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RESEARCH PAPER

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Studies on standardization of malting process for finger millet (ragi)

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● ABSTRACT ●

Finger Millet (*Eleusina coracana*) is one of the neglected millets that save the poor from starvation in developing countries. Finger millet is very good source of micronutrient which could alleviate the wild spread micronutrient malnutrition in the vulnerable segments in the developing country like India. However, millets also contain some anti-nutritional factors which interfere mineral and protein availability. To overcome from these nutritional problems, processing technique such as malting can be used to improve the availability and digestibility of nutrient in addition to improvement of organoleptic quality. But malting for prolonged period also results in significant loss of dry weight. Hence, in present investigation efforts were made to standardize the malting process of finger millet and to assess its nutritional and mineral composition, while high *in vitro* protein digestibility (IVPD), *in vitro* starch digestibility (IVSD) and desirable low viscosity characteristics are considered as criteria for deciding standard method for preparation of finger millet malt. Malt obtained by 16 hrs soaking at room temperature and 48 hrs sprouting in BOD incubator (25^{0}C temperature) considered as standardized maltinig procedure for present study as these malting conditions gave highest amount of IVPD, IVSD and desired low paste viscosity with moderate malt yield.

KEY WORDS : Finger millet, *Eleusina coracana,* Malting, Protein digestibility

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● INTRODUCTION ●

Millets are the numerous small seeded grains and grasses which are originated in Asia and Africa. As per economic stand point the most important millets are finger millet (*Eleusina coracana*), pearl millet (*Panicum americanum*), proso millet (*Panicum miliaceum*) and foxtail millet (*Setaria italica*). Finger millet (*Eleusina coracana*) is also known as *African millet, Koracan Ragi and bajari*. Finger millet constituted about 81% of the minor millets produced in India (Balaravi, 2005). India held first rank in millet production with total production around 10,610,000 tonnes in 2007 (FAO STAT, 2007). In recent years finger millet has gained importance due to its nutritional strength in terms of dietary fiber, functional fiber, starch pattern as well as high calcium and iron content.

The effect of malnutrition on health status has been recognized since antiquity. Studies showed that deficiency of nutrients especially micronutrient will lead to development of cancer. Micronutrient are now claimed to be potent protective agents that act by suppressing carcinogenesis (Grentz and Massey, 2002). Finger millet is good source of minerals specially calcium, phosphorus and iron. According to experimental study, cancer patients feed with enriched finger millet malt has improved their nutritional status (Asha *et al*., 2004). Finger millet is very good source of micronutrient which could alleviate the wide spread micronutrient malnutrition in the vulnerable segments in the developing country like India. However, it must be pointed out that, millets also contains some anti-nutritional factors which interfere mineral and protein bioavailability. Finger millet contains phytic acid, tannins and trypsin inhibitors which are the main anti-nutritional factors normally present (Nagenahally *et al.*, 1983). Tannin reduces the nutritional quality of food as they can bind both exogenous and endogenous proteins including enzymes in the digestive track, affecting utilization of proteins (Ravindran, 1991).

To overcome from all these nutritional problems, malting could be implied as a technoeconomically feasible

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and commercially viable technology. Malting found to improve the availability and digestibility of nutrient in addition to improvement of organoleptic quality of foods (Kapoor and Gupta, 1981). Malting modifies the nutritional composition and the product obtained by malting process called malt. Malting involves controlled soaking and germination under the conditions favorable for production of desirable physical, chemical and biochemical changes associated with germination process. Germination is considered to be an important process responsible for enzyme productions. Malting has also been reported to increase the water soluble proteins, lysine, methionine, soluble sugars and diastatic activity in the malt (Wang and Fields, 1978). The biochemical modification in the grain during malting may be advantageous to produce malt with improved nutritional quality, due to which it can be used in various traditional foods, functional foods, health foods.

But malting for prolonged period results in significant loss of dry weight (Pathirana *et al*., 1983). This is undesirable when malting is intended for traditional food uses. Thus, it is essential to standardize the malting condition to obtain nutritionally improved meal with minimum loss in dry matter. Hence, in present investigation efforts were made to standardize the malting process of finger millet and to assess its nutritional and mineral composition, while high *in vitro* protein digestibility (IVPD), *in vitro* starch digestibility (IVSD) and desirable low viscosity characteristics are considered as criteria for deciding standard method for preparation of finger millet malt.

● MATERIALS AND METHODS ●

Finger millet:

Finger millet of local variety was purchased from the market of Parbhani (MS) India.

Chemicals and processing equipments:

Chemicals used in present investigation were of analytical grade. The equipments *viz.,* BOD incubator (For germination of finger millet), Air flow drier (For drying of germinated finger millet.), sieve analyzer (For obtaining equal particle size), brook field viscometer (For measuring viscosity of finger millet malt), etc were obtained from Department of Food Science and Technology, College of Food Technology, M.A.U., Parbhani (MS) India.

Malting of finger millet:

Process for standardization of malting process for finger millet is summarized (Fig. 1).

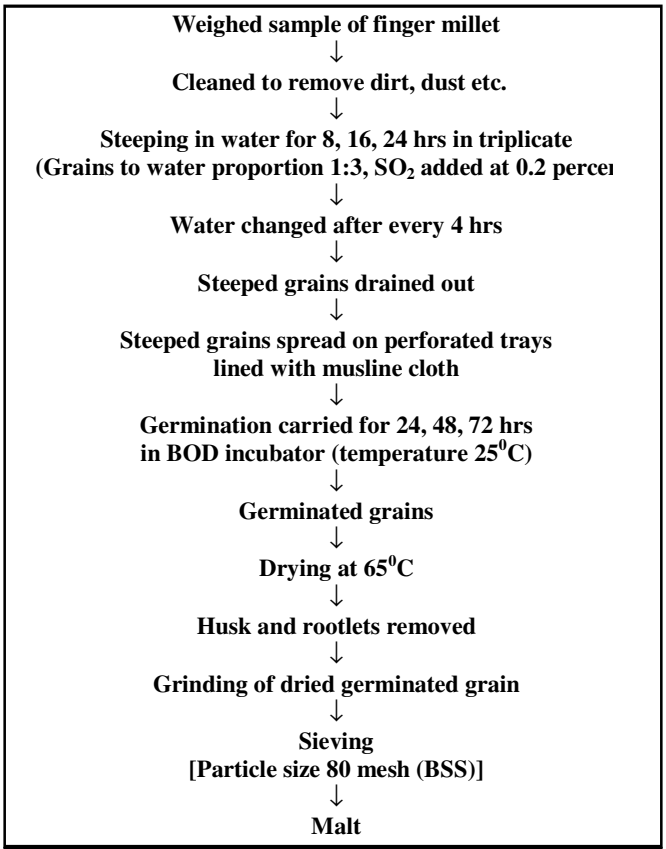

Fig. 1: Flow sheet for the malting process standardization of finger millet

Water steeping:

Weighed sample was steeped in 1:3 proportions with water for 8, 16 and 24 hrs. Every sample was steeped in triplicate to standardize steeping and germination time. Water was changed after every 4 hrs, sodium benzoate chemical (0.2 per cent) was added to prevent fungal growth.

Germination /Sprouting:

The steeped grains were drained and spread on perforated trays lined with musline cloth. The trays were placed in the BOD incubator at 25^{0}C. Water was sprinkled occasionally to avoid drying. Germination was carried out for 24, 48 and 72 hrs.

Drying and grinding:

The germinated grains were dried in air flow drier at temperature 65^{0}C and husk, root portions were manually removed. Husk was removed by rubbing pistel on grain surface. The malted grains were grinded using mixer grinder and sieved to obtained particle size of 80mesh (BSS).

Proximate composition:

The proximate composition *viz.,* moisture, ash, crude

protein, crude fat, carbohydrate, and crude fibers were measured by standard methods (AOAC, 1975).

Mineral composition:

The mineral composition of finger millet *viz.,* calcium, phosphorus, potassium, iron, copper, and zinc were measured by methods given by Ranganna (1995).

***In vitro* protein digestibility (IVPD):**

The *in vitro* protein digestibility was determined by calculating the difference between the amount of nitrogen in the sample before and after hydrolysis with Pepsin (A.O.A.C., 1975).

***In vitro* starch digestibility (IVSD):**

The *in vitro* starch digestibility was determined by the procedure given by Singh *et al.* (1982) using µ-amylase enzyme.

Determination of hot and cold paste viscosity:

Paste viscosity of finger millet malt having different soaking and germination time were determined by the procedure given by Malleshi and Desikachar (1979) using Brookfield viscometer. Finger millet malt was reconstituted with water at 20 per cent solid concentration and heated on water bath to 70^0C for 20 min. Viscosity was measured by viscometer and expressed as hot paste viscosity, then material was cool down to room temperature (27^0C) viscosity measured, as it was cold paste viscosity. Here R61 number spindle with 60 rpm revolution speed used.

Malting loss and malt yield:

Malting loss and yield were estimated by difference in weight of grains, before steeping and after drying of germinated grains.

Statistical analysis:

The analysis of variance of the data obtained was done by using Completely Randomized Design (CRD) for different treatments as per the method given by Panse and Sukhatme (1967). The analysis of variance revealed at significance of $P<0.05$ level S.E. and C.D. at 5per cent level is mentioned wherever required.

● RESULTS AND DISCUSSION ●

The results obtained from the present investigation are summarized under following heads :

Proximate composition:

The data on the proximate composition of finger millet grain sample are presented in Table 1.

Table 1 : Proximate composition of finger millet

Sr. No.	Particulars	Per cent values
1.	Moisture	11.21
2.	Ash	2.57
3.	Crude fat	1.51
4.	Crude protein	7.39
5.	Crude fibre	2.48
6.	Total Carbohydrate	74.84

* Each value represents average of three determinations

The finger millet was found to contain a good amount of crude protein (7.39 per cent) and ash (2.57 per cent). It was also good source of total carbohydrate (74.84 per cent) and crude fiber (2.48 per cent). The several researchers have reported nearly similar observations (Gopalan *et al*., 2004; Ravindran, 1991). Slight variation in nutrients observed were may be due to location of crop, season of year, plant population, selection of variety and fertilizer application (Deosthale and Belavady, 1978; Kadam *et al*., 1977).

Mineral composition:

The data on the mineral composition of finger millets are presented in Table 2.

Table 2 : Mineral composition of finger millet

Sr. No.	Particulars	mg/100g
1.	Calcium	318
2.	Phosphorus	267
3.	Potassium	392
4.	Iron	2.8
5.	Copper	0.34
6.	Zinc	1.51

* Each value represents average of three determinations

The finger millet was found to be a very good source of calcium and micronutrients. It was found to contain calcium 318mg/100g, phosphorus 267 mg/100g, potassium 392mg/100g and iron 2.8mg/100g. Similar results were reported by other scientists (Premavali *et al*., 2003; Rao *et al*.,1973).

Standardization of malting process for finger millet:

Apart from inherent malting quality of the grain, the conditions during the malting process also affected the final quality of malt produced. It is essential to provide all the necessary conditions during malting process so that the potential of the grain is fully exploited bringing the most desirable modifications in the grain and making the malt suitable for specific end use. In the present

investigation, processing conditions such as steeping time and sprouting time were standardized. Effect of variation in these processing conditions were brought necessary changes in the malt characteristics like malting losses, malt yield, *in vitro* protein digestibility (IVPD), *in vitro* starch digestibility (IVSD), hot paste viscosity and cold paste viscosity.

Effect of steeping and sprouting time on malting losses and malt yield:

The data on malting losses and malt yield of finger millet were calculated and presented in Table 3. It is revealed from Table 3 that malting losses were increased from 5.75 per cent to 13.6 per cent during malting process. However, malting loss was minimum (5.75 per cent) in 8 hr of soaking with 24 hrs of sprouting period and maximum malting losses (13.6 per cent) were observed in case of 24 hrs soaking with 72 hrs of sprouting. Pathirana *et al*. (1983) reported that malting loss in 48 hrs germinated sorghum grain was found to increase from 3 to 9.2 per cent when the steeping period was increased from 8 to 18 hrs. In the another study of malting qualities of new varieties of ragi, Malleshi and Desikachar(1979) reported 6.81 to 12.1 per cent malting losses in some varieties of ragi and 11.12 per cent in other.

Table 3 : Effect of steeping and sprouting time variation on malting losses and malt yield (per cent) of finger millet

	Steeping period (hr) at RT	Sprouting period (hr) Temprature25^{0}C		
		24	48	72
Malting losses	8	5.75	9.5	10.4
	16	7.7	11.7	12.8
	24	7.5	12.0	13.6
	S.E.±	0.45	0.615	0.52
	C.D. (P=0.05)	1.15	1.89	1.61
Malt yield	8	94.25	90.5	89.6
	16	92.3	88.3	87.2
	24	92.5	88.0	86.4
	S.E.±	0.37	0.44	0.45
	C.D. (P=0.05)	1.14	1.36	1.38

The malting losses due to sprouting of cereal grains can be attributed to respiratory activity of grains while the increased due to prolonged steeping may be due to faster rate of sprouting (Pathirana *et al*.,1983). However, such losses need to be minimized to avoid the loss of available nutrients. The malting losses have direct influence on malt yield.

The malt yield was decreased with increase in steeping and malting period. It is evident from the Table 3 that malt yield was maximum (94.25 per cent) in 8 hrs steeping and 24 hrs germinated grains and minimum (86.4 per cent) in 24 hrs steeping and 72 hrs germinated grains. In present investigation increase in steeping and malting period showed significant decrease in per cent malt yield with range of 94.25 to 86.4 per cent. This can be attributed to more development of rootlets and subsequent removal of rootlets, more respiratory activity and type of millet malted. From the table it is clear that malt obtained by 16 hrs steeping and 48 hrs sprouting was statistically significant in malting losses over malt obtained by 8 hrs steeping and 48 hrs sprouting. It also seen from table that malt obtained by 8hrs steeping and 48 hrs sprouting was statistically significant over 16 and 24 hrs steeped and 48 hrs sprouted malt with respect to malt yield. Whereas 16 hrs steeped and 48 hrs sprouted malt was at par with malt obtain by 24 hrs steeping and 48 hrs sprouting.

Effect of steeping and sprouting time on *in vitro* protein digestibility (IVPD) and *in vitro* starch digestibility (IVSD):

The data of IVPD and IVSD presented in Table 4 revealed that the IVPD was found decreased during long steeping and malting period. The IVPD increased significantly when the grains were steeped for 8 hrs and malted for 24, 48, 72 hrs, respectively.

It was increased even further when the grains were steeped for 16 hrs and malted for 48 hrs. But an increased in steeping time from 8 to 16 or 24 hrs seemed to nullify this effect because of decrease in IVPD was more or less same. Similar trend was observed by Bhise *et al*. (1988) on sorghum. The possible reasons for such behavior

Table 4 : Effect of steeping and sprouting time variation on IVPD (per cent) and IVSD (mg maltose/g/2 hrs) of finger millet malt

	Steeping period (hr) at RT	Sprouting period (hr) Temprature25^{0}C		
		24	48	72
IVPD	8	82.1	84.0	85.0
	16	81.7	86.2	82.0
	24	80.0	78.0	79.0
	S.E.±	0.49	0.516	0.42
	C.D. (P=0.05)	1.52	1.58	1.30
IVSD	8	114.3	113.9	88
	16	116	117	77
	24	100	74	68
	S.E.±	0.52	0.42	0.33
	C.D. (P=0.05)	1.61	1.31	1.021

need further investigation. The protein digestion is a multienzyme process while only pepsin was used in present study to digest the protein and partially hydrolyzed storage protein during steeping for 16 hrs followed by sprouting for 48 hrs may be more easily available for pepsin attack.

The highest IVSD was observed in grains soaked for 16 hrs and sprouted for 48 hrs. However, the IVSD was found decreased significantly when the steeping and sprouting period increased beyond 16 hrs soaking and 48 hrs sprouting. The starch hydrolysis is the synergistic action of α-amylase which was used for IVSD determinations and this α-amylase may be likely some what less active in hydrolysis of residual starch in the malt obtained from prolonged steeping and sprouting and this might have resulted lower values IVSD during prolonged periods of steeping and malting. Bhise *et al*. (1988) observed similar pattern of IVSD in sorghum. However, they reported that maximum IVSD was observed in sorghum at steeping of grains for 10 hrs and sprouting for 24 hrs.

From the Table 5 it is also evident that malt obtained by 16 hrs steeping and 48 hrs sprouting was significantly superior in IVSD and IVPD over malt obtained by 8 and 24 hrs steeping and 48 hrs sprouting.

Effect of steeping and sprouting time on hot paste and cold paste viscosity:

The data related to hot paste and cold paste viscosity of steeped and sprouted finger malt with variations in time period is summarized in Table 5

The data depicted in Table 5 revealed that hot paste viscosity of malts ranged from 41.2 to 54.8 centipoise. The hot paste viscosity decreased at all periods of steeping and sprouting. However, lowest hot paste viscosity was obtained at 16 hrs steeping and 48hrs sprouting. The reduction in the consistency of the malted flour paste on 16 hrs steeping and 48 hrs sprouting was may be due to increase in amylolytic and proteolytic enzymes. Low hot paste viscosity is desirable for use of the malt in health foods as it fascinates easy intake and good nutrition. Malleshi and Desikachar (1982) observed that hot paste viscosity of malts ranged from 30 to 74 centipoise for foxtail millet and proso millets. Samples with higher á-amylase activity gave slurries of lower paste viscosity. The cold paste viscosity also shows the decrease in viscosity as steeping and germinating time increase. Cold paste viscosity of malts ranged from 54.7 to 71.0 Centipoise. Lowest cold paste viscosity observed at 16 hrs steeping and 48hrs germinating time. The findings support the observation of Malleshi and Desikachar (1979) the amylase activity in the malted finger millet ranged from 75 to 199mg maltose/gm/30 min. The cold viscosity value varies from 46.6 to 19.6 Centipoise. Varieties with high amylase activity gave slurries with low viscosity which is expected. Similarly it can also be confirmed from results that cold paste viscosity was found to increase abruptly during cooling, probably due to retrogradation of amylase. From the suitability point of view for producing the malt that could be used in health foods where; high amylase activity, acceptable low paste viscosity and moderate malt yield of flour free from bran is desired. Hence, malt obtained by 16hrs steeping and 48hrs sprouting procedure considered as the standardized malting procedure for malt required for present study.

Table 5 : Effect of steeping and sprouting time variations on hot paste and cold paste viscosity (centipoise) of finger millet malt

	Steeping period (hr) at RT	Sprouting period (hr) Temprature25^{0}C		
		24	48	72
Hot paste viscosity	8	54.8	49.9	45.1
	16	44.8	41.2	41.6
	24	43.5	42	42.7
	S.E.±	0.49	0.35	0.38
	C.D. (P=0.05)	1.51	1.08	1.18
Cold paste viscosity	8	71.0	65.3	60.0
	16	59.2	54.7	54.9
	24	58.1	57.6	57.1
	S.E.±	0.37	0.46	0.49
	C.D. (P=0.05)	1.14	1.44	1.51

Conclusion:

During the present investigation attempts have been made to study the nutritional and mineral composition of finger millet and the malting process by using varied steeping and sprouting time. In light of the scientific data of present investigation, it may be concluded that:

– Finger millet grains were rich source of minerals specially calcium, potassium, phosphorus and iron. It also contained a good amount of protein, calories and crude fiber.

– Some anti-nutritional factors are present in finger millet which interferes in availability of mineral and protein to human body. These can be minimized using simple processing technique such as malting.

– Malt obtained by 16 hrs soaking at room temperature and 48 hrs sprouting in BOD incubator (25^{0}C temperature) considered as the standardized malting procedure for present study as these malting conditions gave highest amount of IVPD, IVSD and desired low

paste viscosity with moderate malt yield.

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