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A Comparative Study on the Effect of the Traditional and Industrial Milling on the Nutritional Composition of Sorghum, Pearl Millet and Wheat Flour

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ABSTRACT

Pearl millet, sorghum, wheat is a staple food in India. It is milled into flour by traditional and industrial dry milling processes. This research was conducted to help determine how to improve the nutritional value and acceptability of pearl millet. The traditional milling step has lowers the pH of kernels. The effects of the traditional and industrial "dry milling" processes on the physical and nutritional composition of grain were compared. Regarding comparing the milling processes, was conditioned and decorticated traditionally with a millstone and industrially with an roller mille. The traditional decorticated grain was steeped and sun dried for 24 h before milling, whereas the industrially decorticated grain was roller milled. Proximate analyses were conducted on the samples. The traditionally milled flour was lighter in colour than industrial milled flour. However, it was significantly lower in protein, ash and nutrient contents in comparison to industrial milled flour. This was due to the removal of more pericarp and germ in the traditional process. The industrial dry milling process, therefore, produces flour with a higher nutrient content in terms of protein, fat and minerals. However, the traditional milling process makes the colour of the pearl millet flour lighter, which is probably the reason that it is more acceptable to consumers.

Keywords: *Pearl millet, Sorghum, Wheat, Traditional and Industrial "dry milling*

INTRODUCTION

Millets are a group of small-grained cereal food crops which are highly nutritious and are grown under marginal low fertile soil with very low inputs such as fertilizers and pesticides. These crops largely contributed to the food and nutritional security of the country. Most millets crops are native of India and are popularly known as nutricereal as they provide most of the nutrients required for the normal functioning of the human body.

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Millets are rain fed crops and grown in regions with low rainfall and thus resume greater importance for sustained agriculture and food security (Rao, et al.,) Important millet crops grown in India are Sorghum (Great millet), Bajra (Pearl millet), Ragi (Finger millet) and small millets *viz.*, Korra (Foxtail millet), little millet, Kodo millet, Proso millet and Barnyard millet. These are often referred to as coarse cereals, but realizing the nutrient richness of the grains, they are now considered as nutricereals. Millets are rich in minerals like iron, magnesium, phosphorous and potassium. Finger millet is the richest in calcium content, about 10 times that of rice or wheat. In this fashion, nutrient to nutrient, every single millet is extraordinarily superior to rice and wheat and therefore is the solution for the malnutrition that affects a vast majority of the Indian population.

In India, sorghum is consumed popularly as staple food. Which is commonly prepared from decortications endosperm meal. Traditionally, the meal is produced by hand pounding, using a millstone, pestle and mortar, or by grinding with a stone mill (Musty & Kumar, 1995). Presently, milling by mechanical means, commonly using abrasive decorticators and hammer mills, has become popular (Bassey & Schmidt, 1989, & Rohsbch 2003). Although the abrasive decorticators are credited for stimulating the development of a sorghum milling industry, the types commonly used are limited in terms of production throughput and control of meal quality, and they are also associated with high milling losses (Gomez 1993, & Taylor & Dewas 2001). Thus, there is still a lack of suitable sorghum milling technology that could transform sorghum processing into vibrant food industry.

Pearl millet (*Pennisetum glaucum*) is the most widely grown type of millet. Because of its tolerance to difficult growing conditions such as drought, low soil fertility and high temperature. Pearl millet grain is the staple diet for farm households in the world's poorest countries and among the poorest people Pearl millet is a "high-energy" cereal that contains carbohydrates, protein, and fat, rich in vitamins B and A, high in calcium, iron, and zinc, and also contains potassium, phosphorus, magnesium, zinc, copper, and manganese. Feeding trials conducted in India have shown that pearl millet is nutritionally superior to maize and rice (NRC, 1996), DeVries & Toenniessen, 2001).

Wheat (*Triticum aestivum*) is considered as the most paramount cereal crop. It belongs to the genus Triticum of the Poaceae (Gramineae) family (Dewey, 1984). It constitutes as a staple diet of prodigious chunk of the human population. Wheat is an affluent source of carbohydrates and additionally contains other valuable components such as protein, minerals and vitamins (Siddiqui & Sarwar, 2002). The most consequential factor in determining the quality of these end-use products is wheat flour. Wheat flour emanates from the endosperm part of the wheat kernel and contains about 6 - 20% protein, 60 -75% starch, 1.5-2.0% lipids, and 2-3% (Honey, 1994; & Halverson & Zeleny, 1988).

Traditionally, women decorticate pearl millet grain by hand pounding so that the end product is more palatable for consumption. In the traditional chhattisgarshian milling process, pearl millet grain is decorticated manually using a pestle and mortar. Thereafter, it is pulverized into flour manually with the mortar and pestle or mechanically using a roller mill. This traditional process consists of five major unit operations: conditioning, decortication, steeping, and sun drying and pulverizing. The industrial dry milling process for millet comprises several processes, including the use of complex continuous systems of precision roller mills, sifters and air classifiers.

MATERIALS AND METHODS

COLLECTION OF SAMPLE

The grains were collected from local market located in Bilaspur, Chhattisgarh. A total of 6 samples were produced by milling sorghum, pearl millet and wheat grain types grown in Bilaspur, Chhattisgarh, using millstone milling process (hand pounding (HP)) and roller milling process (RM). The milled samples were vacuum packed in batches of 1kg in plastic zipper pouches and stored at room temperature until used.

TRADITIONAL MILLING PROCESS

FLOW CHART PROCESSING OF MILLING FLOUR USING MILESTONE

WATER CONDITIONING

↓

SUN-DRIED

↓

1st DECORTICATION WITH MILLSTONE

↓

WINNOWING

↓

SEMI DECORTICATED GRAINS

↓

GRINDING WITH MILLSTONE

↓

WINNOWING

↙ ↘

CHOKER FLOUR

PHYSICAL ANALYSIS

Grain characterization

Grain hardness (proportion of vitreous to floury endosperm) was determined by cutting twenty kernels longitudinally in half and assessed against standards, A sound pearl millet kernel, germ side up was secured onto a piece of rubbery gum to keep it in place. Using a scalpel, the grain was halved longitudinally in a manner that each half contained an equal portion of germ. The cut kernels were compared against standards. The results were expressed as percentage of hard, medium and soft grains. The grains with a higher proportion of vitreous endosperm are considered harder than those with a higher proportion of floury endosperm.

Milling Recovery Rate (Yield)

Before grinding the grain, we dry it well in sun light so it grinds well. The milling recovery rate (the amount of material recovered after each unit operation of the milling process) was determined by comparing the weights of flour was produced from milling the grains with the original weight of kernels. Before weighing, the grains were sun-dried.

CHEMICAL ANALYSIS

These were determined using a one-stage air oven method, AACC Method 44-01, Moisture One stage air oven method (AACC International, 2000a). Samples were dried by heating at ±103°C for three hours. Ash was determined by the AACC Method 08-01, Ash-Basic Method (AACC International, 2000b), wherein samples were incinerated at 550ºC in a muffle furnace until a light grey ash with a constant weight was obtained. fat was determined by the Soxhlet method. The fat was extracted with petroleum ether with a boiling range of between 30°C and 60°C. dietary fiber was calculated by gravimetric method.

RESULT AND DISCUSSION

Grain characterization

It has been suggested that the physical attributes of grains such as their texture, pericarp thickness and shape are crucial factors that determine their decortication and milling performance (McDonough & Rooney, 1989). The whole grain had a thousand kernel weight of 9.99 g, sorghum kernels weight id 8.98, and wheat kernel weight id 9.93. This indicates that the grain used in this work was slightly larger in size found in this study.

Ash content

Ash content was significantly in the millstone grinding process 1.97 in pearl millet flours, 1.57 in sorghum, 1.51 in wheat flour. This difference in ash content indicates differences in the extent to which the outermost layers of the decorticated grains are lost during decortication by the various methods. Market samples of flour, in a roller milling ash content of sorghum is 1.67, 2.2 in pearl millet, and the ash content of wheat varies from about 1.50 to about 2.00%. The pure endosperm content is about 0.35% considering that the wheat kernel contains 80% endosperm, it become clear that the kernel non-endosperm part of kernel (pericarp, alurone, and germ) are very high is ash compare to endosperm. Ash contain also indicate milling performance which indirectly reveals the amount of bran contamination in flour white flour indicators for low ash content while whole wheat flours have high ash content (buriro et al.,) show that ash content exhibits inverse relationship with the quality of milling process.

Fat content

Fat content followed a similar trend as ash content. The decrease in fat content of flour from kernels subjected to decortication is attributed to the removal of germ, which is rich in fat (hadimani & malleshi, 1993). Fat content obtaind from millstone milling process is 5.49 in pearl millet flour, 3.50 in sorghum, 2.50 in wheat flour, compare to roller milling fat content of pearl millet flour is 7.2, prabhasankar and rao (2001) explained the effect of stone milling on unsaturated fatty acid content of wheat flours. Unsaturated fatty acid, particularly linolenic acid was lower in stone milled flour compared with roller milling flour.

Protein content

Protein quality is an imperative decisive factor for evaluating grain quality. The protein obtained by the grinding process was shown in table 4.1 Anjum et al. (1991) reported that the protein content ranged from 9.68 to 13.45% among the grain varieties. The significance of the independent parameters (grinding speed, feed rate and clearance between stones) for the protein of pearl millet, sorghum, and wheat flour was carried out by analyzing the experimental data recorded. The different levels of grinding speed, feed rate and clearance between stones have significant effect on the protein. The grain pericarp, which is relatively poor in protein, was removed. This was consistent with earlier findings by Taylor and Schussler (1986) that approximately 80%, 60% of the whole grain protein is contained in the endosperm, germ and pericarp, respectively. As expected, the amount of protein retained in the flour was a consequence of the extraction rate.

Table: 4.1 protein content of whole grain, roller milled flour and millstone milled flour

Grain	Whole grain	RMF	MMF
Sorghum flour	10.4	11g	5.77
Pearl Millet flour	11.6	12g	6.65
Wheat flour	11.8	10g	4.20

Dietary fiber

Whole grain millstone milled flour had the dietary fiber in pearl millet it was 1.30, sorghum 1.65, wheat flour have 1.80g of dietary fiber. This is because of decortications remove the pericarp where the dietary fiber is concentrated. Hence, the more substantial decrease in dietary fiber with more extensive milling of the grains.

Table: 4.2 dietary fiber content of the whole grain, roller milled flour, millstone milled flour

Grain	Whole grain	RMF	MMF
Sorghum flour	1.6g	1.3g	1.65g
Pearl Millet flour	1.2g	2.8g	1.30g
Wheat flour	7g	2.7g	1.80g

Iron content

The amount of iron obtained from millstone-milled flour was shown in table 4.4. The analysis of experimental data was carried out to observe the significant effect of various process variables, i.e. grinding speed and clearance between stones on iron.

Table: 4.4 iron content in millstone millet flour

Grains	Whole grain	RMF	MMF
Pearl millet	8.0mg	6mg	0.63mg
Sorghum	4.1mg	3.8mg	0.59mg
Wheat	5.3	4.3mg	0.71

Microbial analysis

The result of the microbiological analysis of sorghum, pearl millet and wheat flour sample are shown in table 5. In this study, TCC of sample 1 (sorghum) is 954, sample 2(pearl millet) 42, sample 3(wheat) 718. The highest TCC was found in sample 1. The yeast and mould count of sample1 was 00/25g, sample 2 00/22, sample had 39/15. A variety of micro organism were found contaminating the flour sample, and these were bacteria, fungi, and mold. The most contaminated products were whole wheat flour which had higher moisture content and Ph values. Flour is susceptible to spoilage, especially when stored improperly or for too long.

Table 4.5 microbial analysis of sample 1, sample 2, sample 3

Sample	TCC	Yeast and mold
Sample 1	954	00/25
Sample 2	42	00/22
Sample 3	718	39cfu/25g

Table 4.6 Overall physiochemical analysis result of pearl millet flour obtained from millstone

PARAMETERS	UNIT OF MEASUREMENT	SORGHUM FLOUR	WHEAT FLOUR	PEARL MILLET FLOUR
Moisture	gm/100gm	11.76	11.76	10.59
Total Protein	gm/100gm	5.77	5.77	6.65
Total Fat	gm/100gm	3.50	3.50	5.49
Total Carbohydrate	gm/100gm	77.40	77.40	75.30
Dietary Fiber	gm/100gm	1.65	1.65	1.30
Sugar	gm/100gm	0.00	0.00	0.00
Iron	mg/100gm	0.59	0.59	0.63
Sodium	mg/100gm	384.52	384.52	456
Calcium	mg/100gm	43.18	43.18	29.53
Magnesium	mg/100gm	18.67	18.67	12.39
Energy	kcal	364.18	364.18	377.21
Vitamin C	mg/100gm	4.00	4.00	4.50
Vitamin A	mg/100gm	1.71	1.71	1.08
Total Ash	gm/100gm	1.57	1.57	1.97
Ash Insoluble In dill HCl	gm/100gm	0.62	0.62	0.71
Ph Value	…..	6.82	6.82	6.59
Water Hydration Capacity	manual	68.00	68.00	76.00

CONCLUSION

The traditional milling process, using a millstone was thought to remove high nutrient compared to that of a mechanical decortication. Mechanical decortication of the grain was thought to remove present in the pericarp tissue and the aleurone, but also those in the germ and part of the peripheral endosperm because of the progressive abrasion of the outer layers of the kernel. However, the results of this study showed that fewer nutrients were found in the traditional milled flour compared to the industrial flour. This may be due to a more precise removal of the pericarp containing to the using a millstone. These findings are in agreement with the lower protein, ash and fat contents of the traditionally milled flour. Decortication using a millstone resulted in the removal of more pericarp. This contributed to the lighter colour found in traditional milled flour compared to the industrial milled flour, which improved its appearance.

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Author Contribution:
All authors contributed equally to establishing the research and design experiment topic.

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