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RESEARCH ARTICLE

EFFECT OF GERMINATION AND FERMENTATION ON SPECIFIC NUTRIENTS IN MILLET KOOZH PREPARED USING SORGHUM BICOLOUR (*MONECH.L*), PEARL MILLET (*PENNISETUM GLAUCUM*) AND FINGER MILLET (*ELEUSINE CORACANA*).

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Key words:-

Germination, fermentation, millet, koozh, nutrients

Abstract

Koozh is a product of double fermentation of millet and rice caused by a mixture of micro flora involving lactic acid bacteria and yeast. The present study was undertaken to determine the effect of germination and fermentation on macro and certain micro nutrient contents in koozh prepared using finger millet, Pearl millet, Red sorghum and white sorghum. It was inferred from the study that fermentation of millet koozh enhanced the protein levels with a substantial reduction in carbohydrate and energy content. Germination and fermentation resulted in a concomitant raise in thiamine levels along with iron and vitamin C. A sensory evaluation of both germinated & fermented and non-germinated & fermented millet koozh revealed equal acceptance with no significant difference in their hedonic scale ratings. There was an increase in the yeast content of fermented koozh which explained the increase in B vitamin content. Thus this study concludes that millets can be used in different proportions to formulate various fermented nutritious food products for all age groups.

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Introduction:-

Millets are one of the oldest foods known to humans and possibly the first cereal grain to be used for domestic purposes^[1]. Millets are not only comparable to major cereals with respect to their nutritional features but are very good sources of carbohydrates, micronutrients and phytochemicals with nutraceutical properties. Millets contain 7-12 per cent protein, 2-5 per cent fat, 65-75 per cent carbohydrates and 15-20 per cent dietary fiber. These millets are a good source of both soluble and insoluble dietary fiber^[2]. A variety of foods from the millets are traditionally prepared and consumed, over the centuries, in the Indian subcontinent, Africa and Central America.

Several traditional household food processing and preparation methods are used to enhance the bioavailability of micronutrients from millets. Koozh is one such preparation that has strong connection with South Indian culture and tradition and has been consumed regularly for breakfast before rice became a common consumable. Koozh is a full millet based preparation along with rice. Millets like finger millet, pearl millet and sorghum are used singly or in combination for Koozh preparation. It is a soft porridge prepared from traditionally processed millet (germinated and fermented).

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Preparation of Koozh involves two fermentation processes, before (primary fermentation) and after cooking (secondary fermentation). During fermentation, the millet slurry would undergo major biochemical changes like starch hydrolysis, sugar transformation and softening. So the conventional process of fermentation is believed to increase the nutritive value of millets. The processing methodology is similar throughout south India with slight modifications in fortifying substances and raw materials. Unlike other cereal and millet based fermented foods in which fermenting microorganisms are killed by thermal treatment, secondary fermentation step in Koozh offers live microbes along with the product. This feature adds functional value to the traditional product and makes it to stand on par with probiotic dairy foods.^[3]

Aim of the study:-

To assess the influence of germination and fermentation on the levels of specific nutrients in millet koozh prepared using finger millet, pearl millet, Red sorghum & white sorghum and broken raw rice

Objectives of the study

To estimate the energy, carbohydrate, protein and fat, ash, fibre, moisture, vitamin C and iron content of millet koozh prepared in the following combinations of processing methods.

1. Non-Germinated and Non-fermented millet Koozh
2. Non- Germinated and fermented millet koozh.
3. Germinated and fermented millet koozh.
4. Germinated and Non-fermented millet Koozh

To assess the levels of Thiamine, Riboflavin and Niacin in

1. Non-germinated & fermented millet koozh and
2. Germinated & fermented millet koozh

To conduct sensory evaluation of

1. Non-germinated & fermented millet koozh and
2. Germinated & fermented millet koozh.

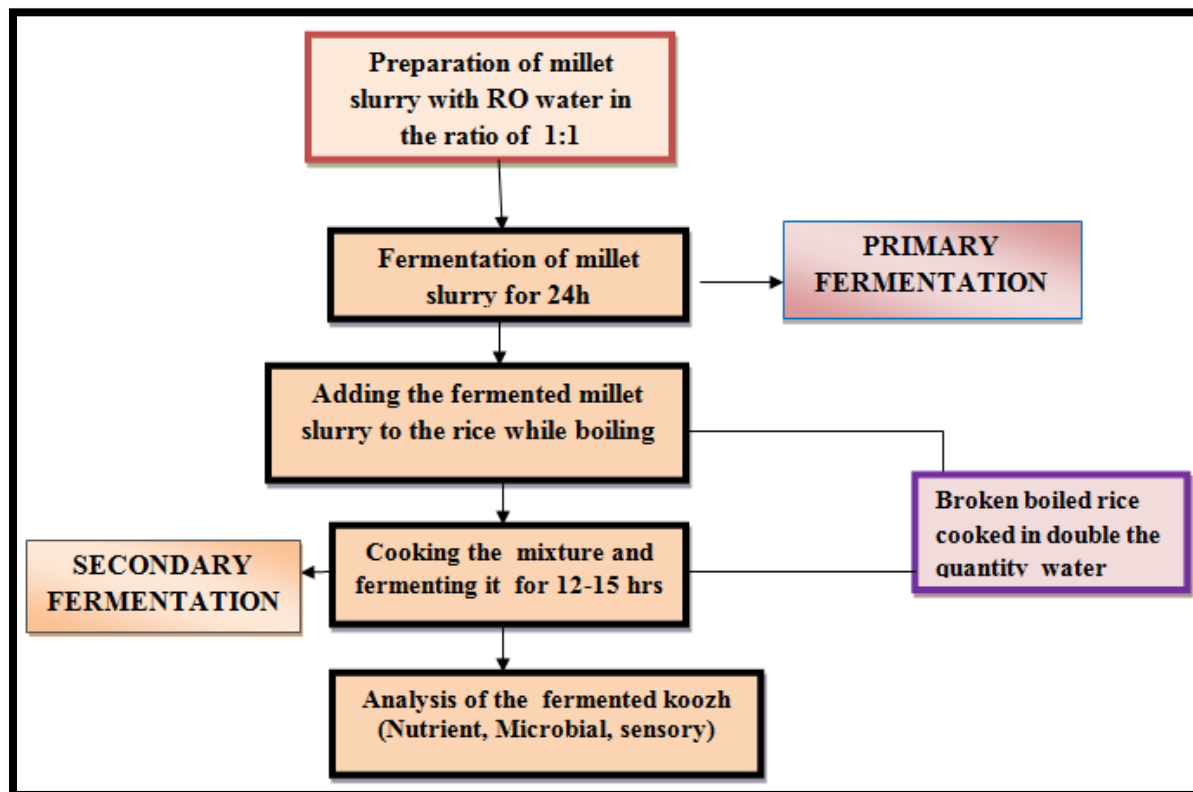
Methodology:-**Research design:-**

The research design of this study is experimental in nature.

Sample selection:-

As the study comprises of germination of millets, those millets which germinated well under optimum conditions were chosen after experimenting on all the major and minor millets available in the market. Red and white varieties of sorghum (*L.Monech*), pearl (*Pennisetum glaucum*) and Finger millet (*Eleusine coracana*) were selected for the study. The millets were obtained from the millet retailer supplying at the Tamil Nadu Agricultural University Centre at Chennai. Ponni raw rice was procured from the grocery.

Flow chart showing the preparation of millet koozh using Finger millet (*Eleusinecoracana*), pearl millet (*Pennisetumglaucum*) and Bi color sorghum (*L.Monech*)



Millet Koozh was prepared in four different combinations of processing methods as shown in table 1. The steps included and omitted in the preparation of millet koozh using the four processing methods are spelt out. This was done to find out the actual effect of germination and fermentation on the nutrient quality of the millet koozh.

Table 1:- Different combinations of Processing Methods adopted in the preparation of millet koozh

Processing methods	Steps adopted and omitted in the preparation of millet koozh
Non-germinated and Non-fermented millet koozh	No germination of millets and fermentation of millet koozh
Non- Germinated and fermented millet koozh	No germination of millets but only fermentation of millet koozh
Germinated and Fermented millet koozh	Germination and fermentation adopted in the preparation of millet koozh
Germinated and Non-fermented millet koozh	Only germination of millets but no fermentation of millet koozh

Results and Discussions:-

Comparison of the proximate principles (carbohydrate, protein and fat) and energy content of millet Koozh

A comparison of the proximate principles (carbohydrate, protein and fat) and energy content of millet Koozh prepared using the stated combinations of processing methods is presented in table 2.

Table 2:- Comparison of proximate composition of Millet Koozh prepared using varying combinations of processing methods.

Processing methods	ENERGY (kcal)			CARBOHYDRATE (g/100g)			PROTEIN (g/100g)			FAT (g/100g)		
	Mean \pm SD	t value	Level of sig	Mean \pm SD	t value	Level of sig	Mean \pm SD	t value	Level of sig	Mean \pm SD	t value	Level of sig
Non-germinated & Non-fermented Millet Koozh	215.94 \pm 0.616	125.09	0.000**	46.79 \pm 0.316	122.82	0.000*	4.03 \pm 0.015	46.80	0.000**	1.41 \pm 0.18	0.849	0.444 ^N _s
Non-germinated & fermented Millet Koozh	138.73 \pm 0.874			24.09 \pm 0.049			7.34 \pm 0.122			1.32 \pm 0.02		
Non-germinated & Non-fermented Millet Koozh	215.94 \pm 0.62	95.56	0.000*	46.79 \pm 0.32	62.03	0.000*	4.03 \pm 0.02	73.89	0.000**	1.41 \pm 0.18	0.652	0.550 ^N _s
Germinated & Non-fermented Millet Koozh	276.33 \pm 0.90			60.7 \pm 0.23			5.33 \pm 0.03			1.34 \pm 0.04		
Non-germinated & non-fermented Millet Koozh	215.9433 \pm 0.616	121.60	0.000*	46.786 \pm 0.316	81.51	0.000*	4.02 \pm 0.015	116.29	0.000**	1.41 \pm 0.18	4.363	0.012
Germinated & Fermented Millet Koozh	161.4333 \pm 0.473			31.090 \pm 0.106			7.27 \pm 0.046			0.94 \pm 0.02		
Germinated & non-fermented Millet Koozh	276.326 \pm 0.905	194.99	0.000*	60.720 \pm 0.227	205.28	0.000*	5.33 \pm 0.026	63.50	0.000*	1.34 \pm 0.03	15.911	0.000*
Germinated & Fermented Millet Koozh	161.433 \pm 0.473			31.090 \pm 0.106			7.27 \pm 0.046			0.94 \pm 0.02		
Non-germinated & Fermented Millet Koozh	138.73 \pm 0.874	39.58	0.000*	24.09 \pm 0.049	103.89	0.000*	7.34 \pm 0.122	0.93	0.404NS	1.32 \pm 0.02	21.16	0.000*
Germinated & Fermented Millet Koozh	161.43 \pm 0.473			31.09 \pm 0.106			7.27 \pm 0.046			0.95 \pm 0.02		

NS- Not significant * - statistically significant

From table 2, it is evident that fermentation of the millet koozh resulted in a substantial reduction in the energy and carbohydrate levels. The fermented samples had the lowest energy value which is due to the low fat and carbohydrate content. The reduction in carbohydrate content in fermented koozh could also be attributed to increased activity of alpha-amylase which hydrolyses starch to simple sugar. The sugar provides a source of energy for the fermenting micro-organisms.^[4] In the present study, fermented koozh was found to exhibit significant ($p < 0.01$) reduction in carbohydrate content. This observation confirms the utilization of the carbohydrate by the fermenting microbes. Carbohydrates are a major energy source for fermenting microbes.

The protein levels also have shown a considerable rise in the fermented millet koozh which reflects on the activation of the proteolytic enzymes during fermentation. Antony and Chandra (1998)^[5], concluded in their study that as fermentation is associated with the degradation of antinutrients, there is an increase in the bioavailability of minerals and an improvement in the digestibility of proteins in tannin-rich cereals.

There was a decrease in fat content after fermentation and a further statistically significant decrease in germinated and fermented millet koozh which may be attributed to the breakdown of fats to fatty acid and glycerol by lipolytic organisms present in the sample during fermentation and the utilization of fat for energy purposes by the fermenting microbes. A similar observation has been reported by Anthony and Babatunde (2014)^[6] where the break down resulted in an increase in aroma, taste, odour and texture of fermented food.

Comparison of Ash and Fiber content of Millet Koozh:-

A comparison of the Ash, fiber and moisture content of millet Koozh prepared in different combinations of processing methods is presented in table 3.

From table 3, it can be seen that the ash content of the millet koozh prepared using different processing methods ranged between 1.03 to 1.4 g/ 100g. The present study elucidates that in all the preparative methods of koozh, even though there was a marginal decrease in the overall ash content of the koozh on germination and fermentation, there were no significant changes. Arora, Jood and Khetarpaul (2011)^[7] found that germination of grains decreased ash content. In the present study, the least ash content was found in germinated and fermented millet koozh.

The fermented koozh samples showed a significant appreciation in the fiber content compared to the non-fermented samples. A similar trend was also observed in the germinated and fermented koozh. It is interesting to note that fermentation increased the crude fiber content.

Table 3:- Comparison of Ash and Fiber content of Millet Koozh prepared using varying combinations of processing methods.

Processing methods	ASH (g)			FIBER (g)		
	Mean ± SD	t value	Level of sig	Mean ±SD	t value	Level of sig
Non-germinated & Non-fermented Millet Koozh	1.13 ±0.058	2.079	0.106 ^{NS}	0.60 ±0.100	51.594	0.000*
Non-germinated & fermented Millet Koozh	1.06 ±0.020			3.61±0.015		
Non-germinated & Non-fermented Millet Koozh	1.13±0.06	2.219	0.091 ^{NS}	0.60±0.10	1.549	0.196 ^{NS}
Germinated & Non-fermented Millet Koozh	1.40±0.20			0.40±0.20		
Non-germinated & non-fermented Millet Koozh	1.133±0.058	2.929	0.043 ^{NS}	0.600±0.100	49.026	0.000*
Germinated & Fermented Millet Koozh	1.030±0.020			3.463±0.015		
Germinated & non-fermented Millet Koozh	1.400±0.200	3.188	0.033*	0.400±0.200	26.452	0.000*
Germinated & Fermented Millet Koozh	1.030±0.020			3.463±0.015		
Non-germinated & Fermented Millet Koozh	1.06±0.020	1.83	0.140 ^{NS}	3.61±0.015	12.02	0.000*
Germinated & Fermented Millet Koozh	1.03±0.020			3.46±0.015		

Vitamin C and Iron content of Millet koozh:-

The vitamin C and iron content of millet koozh subjected to four different processing methods are presented in table 4.

Table 4:- Vitamin C and Iron content of Millet koozh prepared using varying combinations of processing methods.

Processing methods	Vitamin C (mcg/100g)	Iron (mg/100g)
Non-germinated & Non-fermented millet koozh	16.63	2.24
Non-germinated & Fermented millet koozh	36.45	3.17
Germinated & Non-fermented millet koozh	28.83	1.06
Germinated & Fermented millet koozh	53.73	2.81

From table 4 it can be observed that the germinated & fermented millet koozh had the highest vitamin C content of 53.73 mcg/ 100g and the lowest content of 16.63 mcg / 100g was detected in the non-germinated & non-fermented millet koozh. Millets are generally not a source of vitamin C. However on germination, some amount of vitamin

C is synthesized in the grain and on fermentation there is a further rise in the vitamin content as also observed by Juana, Miranda and Doblado (2005)^[8].

It can also be observed from Table 4 that the Non-germinated and fermented millet koozh had the highest iron content of 3.71mg/ 100g and the lowest iron content of 1.06mg/100g was observed in the germinated but non-fermented millet koozh. Saleh et al., (2013)^[9] observed a marked reduction in phytic acid during germination and fermentation that helps release the iron bound to phytates which in turn increases the bioavailability of iron from foods.

Comparison of the vitamin B content in millet koozh:-

The thiamine, riboflavin and niacin content of non-germinated & fermented millet Koozh and germinated & fermented millet koozh are presented in Table 5.

Table 5:- Thiamine, Riboflavin and Niacin content in Non-germinated & fermented millet koozh and Germinated & fermented millet koozh.

Processing method	Thiamine B ₁ (mg/100g)	Riboflavin B ₂ (mg/100g)	Niacin B ₃ (mg/100g)
Non-germinated & fermented millet Koozh	0.2788	0.21	1.7714
Germinated & fermented millet Koozh	0.625	0.272	1.4486

It can be inferred from table 5 that there is an increase in vitamin B₁ and a negligible raise in B₂ in millet Koozh prepared using germinated millets and subjected to subsequent fermentation. The Niacin content of the Non-germinated & fermented millet Koozh was found to be slightly higher than the Germinated & fermented millet Koozh.

The marginal increase in B₁ (Thiamine) from 0.278 to 0.625 mg in the germinated and fermented sample could be due to the presence of yeast in the millet koozh. Khetarpaul et al., (1989)^[10] have stated that yeast fermentation raises the level of thiamine two-three fold times.

In the present study, the appreciation in thiamine and riboflavin levels places the millet koozh as a good complementary food as it meets the RDA of children 1-3 years of age. It can also be used as a nutritious food supplement during convalescence, a nourishing diet for the elderly and a healthy breakfast option for all age groups.

LAB and yeast content of millet koozh:-

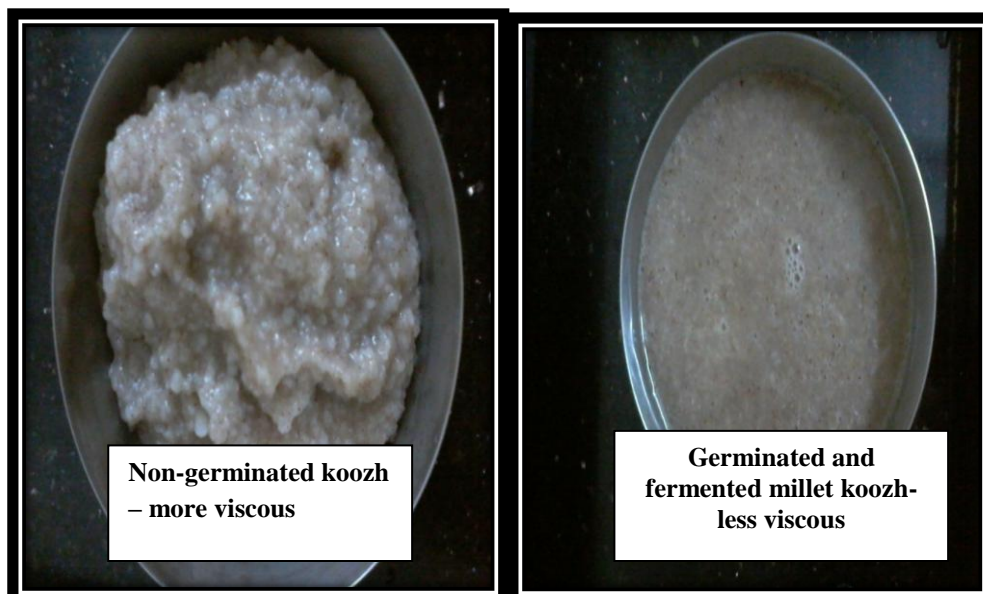
In this study, the presence of Lactic Acid Bacillus (LAB) was seen both in the non-germinated & fermented and the germinated & fermented millet koozh. LAB were generally reported to be the predominant bacteria in almost all fermented cereal and millet products (Khetarpaul et al., 1989)

The yeast content in the germinated & fermented millet koozh was significantly high which also substantiates the increase in B vitamins in the germinated and fermented millet koozh.

Sensory evaluation of millet koozh:-

Non-germinated & fermented millet koozh and Germinated & fermented millet koozh were evaluated for their colour, flavour, texture, taste, aroma and over all acceptability using the 9 point hedonic scale by a panel of twenty five respondents in the age group of 18 to 50 yrs

The germinated & fermented millets scored better on texture than the non-germinated & fermented millet koozh, as the germinated millet koozh was found to be less viscous than the non-germinated & fermented millet koozh (significance at (p<0.01)). Due to enzymatic breakdown of starch to sugars during germination, the viscosity and bulk density of porridge made from sprouted grains were significantly lower.



It was observed that fermentation generally enhanced the taste, flavour, aroma and consistency of the food product. This may be due to softening of the substrate by starch hydrolysing microorganisms causing amylolytic activity (Ojijo&Shimoni, 2004). This emphasizes the importance of starch hydrolysing bacteria population in the koozh fermentation process.

Conclusion:-

This study reveals that germination and fermentation of millets are good processing methods that can be adopted to enhance not only the quantity of nutrients but also their bioavailability. They could serve as a less expensive source of nutrients for all strata of society across all age groups. It could also serve as an ideal food for convalescents and as a weaning food, compared to expensive commercially available formulas. The introduction of millets into the public distribution system and into government meal programmes like the mid-day meal scheme can help the poor and the marginalized households in meeting their nutrition needs.

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