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# Enzymatic Wet milling and Dry milling Process of Corn

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**Abstract:** *Enzymatic corn wet milling (E-Milling) is a method derived from conventional wet milling for the recuperation and purification of starch and co-merchandise. The usage of enzymes in wet milling process eliminates the needs of $SO_2$ and also reduces the steeping time. The E-Milling method consists of grain cleaning, pretreatment, enzymatic treatment, germ separation and recovery, fiber separation and restoration, gluten separation and restoration and starch separation. The E-Milling process turned into discovered the price aggressive with the conventional method for the duration of excessive corn feedstock prices because the enzymatic method complements the yields of the products in a corn wet milling method.*

**Keywords:** Dry milling, enzymatic milling, wet milling, separation, $SO_2$

## INTRODUCTION

In the last 50 years, diverse techniques have evolved to assess the milling characteristics (millability) of corn for moist milling. Wet milling is the most economical method of extracting starch from cereal grains. Wet milling is a capital, time-sensitive and strength-in depth method. For the most effective starch recovery, steeping of corn kernels is generally completed for 24–48 h and calls for nearly 21.0% of the general plant strength and capital costs **(Johnston and Singh, 2001)**. Corn steeping is finished in water containing 0.2% SO2 and 0.5% lactic acid (L.A.) at 50–52 $^0$C. Lactic acid facilitates softening the corn kernel and allows quicker SO2 sorption **(Eckhoff *et al.* 1993)** and as soon as absorbed, SO2 assaults the disulfide bonds of the protein matrix encapsulating starch granules, thereby increasing starch recovery **(Watson and Sanders 1961)**. Another essential position of SO2 in a steeping manner is to govern microbial activity. For the

purpose of shortening steeping time, intermittent milling and dynamic steeping (IMDS) methods have been proposed with the aid of using **(Lopes-Filho *et al.* 1997)** and are similarly delicate with the aid of using **(Mehra *et al.* 2000)**. IMDS process includes a brief period of steeping observed with the aid of kernel cracking and dynamic incubation in SO2 and lactic acid solutions, which allows green germ recovery. Another method for shortening steeping time and decreasing $SO_2$ is the use of proteolytic enzymes termed as enzymatic milling (E-Milling). This method has been proposed and is ultimately delicate. But we used blended milling for this study's separation of starch and protein. The goal of dry milling is to transform complete corn germs into flour within the system of dry milling. Each variety) is converted into flour. The system of dry milling works on the simplest conversion of germ to flour.

In these studies, our goal is to make use of low grade corn into precious bureaucracy as starch and protein separation within the corn is a time eating system, so right here we also use degree milling, moist milling, and dry milling in addition to enzyme to make a quicker separation of starch protein from the corn flour.

Dry milling is the process of drying milling corn with a high degree of separation using enzymes. Here, the goal of drying milling is to transform complete corn germs into flour within the system of drying milling.

Corn millability may be predicted by the use of small samples of corn via a means of figuring out the amount and fine of the recoverable additives in addition to the relative problems encountered in element separation. Millability research has been accomplished to assess variations in moist-milling traits of corn varieties and hybrids.

## DRY MILLING

As described by **Watson (1988)**, the dry milling industry produces flour, grits, and meals for human consumption, and some industries also produce fuel ethanol. Drying milling is used for the separation of the maximum amount of endosperm, germ, and pericarp as possible. Before this process, remove the foreign material, crop residue, and broken kernel. In this process, the degerminating and tempering of corn grains are discussed by **Alexander (1987)**. All PMH1, JL3459, and Buland maize varieties were thoroughly cleaned and milled with a burr mill. After the corn milling, it was observed that the three verities of the effect of the incorporation of additives like xanthan gum (0–1.0%), Gaur gum (0–1.0%), potato starch (0–10.0%) and whey protein concentration (0–15.0%) and analysis of the three verities of pasting properties were described by **Chhabra (2018)**. Commercially dehulled and degermed yellow corn dry-milling streams were supplied by three different firms, referred to as supplied corn grits, corn meal, and corn flour. Each stream was separated based on the separation of corn flour particle size. After separation of corn grits by using a high speed flour mill described by **Jamin (1998)**. Due to the large volume of corn

required, full-scale milling trials under controlled conditions are seldom conducted due to the difficulty of controlling and measuring the variables involved in processing. Typically, test weight for a specific variety decreases as moisture increases, (Paulsen). However, over the moisture range of 12-18%, the test weight of mixed lots of incoming commercial corn did not vary significantly with moisture content. Since the 1982 corn accepted by the plant averaged 732 kg/m3, that value was selected as a dividing level for distinguishing between high and low test weight corn. The 200 g of corn that was retained by the 6.35 mm sieve was tested for breakage susceptibility using a Wisconsin-type breakage tester (WBT). In the breakage tester, kernels were centrifugally discharged by a 254 mm diameter impeller driven at 1800 rpm. After 2300 t (90,000 bushel) were segregated into two or three concrete silos, the corn was transferred to two milling bins without moisture pre-tempering. After the corn was conveyed from the milling bins to the mill, it was weighed and then cleaned on 6.35 mm sieves. The removed screenings were also weighed as described by **Paulsen (1985)**. Three trials were conducted of hominy feed to determine the nutritive value of hominy feed. The hominy feed contained 11.1% CP, 25.2% NDF, 56.9% starch, and 5.3% fat, and replaced dry-rolled corn. In a finishing trial, yearling heifers were fed hominy feed with or without added fat at 0, 13.3 (.67% added fat), 26.7 (1.33% added fat), or 40.0% (2% added fat) of the dietary DM described by **Larson *et al.* (1993)**.

## WET MILLING

The process of wet milling is more complex than either of the processes involved in the dry-milling industries previously discussed. The number and types of food products that can be made in the wet-milling industry are numerous. Two different hybrids, such as flint and dent corn, were taken for this wet milling sample analysis. Prior to conditioning, the grains were screened to obtain samples of uniform size, free of broken kernels and foreign material. The starch, protein, and oil content of the grains were determined for a better understanding of the grains. Describe the analysis of starch, fat, protein analysis, water diffusivity, and water absorption described by **Haros *et al.* (2003).** Samples of corn (100g) are placed in 500-ml Erlenmeyer flasks with 180 ml of steep solution and steeped in a $52^0$C water bath with no stirring or recirculation of the steep solution. Estimation of initial moisture content by forced-air oven procedure. The length of steep time can be varied from 24 hrs. and the steep solution contains 2000 ppm sulphur dioxide and 0.5% (w/w) lactic acid, although the level of sulphur dioxide and lactic acid can be adjusted. At the completion of steeping, the steep water is drained into a 250-ml graduated cylinder, and the unabsorbed steep water volume is measured. The steep water is dried for determination of solids using the two-stage drying procedure (AACC 1983). The two-stage procedure is preferred over a single-stage drying method because of the high percentage of water to be evaporated. The blender is equipped with a tachometer to monitor the rpm of the blades and is controlled by a variable transformer to maintain a speed of 7,500-7,600 rpm. After this germ, washing and grinding procedure the separation described by **Eckhoff (1996)**. High extractible varieties of yellow dent corn, waxy corn, and high amylose corn sourced from commercial seed suppliers were used for the experiments. And

determine moisture content, fat, neutral detergent fiber, starch protein content, gluten protein content, and germ fat content. Co- product moisture contents were determined using the two-stage air oven method. The samples were dried overnight in hot air oven at 49 $^0$C and their moisture contents were measured using a hot air oven at 135 $^0$C for 2 hrs. Standard procedures were used to determine test weight, thousand-kernel weight, and absolute density was measured using the ethanol column test. The starch was scraped from the table. The next day, it was dried in a 49°C hot air oven overnight and analysed for protein content. Gluten slurry was collected in a bucket and, after thoroughly mixing; a 2 L subsample was collected and filtered over a Whatman 4 filter paper and Buchner funnel using a vacuum. After filtration, gluten solids were collected from the filter paper. Samples were dried overnight in a hot air oven at 49$^0$C and analysed for crude protein content (Method 990.03, AOAC, 2003). After skimming, the germ was dried overnight in a hot air oven at 49$^0$C and the crude oil content was determined. After cleaning, 1 kg of corn was steeped in 2 L of water containing 0.2% (2000 ppm) sulphur dioxide generated from 5.92 g of sodium metabisulfite and 0.5% lactic acid (12.9 mL) for 24 h at 52 $^{\circ}$C. After steeping, the steep water was drained and measured using a 2 L graduated cylinder. Steeped corn kernels were mixed with 2 L of fresh water and ground for 5 minutes at 4500 rpm in an inverted (blunt) blade Waring commercial grade blender for cracking open the kernels. For removing starch and fiber, the recovered germ was washed on a 1-mm round hole sieve using 1 L of water as described by **Pavel *et al.* (2021)**. The same-sized and full-ear corn were soaked for 12 hours, 36 hours, and 60 hours at 50$^0$C by mixing 5g of corn (dry matter) with 50ml of sulphurous acid, alcohol, lactic acid, and L-cysteine at various concentrations. After removing the seed coat and germ, the corn was ground with isometric water. The suspension was then centrifuged at 4000 rpm for 5 minutes, and the supernatant was discarded. Then 100ml of water was added to the residue and shaken well to measure the amount of free starch in the solution. A ml of determinant was extracted from the shaking well suspension and immediately transferred to a graduated test tube to be diluted with 80% Ca(NO3) a boiling water bath for 10 minutes, the starch content of the cooling solution was determined by the absorption value at 620nm described by **Chhabra *et al.* (2018)**. Two corn hybrids were used in this work: flint (CARGILL T-42) and dent (PIONEER 3379). The grains were harvested with a moisture content of 0.166 and 0.168 g water per g dry solid, for flint and dent corn, respectively. Conditioning was achieved by adding a calculated quantity of distilled water in the form of a fine spray with periodic agitation of the grains. The corn was then stored in sealed plastic jars for 2 weeks at 4$^0$C to allow for moisture equilibration. The moisture content was determined in two steps by the AACC method 44-15A (1995). The starch, protein, and oil content of the grains were determined for a better understanding of the grains. Starch was measured using the Twers method. Oil was removed by Soxhlet extraction with hexane for 24 h. Single layers of corn weighing 150 g were used for each drying run. An air velocity of 5 ms$^{-1}$ was used in the experiments. Wet and dry bulb thermometers were placed in the inlet duct to measure the relative humidity of the drying air. The rate of water absorption of control (undried) and dried corn samples was determined by the following procedure: control and dried corn samples (10 g) were soaked in a 0.25% $SO_2$ aqueous solution prepared by dissolving the appropriate amount of sodium bisulfite

in distilled water. The grains were placed in 100 ml vessels with screw caps and gently agitated in a thermostatic bath at 52.0 $\pm$ 0.5 $^0$C to reduce film resistance in the steeped solution. At regular time intervals, up to 48 hrs., the flasks were removed from the bath to determine water uptake. The steeping index was used here to have a visual examination of the kernel section after the steeping process of undried and dried corn samples. The samples used for this purpose were steeped in an aqueous $SO_2$ solution, 0.25% v/v, at 52$^0$C for 48 h. Roughly 50 g of artificially dried and undried corn samples were steeped in 250 ml of 0.25% $SO_2$ aqueous solution for 48 h at 52$^0$C. After that, the steep water was decanted and the excess liquid water was removed from the corn by blotting. Steeped corn was ground in the presence of 100 ml of distilled water for 3 min by means of a Waring blender described by **Haros (2003).**

**ENZYMATIC MILLING**

Use of enzymes during steeping was focused primarily on decreasing the protein content of the starch for the production of medical grade glucose **(Roushdi *et al.* 1981)**. Preliminary studies added protease enzymes (bromelain, trypsin, pepsin, and papain) to whole grains during the steeping process, but a decrease in the residual protein content in the produced starch was not observed **(Roushdi *et al.* 1981)**. Statistical changes were observed in the protein content of the starch when unused grains were utilized **(Roushdi *et al.* 1981)**. That initial report proposed that the time required for steeping could be substantially decreased by using enzymes. Other researchers investigated the use of proteases on corn grits (endosperm fraction obtained during dry milling) as either a pretreatment for air classification **(Spanheimer *et al.* 1972)** or to overcome the adverse effects of high-temperature drying on starch-gluten separations during subsequent wet milling **(Eckhoff and Tso 1991)**. Previous attempts to increase starch yield or decrease the total steeping time have investigated the addition of multiple enzymes (hemicellulase, cellulases, pectinases, xylanases, and proteases) during steeping **(Caransa *et al.* 1988; Hassanean and Abdel-Wahed 1986; Steinke and Johnson 1991; Steinke et al 1991; Moheno-Perez *et al.* 1999)**. Enzyme addition during the steeping process has some benefits described by **Johnston (2001)**. E-miiling is a modified wet milling process that uses proteases to reduce overall processing time during corn wet milling and eliminate the need for $SO_2$ as a processing agent. Enzymatic milling process and the minimization of the amount of enzyme, the soaking time, and the first grind parameters were evaluated for the specific processing conditions. Using bromelain enzyme as an example, first grind optimization and pH determinations were evaluated. A combination of different soaking and grinding conditions followed by an incubation step and fixed enzyme addition was optimised by evaluating the first grind. The bromelain enzyme used for E-Milling was observed at pH 3.5–6.5 and the optimum was determined to be pH 5.0. Enzyme addition was then evaluated using the optimised first grind conditions and bromelain additions with 0–1.9 g of enzyme (based on protein)/kg of corn described by **Johnston (2004)**. Enzymatic milling (E-Milling) is a method that might probably replace the sulphur dioxide method currently utilised in all industrial wet-milling facilities. E-Milling includes a quick water soaking step (≤6 hr), a coarse

grind, and using a protease to free the starch granules from the corn endosperm. However, since standard wet milling does not require sulphur dioxide to gain starch yields equal to standard wet milling, the essential antimicrobial outcomes of sulphur dioxide aren't duplicated through the enzymatic method. The use of low tiers of sulphur dioxide (enough for antimicrobial activity) is being proposed as an easily applied method of microbial manipulation in the course of E-Milling. To examine the effectiveness of E-Milling beneath those conditions, fraction yields for milling experiments including sulphur dioxide with and without added enzyme have been compared with fraction yields from traditional 24-hr steeping with 2,000 ppm $SO_2$ and 0.55% lactic acid. Because including enzyme and $SO_2$ can each enhance product yields and compositions independently, it became important to apply a reduced stage of enzyme (a lot less than essential to generate "product quality" material) to study variations in product yields. The effects display considerable variations in starch, fiber, general gluten, and insoluble gluten recoveries among samples milled with $SO_2$ and enzyme as compared with the ones on the identical $SO_2$ stage with no enzyme addition. No considerable variations have been determined for soakwater or germ yields, irrespective of the SO2 degree used. The yield advantages from including each enzyme and $SO_2$ are in reality proven over the addition of each enzyme individually, for all co-product yields except the yields for germ described by **Johnston (2005)**.

## CONCLUSION

In the study, the dry milling of corn has been developed and converted into flour. In the process of dry milling, the corn that was not utilized, broken, and each and every variety of corn was used for making flour. As corn is received later in the crop year, corn breakage susceptibility, determined with a centrifugal impactor as a function of moisture, decreases as corn temperature increases. On the other hand, the wet milling process uses a specific variety of corn for the separation of starch. Wet milling processes require more time for processing compared to dry milling and enzymatic milling. Wet milling takes more time for the process and has a higher moisture content. Nowadays, E-Milling is the best method of starch and protein separation (milled starch), and it takes less time and increases the yield of protein in starch.

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