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Process Optimization for the Development of Ready to eat Corn grits

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Abstract
A technology has been developed to produce corn grits: Ready-to eat food product. The steps involved cleaning and grading, moisture pre-conditioning, dry conduction heating (sand roasting) and grinding of corn. The hydration characteristics and the development of stress cracks on the corn kernel was also studied by soaking corn kernels in excess water at temperature ranging from 30 to 90 ^{0}C for 1 to 1440 min. The pre-conditioned corn kernels were roasted at varying roasting process variables viz., moisture content ranging from 14-22%, sand temperature ranging from 160-200 ^{0}C and roasting time from 30-150 S. A hammer mill was used for grinding experiments at three different Rpm 2645, 1975 and 1648 to investigate the effect of rpm on grits yield. Sieving kinetics tests of hammer mill product of raw and roasted corn firmed that 10 min continuous sieving by a series of standard sieves up to 1.17 mm sieve size was sufficient for obtaining desired size of particle. Particle size distribution of both raw and roasted was influenced by changing rpm of hammer mill, at rpm 1648 the yield of roasted corn grits were 80.6% and raw grits were 72.02% whereas at rpm 2645 yield of raw and roasted corn were 67.8 and 74.75% respectively and at rpm 1975 it was 70.63 and 78.98% respectively. Particle size distribution was also influenced by giving treatments before milling of corn the maximum grits were obtained at low rpm and the yield of roasted corn grits were maximum compared to raw corn grits

Keywords: Maize kernel, Soaking, Hydration kinetics, Roasting, Milling, Particle size distribution, Raw and roasted corn grits

Introduction

Maize is a coarse grain and after initial resistance, it is now being accepted as staple diet and its demand is increasing, consumption of maize in the form of various types of traditional foods such as bread, porridge, steamed products, beverages and snacks. In India, maize grains are roasted and ground to prepare a traditional food *Sattu* (roasted grain flour) which is consumed as a breakfast item by mixing either water or milk with salt or sugar. Maize is also ground whole to make flour and is consumed in the form of chapatti (unleavened Indian bread) at rural level.

There are two distinct processes for processing corn, wet-milling and dry-milling and each process generates unique co-products. Dry milling aims at separation of anatomical parts of grains as cleanly as possible, whereas wet milling attempts to make cleaner separation of bran and germ from the endosperm. In addition, it also separates the endosperm into its chemical constituents of starch and protein. A number of products resulting from wet and dry-milling of maize are starch, dextrin, dextrose, sorbitol, high-fructose syrup, maltodextrine, germ oil, germ meal, maize grits, flour and fiber.

In the dry milling processes, a clear separation of hull from grits and germ is always desirable. Depending on the efficiency of the milling process, small quantities of hull are found adhering to the grits fractions. The close adherence of the germ to the germ to the endosperm creates separation problem. Since he hull, the endosperm and the germ are structurally distinct, their tissues are not continuous with each other thus facilitating their separation from each other during processing (Wolf *et al*., 1952).

Grits were first produced by native Americans and quickly became an important part of early Southern agriculture. The word “grits” comes from the old English term “grytt” meaning “bran” and the term “greot” meaning “something ground.”

In dry milling of maize, it is desirable to obtain the grits of maximum size, generally larger than 4 mm, as large size grits are preferred for the manufacturing of flakes (Brekke, 1970). The procedure of conditioning and tempering of kernels vary considerably depending upon characteristics of the maize being milled, the yield and the types of products desired. Several studies have shown that the temperature, kernel structure and initial moisture content affect the rate of absorption as well as distribution of moisture (Stenvert and Kingwood, 1977;

Abdelrahman and Farrell, 1981). Improved conditioning and degermination procedures should result in higher yields of grits. So keeping in view, finding out the milling characteristics of corn for the development of ready to eat (RTE) corn grits.

Materials and Methods

Milling Characteristics of Corn

Milling is general trade name which normally means reduction of food grain in to various end products like meal, flour, grit and splitted products etc. Milling includes several unit operations like cleaning, grading, separating, mixing pearling dehusking and size reduction. Milling is carried out in to two ways dry milling yields flour and semolina used for making breakfast cereals, pasta product and staple food item like *chapatti* or *roti*. Whereas wet milling process involves initial water soak under carefully controlled conditions to soften the kernels. The corn is then milled and its components separated by screening, centrifugation and washing to produce starch, oil, feed by-products and sweeteners. Here studies were carried out on dry milling characteristics of corn grains by using Hammer Mill. Before the corn is taken for dry milling it is roasted to safer moister level.

Hammer mill

Hammer mills are used for various types of size reduction jobs. At laboratory scale hammer mill showing in Fig 7 was used for steady state continuous grinding experiments for three different mill speed of 2645, 1975 and 1648 rpm respectively and optimized grain moisture contents to investigate the effect of machine and grain parameter on size distribution and grinding. These mills contain a high-speed motor, rotating inside a cylindrical casing. The shaft is usually kept horizontal. Roasted corn is fed into the mill from the top of the casing and broken by the rotating hammers and fall out through a screen at the bottom. The roasted corn or feed is broken by fixed or swinging hammers which are pinned to a rotor. The hammers are rotated between 1648 to 2645 rpm, strike and grind the corn until it becomes small enough to pass through the bottom screen. Fineness of milling is controlled by the 3 mm sieve size. The motor is 3 phases which is connected with energy meter; energy meter was used for measurement of power consumption in making grits.

Particle Size Distribution

A sieve analysis (or gradation test) is a practice or procedure used to assess the particle size distribution (also called *gradation*) of a granular material. The grain size analysis test determines the relative proportions of different grain sizes as they are distributed among certain size ranges. This test is carried out by using Vibratory Laboratory Sieve Shaker using sieve mesh size 100, 70, 50, 35, 30, 20, 14.

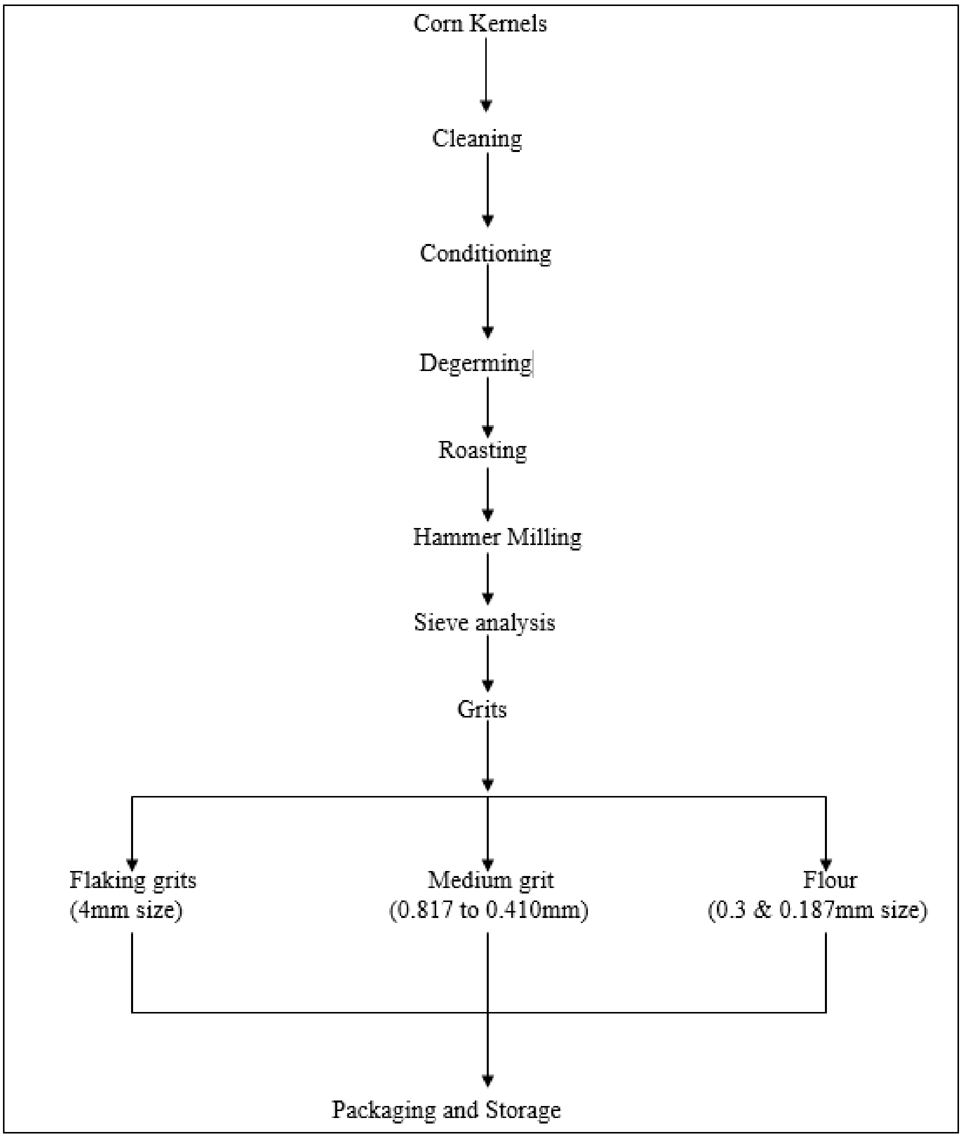

Fig 1: Flow chart of corn grits manufacturing process

Test procedure
Size distribution analysis of the ground product was performed using a set of six ASTM standard sieves size opening of 0.185, 0.3, 0.417, 0.6, 0.833 and 1.17 mm. Three roasted and one raw sample was shaken for 10 min after test grit retain on each sieve is weighed, percentage material retain is calculated. Then the cumulative mass fractions retained were calculated for each sieve. And mass fraction versus particle size distribution curve and cumulative mass fraction versus particle size curve were plotted.

Result and Discussions
Particle Size Analysis
Particle size distribution was found out by using (FRITSCH) vibratory laboratory sieve shaker, the roasted corn after the optimization having around 20% moisture content, 191 ^{0}C temperature, 104 s time, 7.65 kg of hardness and raw corn sample (without roasting) having around 12.2% moisture content were ground in Hammer Mill at three different rpm of 2645, 1975 and 1648 and a comparative study of both roasted and raw samples showing in Table 1 analysis that yield of grits increased with decreasing mill speed (rpm) in both samples but from pre-conditioned and roasted corn sample recovery of grits is higher than the raw sample and prime product (grits, flour) is highest compared to roasted. The feed rate was 7.5x 10^{-3} t/h and the power consumption of raw corn milling and roasted corn milling was calculated 30.85 W and 28.66 W respectively. From fig 3 we can observe that the recovery of corn grits of required particle size 1.17 to 0.417 mm was maximum when the rpm was 1648. Also this size (1190 to 420 um) of grits was obtained by (Adrian *et al*.2008). Here mass retained on three mesh sizes opening of 0.833, 0.6 and 0.417 mm was taken for calculating per cent yield obtained during milling. Particle size distribution curves both differential analysis and cumulative analysis at three different rpm was given in Fig 3, 4, 5 and 6 respectively from which can observed the maximum retaining of grits at different mesh size. Sieve size 0.3 and 0.185 used for obtaining flour. Finally obtained coarse grits, desired grits and flour is given in Fig 8, and the chemical composition of roasted grits and flour is given in Table 2 which have attractive colour and flavour due to roasting process.

Table 1: Milling yield of raw and roasted corn

Milling Speed (rpm)	Milling yield of raw corn%	Milling yield of roasted corn%
2645	67.8	74.75
1975	70.63	78.98
1648	72.02	80.6

Table 2: Final Proximate composition of corn grits and corn flour after roasting

Component	Corn grits	Corn flour
Moisture	11.6	13.0
Protein	7.6	7.4
Fat	3.9	3.8
Crude fiber	0.5	0.6
Ash	0.4	0.4
Starch	73.3	73.6

Conclusion
A common Indian hybrid yellow maize variety was selected and procured for the present investigation. The proximate chemical compositions of maize were determined by adopting standard techniques and methods available in literature. The Hydration behavior of corn was determined by placing the corn at different temperature 30 to 90 ^{0}C at different time 1, 3, 5, 10, 20, 35, 60, 120, 300, 700, 1440 and 1800 min.
The process technology for making roasted corn grits included pre-conditioning, dry heating in a hot sand bed, grinding or milling. Optimization process was carried out by using response surface methodology (RSM).
A particle size distribution was carried out in Laboratory vibratory sieve shaker with sieve opening of 0.147, 0.185, 0.3, 0.417, 0.6, 0.833, 1.17 and 0.074 mm of both raw and roasted corn for comparatively study. Particle size distribution curve of differential analysis and cumulative analysis were plotted for study of percent mass retained on particular sieve. In particle size distribution analysis maximum yield of desired grits were obtained on sieve opening 0.833, 0.6, ad 0.417 mm and the percent yield of grits on low rpm was 80.6% that was maximum compared to highest rpm of 2645 and 1975.
Milling of both raw and roasted corn were completed on three different rpm 2645, 1975 and 1648. It was observed that at low rpm (1648) maximum grits were yield of roasted corn. The feed rate was 7.5 t/hr and the power consumption for raw corn was 307.86 W and for roasted 285.66W.

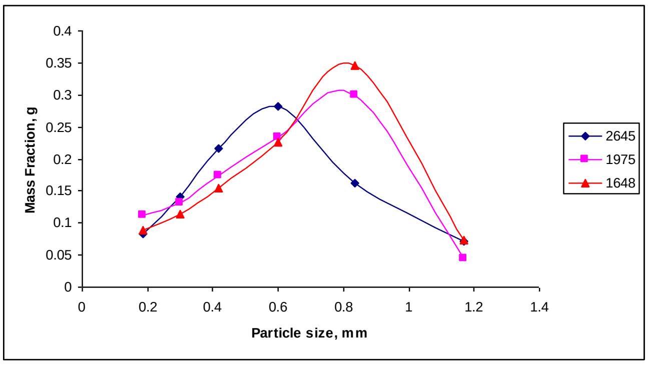

Fig 2: Differential analysis of raw corn at rpm 2645, 1975 and 1648.

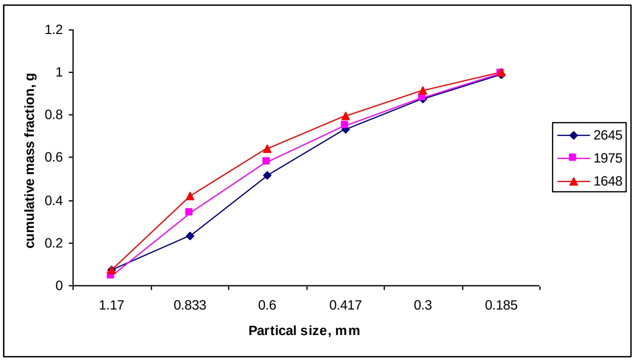

Fig 3: Cumulative analysis of raw corn at rpm 2645, 1975 and 1648.

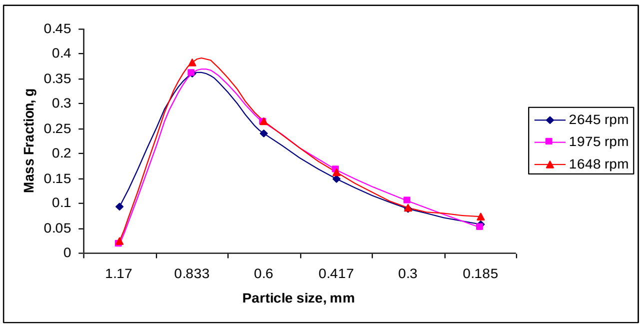

Fig 4: Differential analysis of roasted corn at rpm 2645, 1975 and 1648.

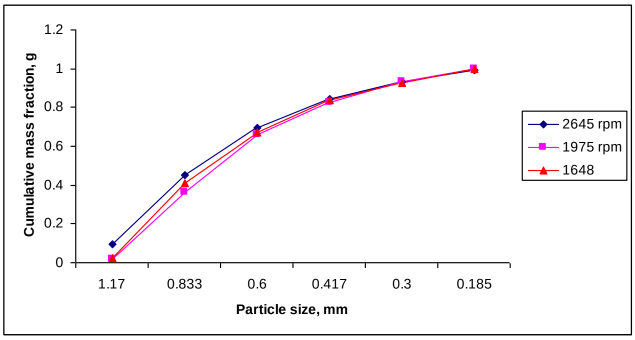

Fig 5: Cumulative analysis of roasted corn at rpm 2645, 1975 and 1648.

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