GLOBAL JOURNAL OF BIO-SCIENCE AND BIOTECHNOLOGY

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HYDRATION BEHAVIOR OF CORN FOR PROCESS DEVELOPMENT OF RTE (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 are cleaning and grading, moisture pre-conditioning, dry conduction heating (sand roasting) and grinding of corn. Hydration Characteristics of corn investigated at different temperature of 30, 40, 50, 60, 70, 80, and 90^0 C at time period 1, 3, 5, 10, 20, 35, 60, 120, 300, 700, 1440 and 1800 min. and found that with increase steeping water temperature, the amounts of water absorbed is increased. The high rate of water absorption during the initial stages of soaking is generally attributed to the natural capillaries present in the surface of the kernels which can be explained by the diffusion phenomenon. And also found that the gradual increase in the rate of water absorption up to 300 min after 300 min the curve becomes linear for water absorption.

KEYWORDS - Maize kernel, Soaking, Hydration kinetics, water absorption.

INTRODUCTION

Maize (*Zeamays L.*) also called corn is the most important cereals crops in the world, grown over an area of 132 million hectare and second highest produced cereal grain crop of the world with the total annual production of 570 million tonnes (Watson and Ramstad, 1987). India has an average area of about 5.99 million hectares under coarse cereals (*i.e.* sorghum, ragi, jowar maize and bajra) cultivation. Maize alone accounted for much larger production of 15.35 million tonnes in 2006-07. Utter Pradesh, Madhya Pradesh, Bihar, Rajasthan, Punjab are the leading states in India growing maize on large scale. Jammu and Kashmir, Andhra Pradesh, Gujarat and Himachal Pradesh also grow considerable amount of maize. Maize (both yellow and white) are produced in abundance in India but is not being utilized properly and most of the produce is used for cattle feed, especially in Bihar. There is a need of developing a ready to eat (RTE) food from the yellow corn, which would not only help to utilize this available maize but also help in solving the problem of food shortage. 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.”

The kinetics of the overall water uptake by three corn varieties (Cacahuazintle corn, yellow dent corn and chalco corn) soaked in water and in alkaline solution with two different concentrations of $Ca(OH)_2$ results showed that the uptake of water takes place in different kinetic stages of reaction and diffusion process (Laria *et al.*, 2005). Each stage was correlated with a specific structural change that occurs in the pericarp, in the aleurone layer and in the outermost structure of the endosperm. 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 hydration characteristics during roasting and the development of ready to eat (RTE) corn grits.

MATERIALS & METHODS

Maize Fraction and Constituents

Maize (Amarnath varities, yellow corn) procured from the local market of IIT; Kharagpur were cleaned, graded and subsequently used for the various experiments. The above mentioned variety of maize is kept in oven for moisture measurement and for determination of hydration characteristics known quantities of sample were kept in water bath for different time and temperature combination.

Hydration Techniques

Several hydration techniques were investigated for determining hydration behavior of the corn which increase the hardness of the grains by absorbing maximum amount of water and also caused minimum stress cracks in the kernels.

The hydration techniques *viz.* water spray, steam treatment, steaming-water soaking and soaking in water was investigated for determining hydration behavior of maize with minimum stress cracks development and maximum water absorption.

Soaking in water

The techniques which we used for the present research was soaking of kernels in to water. The experimental

kernels were visually inspected for relatively uniformed weight. Then samples of corn kernels, about 20 g each, were weighed using an electronic balance. Each sample was placed in a flask containing 250 ml of water. The flasks were placed in water bath. Individual flasks were removed from the water bath at 1, 3, 5, 10, 20, 35, 60, 120, 300, 700, 1440 and 1800 min. the kernels were dried using blotting paper to eliminate the surface water. Then they were weighed and the percentage of the moisture content of the sample M, at each interval was determined by following.

$$\%M = \frac{(m - m_i) + m_i * IM}{m} * 100\% \qquad \ldots\ldots\ldots\ldots (1)$$

Where, m = mass of the sample at a specified time interval

m_i = mass of the sample prior to soaking

IM= initial moisture content of the kernels

The experiments were performed at temperature of 30, 40, 50, 60, 70, 80 and 90 ^{0}C.

Theoretical Model

During the water absorption the water transfer in to the kernels and reacts with the starch granules as the water reaches the outer layer of starch granules, it hydrolysis the granules and fill the intergranular spaces. The water is retained by the starch molecules while the moisture diffused processed towards the center of the kernels. A mechanism used for diffusion is Fick's second law of liquid/vapor diffusion (Muthukurappan and Gunasekaran, 1994) described by:

$$\frac{¢M}{¢t} = D\left(\frac{\partial^2 M}{\partial x^2} + \frac{\partial^2 M}{\partial y^2} + \frac{\partial^2 M}{\partial z^2}\right) \qquad \ldots\ldots\ldots (2)$$

Where, M (g) is moisture, at x, y and z location within the object at time t (s) and D is the diffusion coefficients (m^2/sec).

For moisture absorption process, with a suitable set of assumptions for initial and boundary conditions (Muthukumarappan and Gunasekaran, 1994) a solution give for the above equation.

$$MR = \left[1 - \exp(-kt)\right] \qquad \ldots\ldots\ldots\ldots\ldots (3)$$

Where k is coefficients of moisture absorption and MR is the instantaneous ratio defined by:

$$MR = \frac{M - M_o}{M_s - M_o} \qquad \ldots\ldots\ldots\ldots\ldots (4)$$

Where M is the instantaneous moisture, Ms is the saturation and Mo is the initial moisture content of the objects.

RESULTS & DISCUSSIONS

Hydration Characteristics of Corn

The hydration technique which was used in this experiment was soaking in the water. The amounts of moisture gained by the corn kernels at different time and temperature are presented in Table-1, the moisture absorption by the corn kernels verses time are presented in the Fig. 1 according to the Fig. 1 with increasing in steeping water temperature, the amounts of water absorbed is increased. Increase in the rate of water absorption with the increase in the water temperature also reported by (Sayar *et al.*, 2006). The high rate of water absorption during the initial stages of soaking is generally attributed to the natural capillaries present in the surface of the kernels which can be explained by the diffusion phenomenon.

TABLE 1: Hydration behavior of corn at different temperature and time combinations

Time	Temperature ^{0}C						
(min)	30	40	50	60	70	80	90
0	12.2	12.2	12.2	12.2	12.2	12.2	12.2
1	13.5	14.4	15.7	16.5	18	18.7	19.8
3	15.6	16.8	17.9	19.4	20.7	22.1	23.4
5	16	18.6	19.6	21	23.2	24.3	25.5
10	17	20.2	21.4	22.7	24.1	26.3	28.7
20	20	21.3	22.6	23.5	26.4	28.6	29.7
35	21	22.3	24.3	25.4	29.6	30.1	34
60	23	24.5	25.16	28.4	32.4	34	39.4
120	25	26.8	29.12	32	36.4	40.1	45
300	29.2	32	37.5	39	47.6	52	59
700	35.6	40	47	50.1	58.8	68.6	72
1140	36.5	40.4	48	52	63.5	72.1	77.8
1440	36.7	40.6	48.2	52.4	63.8	72.4	79.5
1800	36.8	39.8	48.6	51.9	63.4	72.8	79.9

Fig. 1 shows that the gradual increase in the rate of water absorption up to 300 min and after 300 min the curve becomes linear for water absorption. However, for the treatments above 60° C the slope is slightly steeper indicating that in addition to simple water diffusion, some water is also utilized for the gelatinization of starch. Stress crack kernel were observed at a soaking temperature of 80° C and 90° C this indicate that during hot soaking heat weakens the starch granules by disrupting the hydrogen bond, therefore more surface area is available by the starch granules for the water absorption.

Hydration equations

The hydration equations have been developed to correlate hydration time with moisture content at the temperature of 90, 80, 70, 60, 50, 40 and 30° C. The correlation coefficients show in Table 2, that the equations developed are good fit to the observed data.

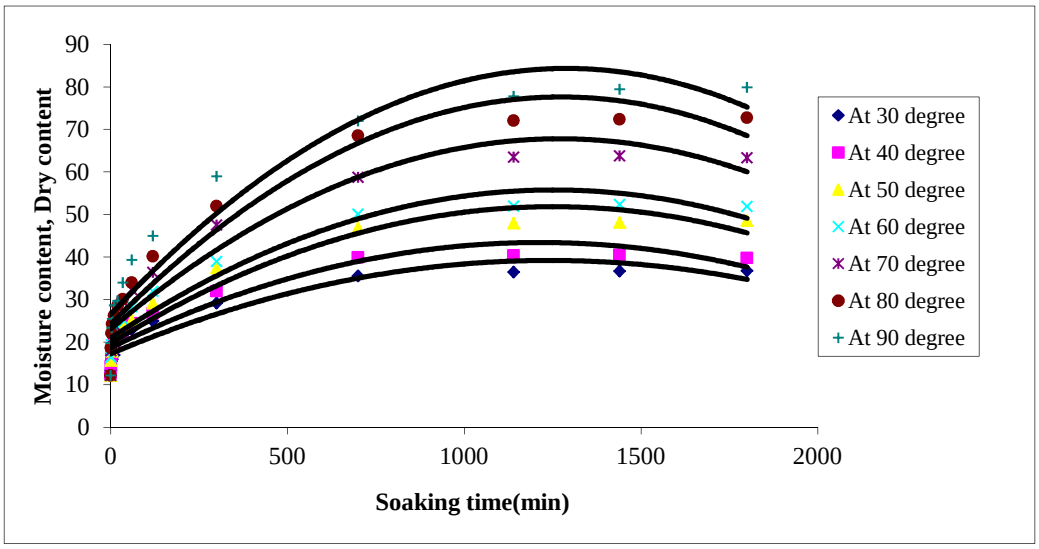

FIGURE 1. Hydration characteristics of corn at different temperatures**.**

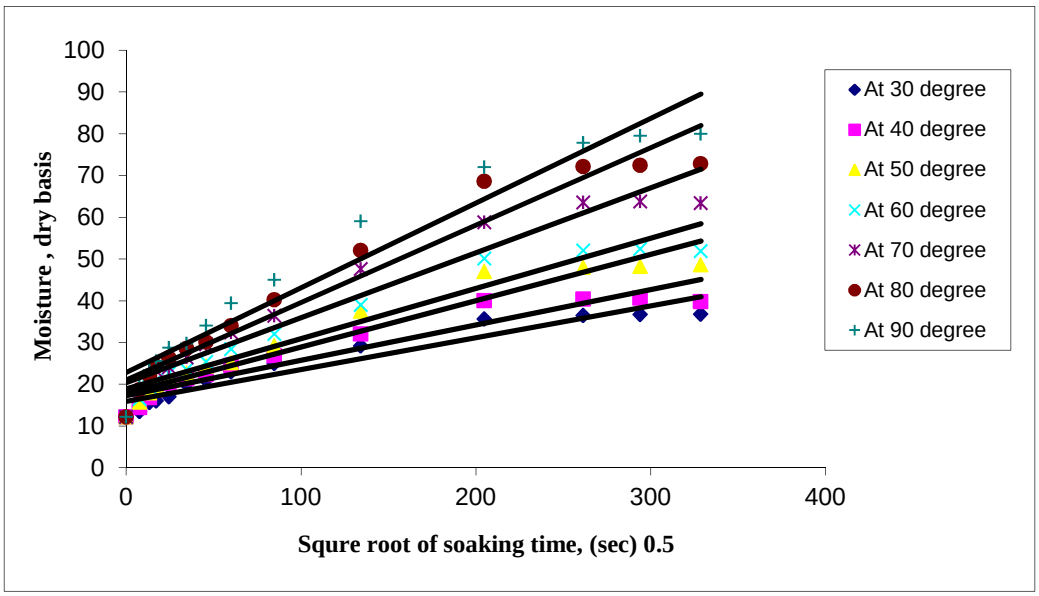

FIG.URE 2. Relationship between square root of soaking time and moisture uptake**.**

TABLE 2. Hydration equation for maize grains at different soaking temperature

Sl No.	Temperature (^{0}C)	Hydration equations	R^2
1	90	y = -3E-05x^2+0.0897x+26.539	0.9435
2	80	y = -3E-05x^2+0.0838x+22.251	0.9463
3	70	y = -3E-05x^2+0.0704x+23.100	0.9415
4	60	y = -2E-05x^2+0.0556x+20.955	0.9337
5	50	y = -2E-05x^2+0.0513x+19.724	0.9335
6	40	y = -2E-05x^2+0.0408x+18.665	0.9086
7	30	y = -1E-05x^2+0.0354x+17.262	0.9177

TABLE 3. Linear relationships between moisture uptake and square root of time

Sl No.	Temperature (^{0}C)	Hydration equations	R^2
1	90	$y = 0.2027x + 22.817$	0.9435
2	80	$y = 0.1854x + 21.016$	0.9463
3	70	$y = 0.1555x + 20.359$	0.9415
4	60	$y = 0.1204x + 18.891$	0.9337
5	50	$y = 0.111x + 17.829$	0.9335
6	40	$y = 0.0846x + 17.288$	0.9086
7	30	$y = 0.0761x + 15.937$	0.9177

The linear hydration equations have been developed to relate moisture uptake with square root of soaking time at different temperatures are given in the Table 2. The plots between moisture verses square root of time are given in Figure 2 the correlation coefficients of these ranges from 0.9086 to 0.9463.

CONCLUSION

Hydration Characteristics of corn investigated at different temperature of 30, 40, 50, 60, 70, 80, and 90^0 C at time period 1, 3, 5, 10, 20, 35, 60, 120, 300, 700, 1440 and 1800 min. and found that with increase steeping water temperature, the amounts of water absorbed is increased. Increased in the rate of water absorption with the increase in the water temperature also reported by (Sayar *et al.*, 2006). The high rate of water absorption during the initial stages of soaking is generally attributed to the natural capillaries present in the surface of the kernels which can be explained by the diffusion phenomenon. And also found that the gradual increase in the rate of water absorption up to 300 min after 300 min the curve becomes linear for water absorption.

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