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Effect of Temperature on Soybean Quality Using Spouted Bed Technique

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ABSTRACT

The effect of temperature on moisture reduction rate and soybean qualities using a two-dimensional spouted bed dryer has been studied. Air velocity was varied in a range of 15.86-20.50 m/s, with a fixed hold-up of 25 kgs. The soybeans with initial moisture levels varying between 28 and 32% dry basis were dried to 12-17% dry basis using inlet air temperatures of 120-150°C. The experimental results indicate that higher temperatures provide faster moisture reduction rate.

The qualities of soybean have also been considered in terms of stress cracking, breakage, urease activity and protein solubility in 0.2% KOH. It is shown that the percentages of cracking and breakage depend on temperature, final moisture content and degree of collision of kernel with deflector. The percentages of stress crack and breakage lie in the range of 50-60% and of 3-24%, respectively. The urease activity and protein solubility are accepted with slightly changing in the protein quality.

Key words: grain; pH change; protein solubility

INTRODUCTION

Soybean (*Glycine max* (L.) Merrill) is classified as an oilseed legume which contains both of heat-labile anti-nutritional factors, i.e. trypsin inhibitor, hemagglutinin, and heat-stable anti-nutritional factor, i.e. saponin. These factors directly affect the growth of various species of animals (Liener, 1988). The trypsin inhibitor (TI) is the one to be of practical interest in considering the quality of soybean because it increases the secretory activity of pancreas, causing the pancreatic hypertrophy and the growth depression. When soybean is treated with sufficiently high heat processing, the trypsin inhibitor and the other anti-nutritional factors are inactive, but their nutritional components are improved (White *et al*., 1967; Faber and Zimmerman, 1973; Qin *et al*., 1996).

White *et al*. (1967) reported growth response of chick fed. In the work, soybean used as a protein supplement was treated by different methods such as autoclaving, extrusion and infrared roasting. It indicated that gain weight and feed to gain ratio depended on the methods of treatment. The extruded soybean gave higher gain weight and feed to gain ratio than the roasted and autoclaved soybeans. Faber and Zimmerman (1973) studied the growth response of baby pigs, which was similar to the report of White *et al.* (1967).

In addition to the above-mentioned heat treatment processes, fluidization technique has recently been applied for eliminating the trypsin

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inhibitor existing in soybean (Soponronnarit *et al.*, 2001). It showed a positive result of reduction in the urease activity. The measurement of urease activity is an indirect method to indicate the trypsin inhibitor. With the fluidization technique, the minimum temperature required to reduce the urease activity to level lower than 0.30 ΔpH should be not lower than 120°C. The protein level was insignificantly reduced in a temperature range of 110-140°C. For the physical qualities, the degree of cracking and breakage were found to be higher with increase of drying temperature.

However, the conventional fluidized bed usually provides the poor quality of fluidization (bubbling and slugging) for such coarse particles, resulting in low heat and mass transfer between solid and gas phases (Gishler, 1983). Thus spouted bed technique was developed for improving such cause. Several researchers have used this technique for drying cereal grains (Mathur and Eptein, 1974; Viswanathan *et al.*, 1986; Massarani, 1987; Pasos *et al.*, 1987,1989). This technique has the advantages as follows: simple design and construction, regular cyclic movement of solids, easily handling and lower pressure drop.

The use of two-dimensional spouted bed as a heat processing to reduce the trypsin inhibitor in the soybean has been of less interest. Therefore, this work studies the drying rate of soybean in a two-dimensional spouted bed and the effect of temperature on the soybean qualities such as percentages of cracking and breakage, urease activity and protein solubility.

MATERIALS AND METHODS

Drying rate

A batch two-dimensional spouted bed dryer as shown in Figure 1 was used for drying and heat treatment. The system consisted of a spouted bed dryer with a width of 60 cm, a height of 200 cm, a 24 kW electric heater, an on-off temperature controller and a backward-curved blade centrifugal fan (2.2 kW motor). Geometry of dryer was the inlet cross sectional area of 4 × 15 cm^2, the spout width of 8 cm and the entrance height of 12.5 cm.

Temperatures were recorded by Chromel-Alumel (Type K) thermocouples connected to a data logger with an accuracy of ± 1°C. Pressure drop across bed and air velocity were respectively measured by a U-tube manometer and a hot wire anemometer.

Soybeans were rewetted to obtain the desired moisture content and then placed at temperature controlled room between 8 and 10°C for 5 or 7 days to ensure uniform moisture content of kernels. The experimental conditions were set up as follows: initial moisture contents of 28-32% dry basis, a fixed hold up of 25 kgs, temperatures of 120-150 °C and a fixed air velocity of 20.5 m/s. Sample taken at every five minutes for periods of 5-30 minutes were collected in an electric oven for 72 hrs at temperature of 103°C to determine the moisture content.

Quality

Percentages of cracking and breakage

Cracking and breakage were considered by visually sorting out the cracked and broken kernels with fluorescent from 200 gram sample. The percentages of cracking and breakage were expressed by the following equations:

Percentage of cracking

$$= \frac{\text{weight of cracked ker nel}}{\text{weight of sample}} \times 100 \qquad (1)$$

Percentage of breakage

$$= \frac{\text{weight of broken ker nel}}{\text{weight of sample}} \times 100 \qquad (2)$$

Urease activity

The urease activity could be measured by detecting pH change, which is caused by the urease converting urea to ammonia. This method is an indirect test for level of trypsin inhibitor. A properly

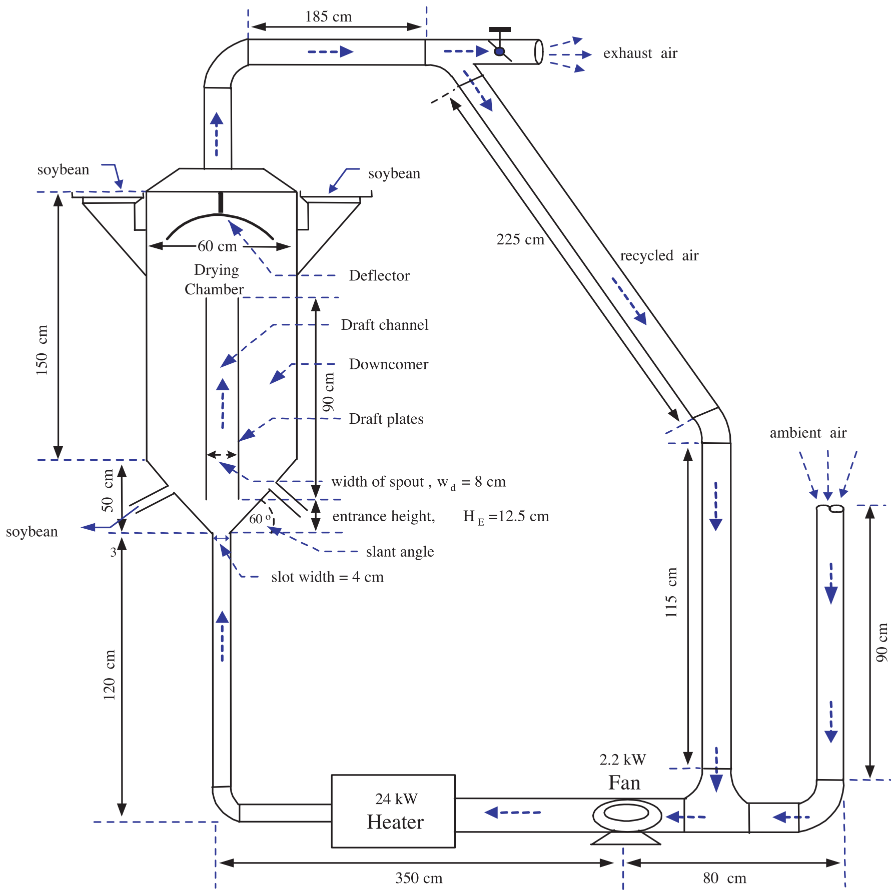

Figure 1 Schematic diagram of a Two-dimensional Spouted Bed Dryer (not to scale).

cooked soybean will give a urease activity of 0.30 rise in ΔpH. The measurement method follows the AACC procedure (1944).

Crude protein

Nitrogen content of soybean was estimated by Kjeldahl method (AOAC, 1980) using a nitrogen analyzer (Model VAPODEST12) and crude protein content was calculated by %N x 6.25.

Protein solubility

Protein solubility indicates the dispersion of proteins in 0.2% KOH solution. The nitrogen in the supernatant is determined by the Kjeldahl method. According to Cheong (1997), protein solubility should be in a normal range between 70 and 85%. If its value is lower than 70%, it means the soybean is overcooked, but if it is higher than 85%, soybean is insufficiently cooked. Protein solubility was calculated by

Protein solubility

$$= \frac{\text{nitrogen of the supernatant in 0.2\% KOH solution}}{\text{crude protein}} \times 100 \quad (3)$$

RESULTS AND DISCUSSION

Effect of temperatures on drying rate

A set of drying curves of soybeans at different inlet air temperatures is given in figure 2. It is clearly illustrated that moisture content is decreased rapidly at the beginning of drying period and then reduces slowly at the end of drying period. In all cases, drying rates of soybean are increased with inlet air temperature and drying of soybean is in the falling rate period. During this period, moisture movement is controlled by internal diffusion.

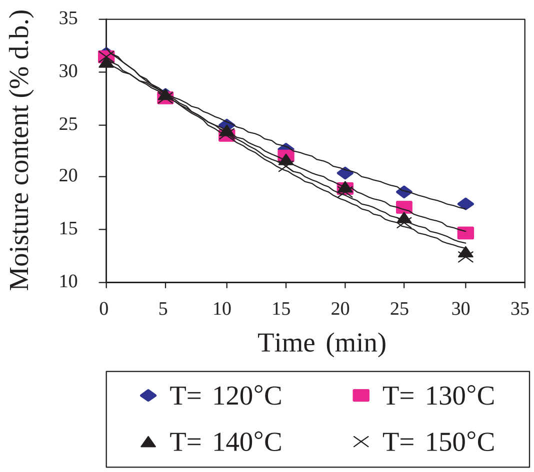

Figure 2 Effect of temperatures on reduction of moisture content.

Effect of temperatures on cracking and breakage

The cracking and breakage of soybean caused by drying at high temperatures is formed in V-shape. These results are similar to those reported by Overhults *et al.* (1973) and Soponronnarit *et al.* (2001).

The percentages of cracking and breakage shown in figures 3 and 4, respectively, were obtained by the following conditions: inlet air temperatures of 120-150°C, a deflector height of 138 cm from the entry of air inlet and a fixed air velocity of 20.5 m/s. They reveal that percentages of cracking and breakage depend strongly on the final moisture content and the inlet air temperatures; they increase with decrease of final moisture contents and increase of inlet air temperatures. Such defects are caused by the slow movement of water from the inside to the outside. Hence, soybean becomes brittle at the surface and tends to be cracked. Furthermore, the surface temperature of soybean rapidly increases as drying proceeds.

As illustrated in figure 4, the percentage of breakage of final product lies in a range of 6-24% higher than an acceptable level (3%). The cause of

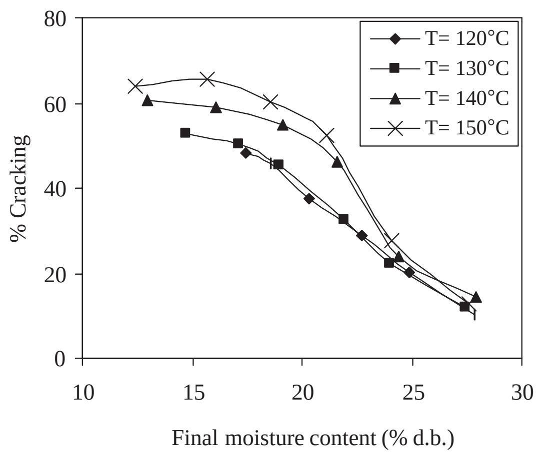

Figure 3 Effect of temperatures on the percentages of cracking at a fixed air velocity of 20.5 m/s and a deflector height of 138 cm.

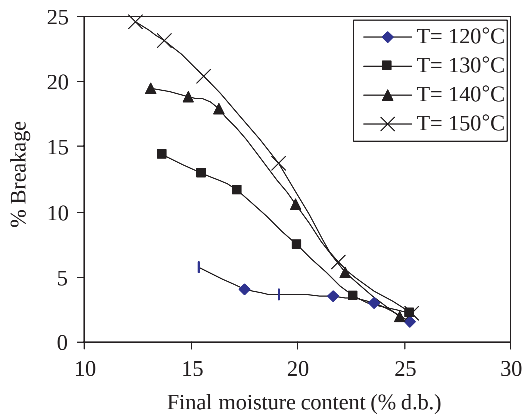

Figure 4 Effect of temperatures on the percentages of breakage at a fixed air velocity of 20.5 m/s and a deflector height of 138 cm.

such result is due to the effect of strong collision of kernels with the deflector, besides the drying effect. The effect of the deflector will be discussed in the next section.

Effects of air velocity and deflector height on cracking and breakage

Figures 5 and 6 show the increased percentages of cracking and breakage at the different air velocities and a deflector height of 142 cm. It is found that the percentages of cracking are insignificantly changed with increase of air velocity, but the percentages of breakage are substantially higher. When compared to figure 4 at 130°C in which degree of collision of kernel with deflector is higher than that in figure 6, it reveals that percentages of breakage at 142 cm deflector height (figure 6) are approximately 3% and 8% for air velocities of 15.86 and 17.12 m/s, respectively, whilst the percentage of breakage at 138 cm deflector height (figure 4) is 15% for air velocity of 20.5 m/s at the same drying conditions.

Effect of temperatures on urease activity and protein solubility

Figures 7 and 8 show the levels of urease of soybeans obtained from each treatment. In all tests, the pH is insignificantly changed at the early period and it is then reduced sharply. From the urease curve at 120°C, it can be seen that the level of urease is still higher than an acceptable limit of 0.30 ΔpH, according to FAO standard. At 130°C and initial moisture content of 28% d.b., urease can be reduced to be lower than an acceptable level, but at higher initial moisture content of 31-32% d.b., it is still higher than the acceptable level (pH change of 0.60). However, the capability of reducing the urease becomes more effectiveness when using the air temperature up to 140 or 150°C for reducing moisture content from a thorough range of 28-32% d.b. to 15% d.b.

Table 1 shows protein, urease activity and protein solubility in all heat treatments. It is found that the protein is insignificantly different and the protein solubility varies between 78-85%, indicating that the soybeans were properly treated.

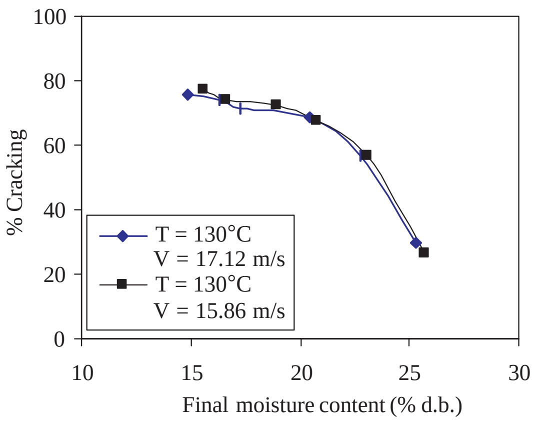

Figure 5 Effect of air velocities and deflector height on the percentages of cracking at a fixed temperature of 130°C, initial moisture content of 28% d.b. and a deflector height of 142 cm.

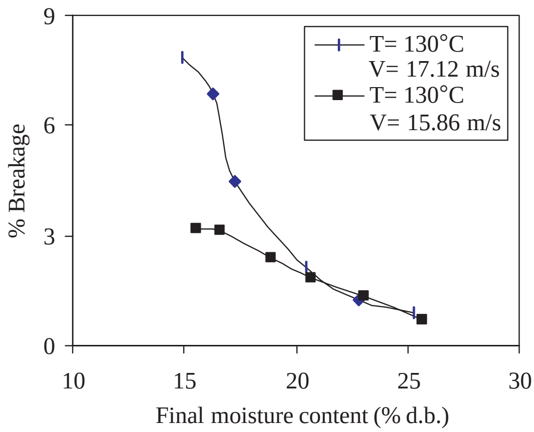

Figure 6 Effect of air velocities and deflector height on the percentages of breakage at a fixed temperature of 130°C, initial moisture content of 28% d.b.and a deflector height of 142 cm.

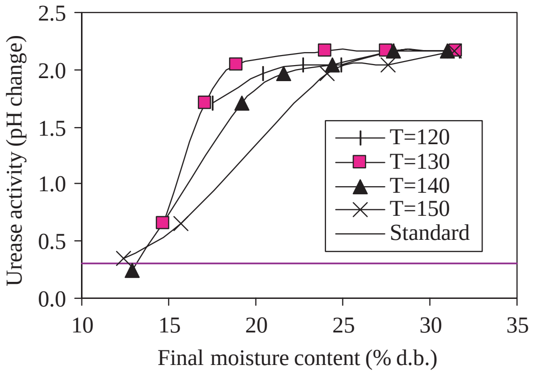

Figure 7 Effect of temperatures on the urease activity at the air velocity of 20.5 m/s, a deflector height of 138 cm and initial moisture content of 31-32% d.b.

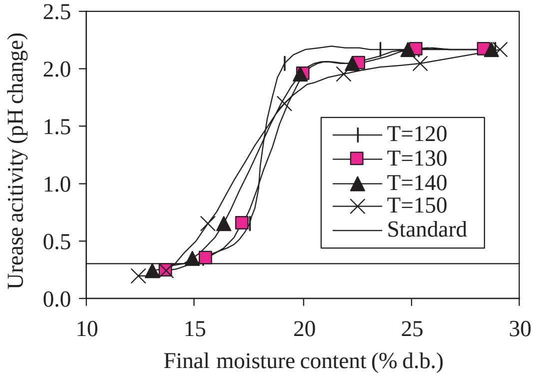

Figure 8 Effect of temperatures on the urease activity at the air velocity of 20.5 m/s, a deflector height of 138 cm and initial moisture content of 28% d.b.

Table 1 Analysis of protein solubility in 0.2% KOH at initial moisture content of 28-32% d.b.

T (°C)	MI (% d.b.)	Mf (% d.b.)	Protein (%)	Urease activity (ΔpH)	Protein solubility (%)
120	28.88	15.35	37.15	0.35	80.96
130	28.37	13.72	38.06	0.24	80.72
140	31.01	12.95	38.04	0.24	79.65
140	28.69	13.09	38.04	0.24	79.08
150	31.40	12.40	38.07	0.35	85.33
150	29.12	12.37	38.12	0.20	78.13
Initial sample			38.04-38.91	2.16	90.54-93.73

CONCLUSIONS

Drying at high air temperature can reduce the moisture content of soybean faster than that at low temperature. The percentages of cracking and breakage depend upon the temperature, final moisture content and degree of collision of kernel with deflector. Two-dimensional spouted bed dryer has a great potential to decrease the urease activity to the acceptable limit, along with maintaining the protein quality, when using the drying air temperature between 140 and 150°C. Under satisfaction of both qualities, moisture contents of soybean were reduced from 28 – 32% to be lower than 14% dry basis.

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