornmeal, and wheat flour)
- "Bio fortification one their nutritional content; this can involve both traditional selective breeding and genetic engineering)
- Personal augmentation (e.g., vitamin D drops) (Ravindran, 1992)

2 Material and methods

The present study was conducted in the Department of Food science and Nutrition, College of Community Science, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh.

2.1 Procurement of Raw Material

Foxtail millet grain, Barnyard millet grain , peanuts, coconut powder, jaggeryand sesame seed was processed from the local market of Kanpur.

2.2 Preparation of Foxtail Millet and Barnyard Millet flour

To eliminate dust, dirt, stones, and other foreign matter, Foxtail millet, and Barnyard millet were all carefully cleaned. To prevent deterioration from a biological agent, Foxtail Millet and Barnyard Millet grains were first washed under running water and then dried in an oven at 120 °C for six hours. The fully dried grains grinding was done on were subjected to grinding. The ground material was passed through 60 mesh sieves.

2.3 Formulation of energy bar

Table 1 Varied Combination of ingredient used in the development of energy bar

Ingredient (in g.)	T0	T1	T2	T3
Barnyard millet (flour)	-	8	10	12
Foxtail millet (flour)	-	8	10	12
Peanuts	30	14	10	6
Sesame seeds	20	20	20	20
Jaggery	50	50	50	50
Total	100	100	100	100

The work was done step by step. First, control energy bar formulated by using jaggery, sesame seed and peanuts. Then, fortified energy bar was formulate by using foxtail and barnyard millet flour with jaggary, peanuts and sesame seed.

Different proportions of millet flour, jaggery, peanuts and sesame seed used in formulation of energy bar were given in the table-1.

2.4 Method

- All ingredients were weighted according to the set formulation.
- Peanuts, sesame seed, Foxtail millet flour and Barnyard millet flour roasted in a pan separately.
- Take a pan at a low flame add butter in to it.
- Then add jaggery and water into the same pan and mixed it well with the help of spatula.
- Aftar that, all the dry ingredients viz- millets flour, peanuts and sesame seed in to jaggery mixture. And cooked it for 8-10 min at medium flame.
- Now, transfer all the mixture to a tray and cool it at normal temp.
- Now coat the energy bar with decicated coconut powder.
- Lastly cut the energy bar into desired shape and size. And store it.

2.5 Proximate Analysis of Nutrient

These refer to the determination of the percentage of moisture, total ash, crude protein, crude fat and crude fiber in food. The total of these percentages subtracted from 100 gives percentage of carbohydrate by difference. All the estimations were done in triplicates.

2.6 Sensory evaluation

Sensory quality of Developed fortified product was evaluated by nine point Hedonic scale and score card method (Amerine*et al.,* 1965).

3 Results and discussion

The experiment outcomes are discussed in this chapter. The purpose of the experiment was to assess the nutritional value of fortified millet-based food products. Analysis of variance tables for various attributes and replication-wise data of several chemical parameters are provided in the appendices. The outcomes are explained below.

3.1 Sensory Quality of control & fortified energy bar with Barnyard and foxtail Millet

The Energy bar was evaluated for their sensory qualities using score card method. The results have been presented in table.

Table 2 Sensory Content of control & fortified energy bar with Barnyard and foxtail Millet

Sensory evaluation	T0	T1	T2	T3	CD (5%)	S.EM	F Value
Taste	7.6± 0.54	8± 1.41	7.8±1.09	7.8±0.44	1.29	0.43	NS
Texture	7.8±0.44	8.2±0.83	7.4±0.54	7.2±0.44	0.79	0.26	NS
Appearance	8.4±0.54	8.8±0.44	7.8±0.54	7.6±0.83	0.82	0.27	S
Flavour	7.8±1.09	8.6±0.54	7.6±0.89	7.4±0.54	1.08	0.36	NS
Colour	8.4±0.54	8.4±0.54	7.8±0.89	7.4±0.83	0.97	0.32	NS
OverallAcceptability	8.4±0.54	8.6±0.54	7.2±0.44	7±0.83	0.82	0.27	S

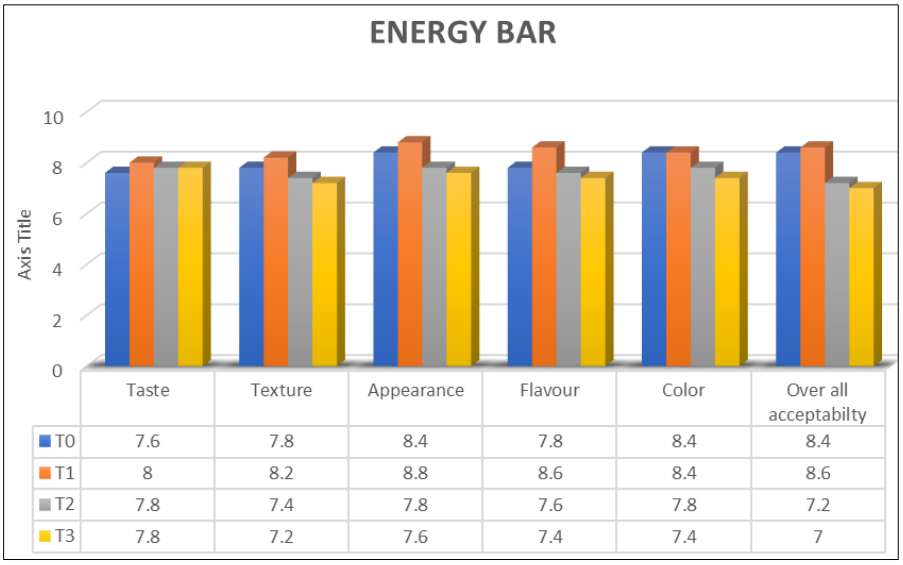

Figure 1 Sensory Quality of control & fortified energy bar

According to score card of sensory evaluation code T1 (8g barnyard, 10g foxtail millet) obtained a mean score of 8.6 was liked very much, and also coda T1 scored highest in all parameter after control T0 (50g Jaggery, 20gSesame, and 30gPeanuts). Therefor based on the above mentioned result T1 was most acceptable developed fortified energy bar.

Code T0 (100gm of refined wheat flour) are a regular energy bar and generally, they are available in the market. Therefor code T0 (100gm refined wheat flour) chosen as a control as a control energy bar for the study.

Table no depicts that, the taste, texture, appearance, flavour, colour& overall acceptability decreased as the proportion of Barnyard and foxtail millet flour increased.

3.2 The Nutritive value of developed fortified millet-based product

Nutritional Evaluation of Control Energy bar (T0) and fortified Energy bar with barnyard and foxtail millet (T1, T2, & T3):

Table 3 Nutritional Quality of control & fortified energy bar with Barnyard and foxtail Millet

Proximate composition	T0	T1	T2	T3	CD (5%)	S.Em	F Value
Moisture	10.09±0.11	18.46±0.15	14.35±0.55	12.21±0.09	0.55	0.17	S
Protein	6.93±0.08	8.61±0.52	8.52±0.60	7.92±0.36	0.77	0.24	S
Fat	15.16±0.32	22.36±0.41	19.49±0.11	18.76±0.10	0.51	0.16	S
Ash	1.34±0.05	6.2±0.1	5.69±0.18	4.17±0.19	0.27	0.08	S
CHO	55.7±0.12	69.25±0.11	67.43±0.50	65.99±0.2	0.50	0.15	S
Fiber	4.54±0.04	7.14±0.05	6.84±0.20	5.70±0.03	0.21	0.06	S
Energy	428.83±0.73	480.09±0.510	478.5±1.025	458.82±0.606	1.40	0.43	S

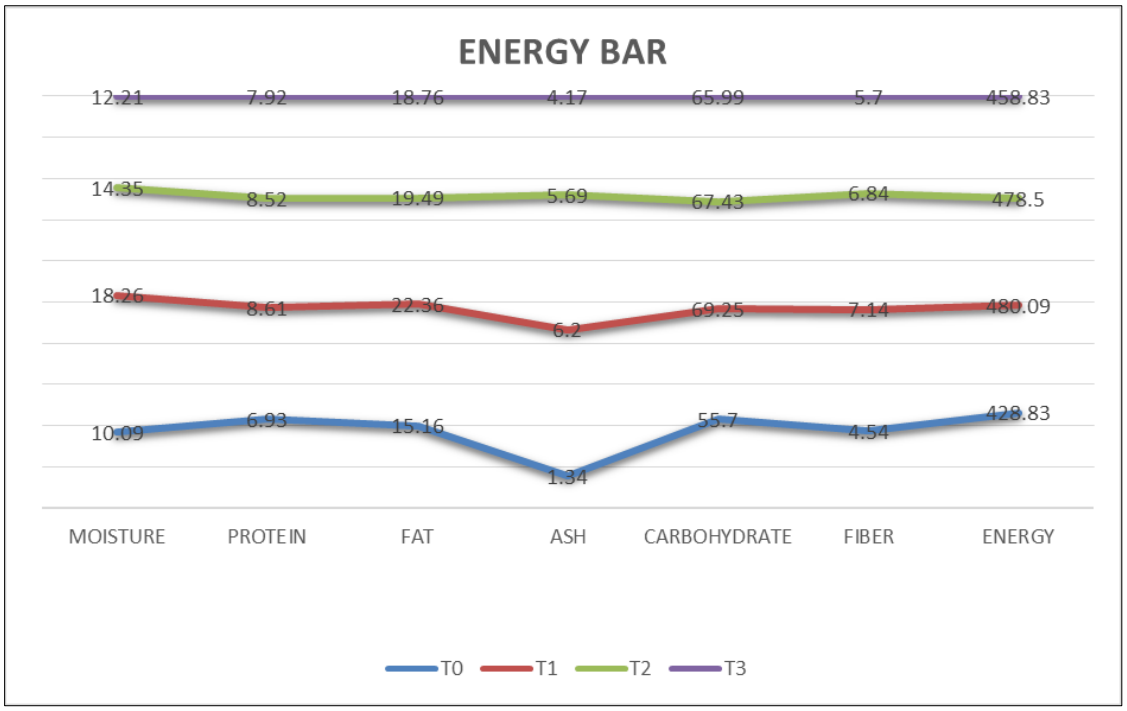

Figure 2 Nutritional Quality of control & fortified energy bar

The results of nutritional composition of control (T0) and fortified energy bar (T1, T2, &T3) are given in the table & fig. Nutritional composition comprises of crude protein, total moisture, crude fat, total ash, crude fibre, carbohydrates and physiological energy.

3.2.1 Moisture content

A significant difference was observed between the control energy bar i.e. T0 (50g Jaggery, 20gSesame, and 30gPeanuts) and fortified energy bar i.e. T1 (8g barnyard, 10g foxtail millet), T2 (8g barnyard, 10g foxtail millet), T3 (8g barnyard, 10g foxtail millet). The moisture content of control energy bar was 10.09% whereas the moisture content of T1, T2, and T3 was observed ,18.46%, 14.35%, and 12.21%, respectively.

The moisture content of fortified energy bar (fortified with barnyard and foxtail millet) decreased with the addition of barnyard and foxtail millet.

Saleh, A., Zhang, Q., Chen, J., and Shen, Q. (2013). reported, the moisture content of foxtail millet enrgy bar was 11.16%. PRJ-1, a type of barnyard millet, with a moisture content of 11.86%. Gopalan*et al*. (2007) noted a barnyard millet yield of 11.9%.According Meenu Aggarwal and Dipti Sharma (2020)having a moisture content of 9.89%.

3.2.2 Protein content

A significant difference was observed between the control energy bar i.e. T0 (50g Jaggery, 20g Sesame, and 30g Peanuts) and fortified energy bar i.e. T1 (8g barnyard, 10g foxtail millet), T2 (8g barnyard, 10g foxtail millet), T3 (8g barnyard, 10g foxtail millet). The protein content of control energy bar was 6.93% whereas the protein content of T1,T2, and T3 was observed ,8.61%, 8.53%, and 7.92%, respectively.

The protein content of fortified energy bar (fortified with barnyard and foxtail millet) decreased with the addition of barnyard and foxtail millet.

3.2.3 Fat content

A significant difference was observed between the control energy bar i.e. T0 (50g Jaggery, 20gSesame, and 30gPeanuts) and fortified energy bar i.e. T1 (8g barnyard, 10g foxtail millet), T2 (8g barnyard, 10g foxtail millet), T3 (8g barnyard, 10g foxtail millets). The fat content of control energy bar was 15.16% whereas the fat content of T1,T2, and T3 was observed ,22.36%, 19.49%, and 18.76%, respectively.

The fat content of fortified energy bar (fortified with barnyard and foxtail millet) decreased with the addition of barnyard and foxtail millet.

3.2.4 Ash content

A significant difference was observed between the control energy bar i.e. T0 (50g Jaggery, 20gSesame, and 30g Peanuts) and fortified energy bar i.e. T1 (8g barnyard, 10g foxtail millet), T2 (8g barnyard, 10g foxtail millet), T3 (8g barnyard, 10g foxtail millet). The ash content of control energy bar was 1.34% whereas the ash content of T1,T2, and T3 was observed, 6.2%, 5.69%, and 4.17%, respectively.

The ash content of fortified energy bar (fortified with barnyard and foxtail millet) increased with the addition of barnyard and foxtail millet Saleh, A., Zhang, Q., Chen, J., and Shen, Q. (2013). reported, the ash content of foxtail millet energy bar was 2.15%.

3.2.5 Carbohydrate content

A significant difference was observed between the control energy bar i.e. T0 (50g Jaggery, 20gSesame, and 30gPeanuts) and fortified energy bar i.e. T1 (8g barnyard, 10g foxtail millet), T2 (8g barnyard, 10g foxtail millet), T3 (8g barnyard, 10g foxtail millet). The carbohydrate content of control energy bar was 55.7% whereas the carbohydrate content of T1,T2, and T3 was observed, 69.25%, 67.43%, and 65.99%, respectively.

The carbohydrate content of fortified energy bar (fortified with barnyard and foxtail millet) decreased with the addition of barnyard and foxtail millet.

Saleh, A., Zhang, Q., Chen, J., and Shen, Q. (2013) reported, the carbohydrate content of foxtail millet energy bar was 73.55%.

3.2.6 Fiber content

A significant difference was observed between the control energy bar i.e. T0 (50g Jaggery, 20gSesame, and 30gPeanuts) and fortified energy bar i.e. T1 (8g barnyard, 10g foxtail millet), T2 (8g barnyard, 10g foxtail millet), T3 (8g barnyard, 10g foxtail millet). The fibber content of control energy bar was 4.54% whereas the fibber content of T1, T2, and T3 was observed, 7.14%, 6.84%, and 5.70%, respectively.

The fibber content of fortified energy bar (fortified with barnyard and foxtail millet) increased with the addition of barnyard and foxtail millet.

3.2.7 Energy content

A significant difference was observed between the control energy bar i.e. T0 (50g Jaggery, 20gSesame, and 30gPeanuts) and fortified energy bar i.e. T1 (8g barnyard, 10g foxtail millet), T2 (8g barnyard, 10g foxtail millet), T3 (8g barnyard,

10g foxtail millet). The energy content of control energy bar was 428.83% whereas the energy content of T1, T2, and T3 was observed, 480.09%, 478.5%, and 458.82%, respectively.

The energy content of fortified energy bar (fortified with barnyard and foxtail millet) decreased with the addition of barnyard and foxtail millet.

Saleh, A., Zhang, Q., Chen, J., and Shen, Q. (2013) reported, the energy content of foxtail millet energy bar was 423.3%

Minerals Evaluation of Control Energy bar (T0) and fortified Energy bar with barnyard and foxtail millet (T1, T2, & T3)

Table 4 Minerals Quality of control & fortified energy bar with Barnyard and foxtail Millet

Minerals composition	T0	T1	T2	T3	CD (5%)	S.EM	F Value
Iron	6.26±0.03	6.68±0.20	7.19±0.06	8.45±0.47	0.49	0.15	S
Zinc	2.98±0.03	3.28±0.07	4.36±0.05	5.3±0.2	0.21	0.06	S

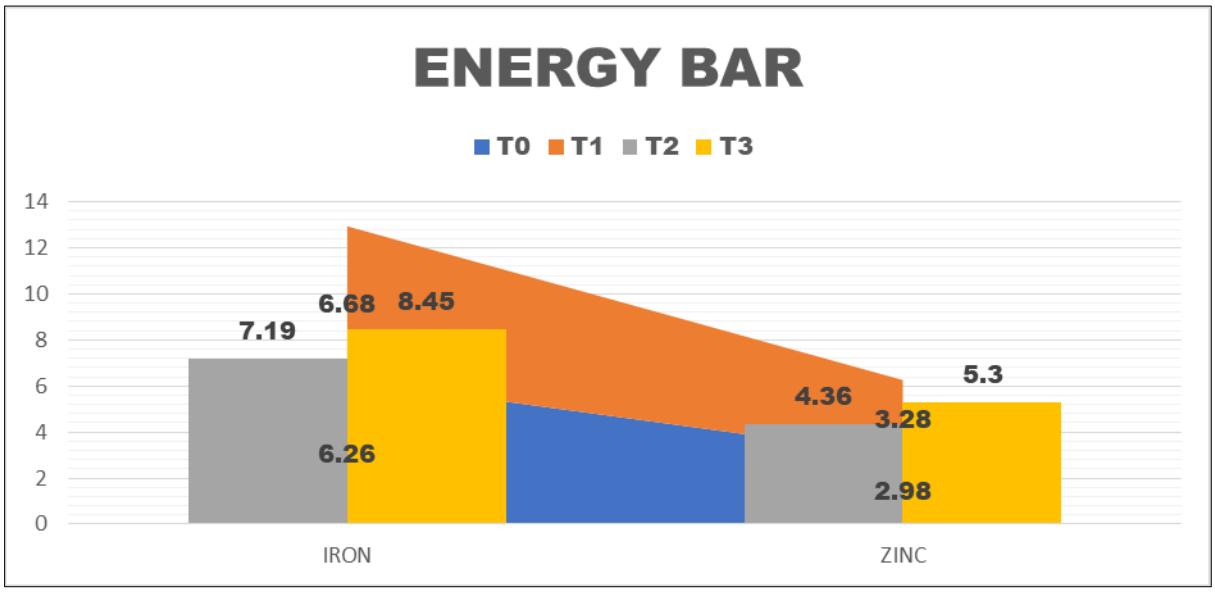

Figure 3 Minerals Quality of control & fortified energy bar

The results of nutritional composition of control (T0) and fortified energy bar (T1, T2, &T3) are given in the table & fig. Minerals comprises of Iron, and Zinc.

3.2.8 Iron content

A significant difference was observed between the control energy bar i.e. T0 (50g Jaggery, 20gSesame, and 30gPeanuts) and fortified energy bar i.e. T1 (8g barnyard, 10g foxtail millet), T2 (8g barnyard, 10g foxtail millet), T3 (8g barnyard, 10g foxtail millet). The iron content of control energy bar was 6.24% whereas the iron content of T1, T2, and T3 was observed, 6.68%, 7.19%, and 8.45%, respectively.

The iron content of fortified energy bar (fortified with barnyard and foxtail millet) increased with the addition of barnyard and foxtail millet.

3.2.9 Zinc content

A significant difference was observed between the control energy bar i.e. T0 (50g Jaggery, 20gSesame, and 30gPeanuts) and fortified energy bar i.e. T1 (8g barnyard, 10g foxtail millet), T2 (8g barnyard, 10g foxtail millet), T3 (8g barnyard, 10g foxtail millet). The zinc content of control energy bar was 2.98% whereas the zinc content of T1, T2, and T3 was observed, 3.28%, 4.36%, and 5.3%, respectively.

The zinc content of fortified energy bar (fortified with barnyard and foxtail millet) increased with the addition of barnyard and foxtail millet.

4 Conclusion

From the above study, it has been concluded that through the sensory evaluation the colour, taste, appearance, puffing score was found to be best in "Foxtail and Barnyard" developed fortified millet-based product. Texture was found to be good in developed fortified millet-based product where as overall acceptability was found moderately good in developed fortified milletbased product(Foxtail and Barnyard).It has been concluded that nutritive analysis of various parameters such as moisture, fat, crude protein, carbohydrate, crude Fibber, total ash, Energy, Iron and zinc. Millet's is a staple grains of diet. In our country, all people eat millet because it is readily available, cheap and easy to make. It is used in various forms. This study showed that "Foxtail and Barnyard" result in the increase in many nutrients, such as protein, fat, carbohydrate, fibber, mineral and vitamins. Developed fortified millet-based product were good for infants, children and old aged people because of increased nutrients and good digestibility. It is good for obese and diabetic patient because of high carbohydrate. It can also be recommended for the Protein Energy Malnutrition (PEM) patients

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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