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Effect of Dehydration on the Quality Characteristics of Extruded Pasta Using Millet Milk Powder

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Abstract

Millet is an indispensable food for millions of people inhabiting the semi-arid tropics. It is used primarily for human food and remains a major source of calories and a vital component of food security in the semi-arid areas in the developing world. The present study focused on the use of underexploited millets for production of ready-to-eat products using extrusion cooking. The millet were selected for study namely Finger millet. The techniques used for processing millets are soaking, sprouting, extraction of milk from millets, dehydration and milling were carried out for development of millet milk powder. Physical properties namely bulk density, swelling power, water holding capacity, foam capacity and foam stability and nutritional properties namely, protein, ash, fat and carbohydrate, calorific value of the millet milk powder were analyzed. Extrusion cooking was carried out using a single screw extruder at 400 rpm. The organoleptic qualities of extruded samples were analyzed by panelists on a 9 point hedonic scale. The findings of the study revealed that significance difference ($P<0.05$) was observed in all the parameters between the control and millet milk powder. Organoleptic evaluation stated that the millet milk pasta had higher scores and highly acceptable among the panelist.

Keywords: Soaking; Sprouting; Extraction; Dehydration; Extrusion; Pasta

Introduction

Agro biodiversity plays a vital role in food security, poverty reduction and management of natural resources. Changing socio-economic and climatic conditions are leading to loss of biodiversity and degradation of the ecosystem. Among the cereals only three cereals i.e. rice, wheat and maize fulfill 90% of the global food needs. Therefore, there is an urgent need for widening the food basket to ensure sustainable development. Minor millets in particular are used as food sources mainly in arid and semiarid regions of the world. They play an important role in the food and nutritional security of the poor. However, their presence in the Indian food basket has been declining over the years. One reason for this decline is the increased availability of rice, wheat and maize (particularly rice and wheat under subsidized public distribution system).The lack of modern technologies for their effective processing and utilization is an important reason for their decline. All these elements have collectively contributed to the neglect and underutilization of 20 minor millets in South Asia of these millets leading to their increased marginalization, accelerated loss of their genetic diversity and traditional food culture associated with them. Their cheaper price, compared to that of rice and wheat makes them more accessible to the poor people and those living in economically backward mountainous and semi-arid regions of South Asia. Over the last few years, there is an increasing recognition of their favorable nutrient composition and benefits as healthy food, hence the protein content in these species is high to that of wheat, but in addition they are also rich in B-vitamins, especially niacin, B6 and calcium, iron, potassium, magnesium and zinc. Minor millets do not contain gluten; hence they are appropriate food for those with celiac disease or other forms of allergies or wheat intolerance [1]. Thus, apart from their continued strategic role as staple for the poor in marginal agricultural regions, they are also assuming a new role as a health food for the urban high income people. In order to amplify the importance of the underutilized millets the specific following objectives was focused, to develop a process of Finger millet milk powder and utilization in production pasta and to evaluate the quality characteristics of developed Finger millet milk powder and pasta.

Methods and Materials

Preliminary processing and preparation of Finger millet milk powder

Preliminary preparation of sample: Finger millet (Eleusine *coracana*) was obtained from the local super market in Puducherry. The finger millet seeds were cleaned manually to remove broken seeds, dust and other extraneous materials. The techniques used for processing millets were soaked, sprouted, extraction of milk from millets; dehydration and milling were carried out for development of millet milk powder.

Process involved in extraction of milk from processed finger millet: After preliminary processing of millets they were soaked separately in water overnight for a period of 12 hours. One half of the soaked millets namely finger millet were processed further for grinding and extraction of milk and the other half of the millets was left for sprouted. Sprouted finger millet was processed for extraction of milk by using same techniques. The schematic representation of steps involved in extraction of milk is given in figure 1.

Dehydration process: The extracted milk was dehydrated by two techniques namely hot air oven drying 70°C and sun drying. The millet milk which was extracted from soaked and sprouted millets was dehydrated in sun drying and hot air oven drying and further grouped.

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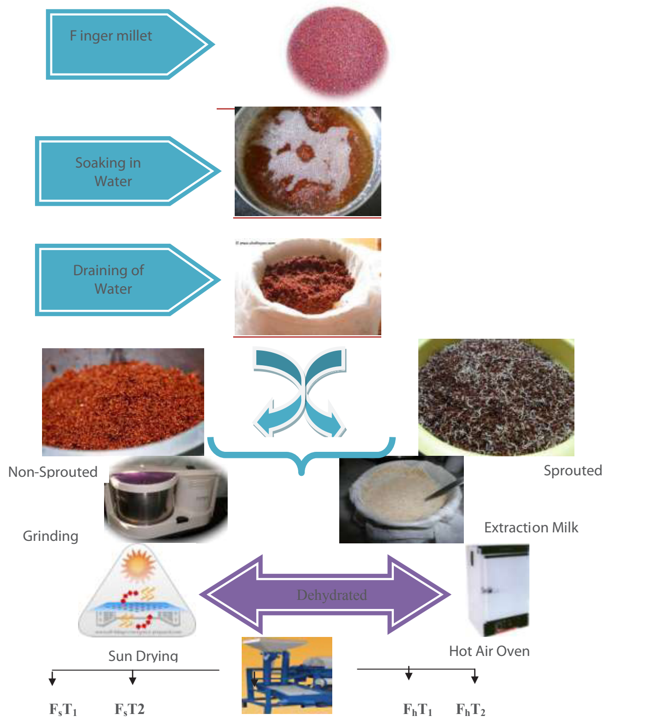

F_sT_1 -Finger millet sun drying soaked, F_sT2 –Finger millet sun drying sprouted, F_hT_1- Finger millet hot air oven soaked F_hT2 –Finger millet hot air oven sprouted

Figure 1: Process involved in the preparation of finger millet milk powder.

Ratio	Millet milk powder%	Maida %
50:50	50	50
70:30	70	30
90:10	90	10

Table 1: Ratio of millet milk powder for extrusion.

F_sT_1 constituted finger millet, sun drying soaked, and F_sT_2 constituted finger millet, sun drying sprouted, F_hT_1 constituted finger millet, hot air drying oven soaked, F_hT_2 constituted finger millet, hot air oven drying sprouted. The dehydrated millet milk was milled to fine powder. Thus acquired millet milk powder is stored in suitable packaging material.

Processing of pasta from millet milk powder: Extrusion is a process used to create objects of a fixed cross-sectional profile. A material is pushed or drawn through a die of the desired cross-section. The two main advantages of this process over other manufacturing processes are its ability to create very complex cross-sections and work materials that are brittle, because the material only encounters compressive and shear stresses. It also forms finished parts with an excellent surface finish [2]. The experiments used a cold extrusion with single screw extruder (La Monferrinasrl Model dolly) at a pressure of 400 rpm. After several permutation and combination the Finger millet milk powder was developed for the extrusion of pasta, 1.6 g of guar gum was added as a binding agent to the 100% of the millet milk powder. The ratio of millet milk powder is given in table 1. The extruded pasta was dried in hot air oven at 60°C for 2 hours. The step involved in processing of pasta from millet milk powder is given in figure 2.

Quality characteristics of millet milk powder and pasta

Physical properties of millet milk powder: The millet milk powder was analyzed for bulk density [3], water holding capacity [4], foam capacity and foam stability [5] and swelling index (Table 2).

Sensory analysis: The sensory assessments were conducted in a Food Science and Technology laboratory. Around 20 panel members

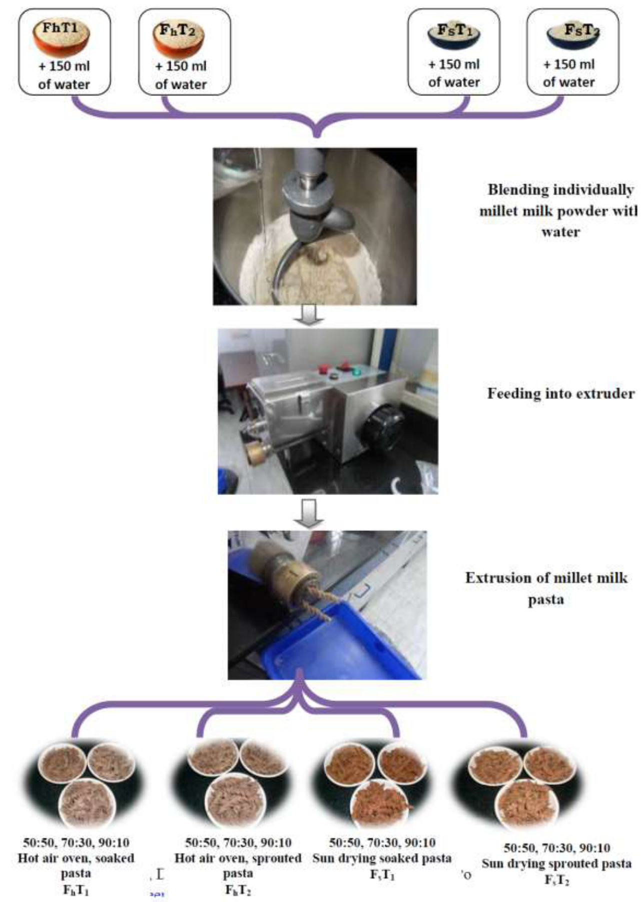

Figure 2: Process involved in the preparation of pasta

Sample	Appearance	Color	Flavor	Texture	Taste	Mouth feel	Overall Acceptability
Control	7.8	8	7.46	7.86	7.6	7.6	7.9
Sample F_hT_1							
50:50	6.53	6.09	6	6.3	6	5.75	6.08
70:30	6.7	5.9	6.1	6.18	6.16	6.2	6.41
90:10	5.5	4.9	5.45	5.46	5.41	5.46	5.66
Sample F_hT_2							
50:50	5.57	6	5.07	5.80	4.57	4.84	5.15
70:30	4.50	4.69	4.27	4.57	4.46	4.41	4.53
90:10	4.15	3.84	3.72	4.14	4	3.69	3.69
Sample F_sT_1							
50:50	3.1	4.0	3.7	3.6	4.0	3.9	4.8
70:30	4.5	4.6	4.1	4.7	5.0	4.8	4.5
90:10	4.8	5.0	4.8	4.5	3.2	3.0	3.6
Sample F_sT_2							
50:50	3.6	4.5	3.9	3.3	4.0	3.6	3.9
70:30	4.0	3.6	3.0	3.2	4.0	4.2	4.1
90:10	4.2	4.5	4.2	4.0	4.3	4.2	4.3

Table 2: Sensory evaluation of the millet milk pasta and its control.

Parameters	Hot Air oven(Fh)		Sun drying(Fs)	
	Soaked (T_1) (Mean±SD)	Sprouted (T_2) (Mean±SD)	Soaked (T_1) (Mean±SD)	Sprouted (T_2) (Mean±SD)
Bulk density	0.55±.005^b	0.533±.003^d	0.68±.017^a	0.65±.005^c
Swelling Index	3.875±.058^b	4.9±.022^d	3.05±.057^a	3.45±.028^c
Water Absorption Capacity	0.9±.005^{ac}	0.95±.026^{bcd}	0.9±.057^a	0.98±.034^{bcd}
Foam capacity	2.4±.115^b	3.8±.115^d	2.9±.05^a	3.4±.05^c
Foam stability	96.2±.011^b	98±.02^d	95.06±.02^a	96.65±.04^c

Column followed by different letters are significantly different ($p<0.05$), Fs-Sun drying

Fh- Hot air oven drying,T_1- Soaking, T_2 – Sprouting

Table 3: Physical properties of finger millet milk powder.

were selected by the threshold test. Control and sample (A, B, C & D) was served to panel member in hot and different ratio. The products were evaluated based on its flavour, color, texture, taste, appearance, mouth feel and over all acceptability using Nine-point hedonics scale (1=dislike extremely) to (9=like extremely). From the scores of the sensory evaluation the best one was been selected among the four different variations. It was found that the product F_hT_1 (70:30) was been highly preferred by the panelists which was finalized for further evaluation of its quality characteristics.

Nutrient analysis of millet milk powder and pasta: The processed millet milk powder and pasta was analyzed for protein by kjedhal method [6], carbohydrate by using anthrone method [7], fat by soxhlet extraction method, iron, ash and moisture [6,8] was done using standard procedure.

Compilation of data: All analysis was carried out in triplicate. Statistical analysis was carried out using statistical tool SPSS. The data was subjected to ANOVA. The significance of mean differences was determined by Least Significant Difference (LSD).

Results and Discussion

Physical properties

Bulk density controls the volume of storage container and affects the packing cost of the dried products [9]. Finger millet in both the processing methods and treatment ranged between 0.533-0.68 for bulk density of millet milk powder. Sample F_sT_1 had highest value. This may be due to the higher moisture content, resulting in dense packing of the starch particles in addition to the higher and greater regulatory in shape of the starch granules (Table 3).

Swelling power is the uptake of water during the gelatinization of starch [10,11]. Swelling power of finger millet in both the processing methods and treatment was found to be 3.05-4.9. When compared to other treatments, F_hT_2 had higher value. Zobel stated that the higher swelling power of the powder obtained from germinated millet grains as compared to the other powder from untreated millet grains may be due to the reduced swelling content of the powder.

Water absorption capacity is an important protein water interaction that occurs in various food systems. Water absorption capacity is the ability of a protein matrix to absorb and retain bound, hydrodynamic, capillary physically entrapped water against gravity. The values were found to be 0.9 to 0.98 of finger millet in both the processing methods and treatment. The highest water absorption capacity was observed in the sample F_sT_2. The high water absorption capacity obtained in germinated millet powder may be due to changes in the quality of proteins in the powder.

The reason for conducing foam volume and foam stability is influenced by protein concentration. Foam obtained with a higher concentration of protein is denser and more stable in case increase in thickness of intrafacial films. The foam surface pressure changes density foaming depends primarily on the rate of protein absorption. Sample F_hT_2 have more foaming capacity when compared to other treatments. After 1 hour, foam stability was found to be high in sample F_hT_2. The foam stability of other treatments was more or less similar (Table 4).

Proximate analysis

Irrespective of both the processing methods and treatments the moisture content ranged between 9.4-12.05%. The results were comparable to the observations of Singh who reported that the moisture content of millet powder is 10.01 to 12.17%. When compared with other treatment, F_hT_2 had lesser moisture content. During germination and sprouting there is decrease in the moisture content of millets.

The ash content of the finger millet milk powder in both the processing methods and treatments ranged between the 2.33 to 2.85. When compared to other treatments, F_hT_2 had a less value. Similar trend was observed by IkeneBomah [12] stated that the germinated and fermented powder was to reduce the total ash content. The ash content indicated a rough estimation of the mineral value of the product. This reduction may be due to the leaching of the soluble inorganic salts during germination.

The protein content of the finger millet milk powder in both the processing methods and treatments ranged between 8.05-10.01 g. Malleshi and Hadimani [13] stated that the protein content ranged between 8-11% of finger millet is comparable to other cereals. In the finger millet it was found that F_sT_2 (10.01) had highest protein. During germination seed proteins were degraded to increase the soluble protein content [14].

The fat content ranged between 3.05 to 4.01 in both the processing methods and treatments. Malleshi and Hadimani reported that the range of the fat content is 2.6-3.7% of seed coat matter from native and malted millet [13,14]. When compared to other treatments, F_sT_2 had the low fat content. Similar finding was observed by Fasasi [16] who reported that the low fat content recorded in fermented and germinated powder sample will help in increasing the shelf life of the samples by decreasing the changes of rancidity and will also contribute to the low energy value of the sample.

The carbohydrate content of the finger millet milk powder in both the processing methods and treatments ranged between 70.6-72.8 g. The values seem to be more or less similar in the all treated samples.

Parameters	Hot Air oven(F_h)		Sun drying(F_s)	
	Soaked(T_1) (Mean±SD)	Sprouted (T_2) (Mean±SD)	Soaked(T_1) (Mean±SD)	Sprouted(T_2) (Mean±SD)
Moisture	10.6±.11^b	9.4±.11^d	12.05±.02^a	11.15±.028^c
Ash	2.74±.011^a	2.33±.017^c	2.85±.028^b	2.40±.11^d
Protein	8.05±.011^b	8.68±.023^d	9.80±.05^a	10.01±.011^c
Fat	3.95±.057^b	3.08±.011^c	4.01±.005^a	3.05±.017^{cd}
Carbohydrates	72.4±.11^b	70.6±.11^c	72.8±.11^a	70.9±.23^d
Energy	357±1.15^b	312±1.15^d	352±1.15^a	342±1.15^c
Iron	5.7±.115^b	4.87±.02^c	6.2±.057^a	5±.28^d

Column followed by different letters are significantly different ($p<0.05$), Fs-Sun drying,

Fh- Hot air oven drying,T_1- Soaking, T_2 – Sprouting

Table 4: Proximate Analysis of Finger millet milk powder.

Parameters	Control	Sample F_hT_1
Energy (Kcal.)	293	336
Protein (g)	5.25	6.65
Fat (g)	0.01	3.4
Carbohydrate (g)	68	68.45
Ash %	0.4	0.6
Iron (mg)	1.0	2

F_hT_1 (Finger millet hot air oven soaking 70:30)

Table 5: Nutrient analysis millet milk powder pasta.

Malleshi and Hadimani stated that the carbohydrate content is 72% of the millet [13]. When compared to other treatments, F_sT_2 had the lowest value. The decrease in carbohydrate content of germinated seed powder may be due to the utilization of some of the sugar during the growth metabolic activity reported by Fasasi [16] (Table 5).

The calorific value of finger millet milk powder was ranged between 312-357 kcal. Samples F_hT_1 had highest calorific value when compared to other treatments.

The range of iron content in finger millet milk powder were found to be 4.89-6.2 mg respectively, sample F_sT_1 had slightly higher iron content when compared to the other treatment. In accordance with Gopalan [17] reported that the iron value ranged between 2.4-6.4 mg of finger millet powder.

Sensory evaluation of millet milk powder pasta

The panels of semi- trained judges consisting of 20 members were given the extruded pasta for evaluation of organoleptic characteristics viz. appearance, colour, taste, flavour, texture, mouthfeel and overall acceptability. It was served to judges on the day of preparation. The mean scores of sensory evaluation showed that all the extruded products prepared from different ratio of finger millet were within the acceptable range, while the extruded product prepared from ratio of 70:30(F_hT_1) had significantly better appearance (6.7), color (5.9), flavour (6.8), texture (6.9), taste (6.7), mouthfeel (6.5) and overall acceptability (7.0) when all the prepared extruded samples were compared with the commercial control. It was revealed from the scores of the overall acceptability that the finger millet milk powder 70:30(F_hT_1) is acceptable among the panelist. Hence was finalized and selected for further analysis.

Nutrient analysis of millet milk pasta

The energy value was found to be highest in sample F_hT_1 (336 Kcal.) when compared to control (278 Kcal). Finding was observed by Mbithi-Mwikya [18] stated that the traditional technologies such as decortications, soaking process to reduce the antinutritional factors and increases the energy of the millet grains.

The protein content of pasta ranged between 5.25-7.58. Sample F_hT_1 had higher protein content when compared with control pasta. As far as the protein content is concerned, sample F_hT_1 had highest protein content when compared to control. Gopalan [17] resulted that the finger millet was rich in protein content.

The fat content of pasta ranged between 0.01 to 4.43. The fat content was rich in sample F_hT_1 (3.4) when compared to control (0.01). Duke [19] who stated that the pearl millet grain has high fat content when compared to other millet. Kurien [20] stated that the finger millet seed fraction contain 3.2% fat content. Mtebe stated that the millet has been reported to be low in fat content.

The carbohydrate values were found to be highest in sample F_hT_1 (68.45) when compared to control (68). The higher carbohydrate values were found to be in pasta from sample F_hT_1. whereas the carbohydrate level increased when the proportion of millet was greater in pasta.

The ash content of pasta ranged between 0.04 to 0.06. The ash content was rich in sample F_hT_1 when compared to control. As far as the ash content is concerned, sample F_hT_1 had more ash content when compared to other sample. Ikenebomah [12] reported that the ash content indicated a rough estimation of the mineral value of the product. The iron content of pastas ranged between 1 to 2 mg. When compared to control sample F_hT_1 had more iron content. Gopalan [17] resulted that the finger millet rich in mineral content (iron). Klopfenstein and Hoseney [21] stated that the finger millet has high levels of iron content. The iron content was found to be highest in sample F_hT_1 when compared to control.

Conclusion

One of the greatest constraints in the popularization and commercialization of coarse cereals has been its branding as poor man's food, which seems to be misplaced. They could not make it to the food basket of urban elite whose consumption choices play a dominant role in the commercialization of any food product. The study concluded that the millets would probably be more widely used if processing were improved and if sufficient good-quality flour were made available to meet the demand. Due to modernization and lack of time, the usage of commercially available ready to eat foods usage comes in to existence. Most single commercial cereals products are made from refined and over processed grains, having lost most of the vital nutrients in the process. In order to produce good quality flour and to overcome cumbersome and time-consuming food preparation of millets, ready-to-eat and convenient food process should be developed. Ready-to-eat millet based products made by adopting traditional processing methods gives you a healthful addition for a better lifestyle. These millets were selected because of its high nutritive value and its increasing health significance. It is recommended for all age groups and for metabolic disorders. The immense potentialities that dehydrated millet milk powder possesses could be utilized in development of novel food products at therapeutic end.

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