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EFFECT OF STATIC HEIGHT OF BED ON THE KINETICS OF POTATO PROTEIN DRYING IN A SPOUTED BED DRYER

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Abstract. Experiments on drying potato protein concentrates at a different height of static bed in the drying chamber $H_0 = 0.07$ m, 0.1 m, 0.12 m, 0.15 m at a constant velocity ($v = 0.8$ m s^{-1}) and the air temperature inlet ($t = 70$°C) of the drying medium were carried out on a laboratory scale. The influence of the height of the bed of potato protein on the drying rate and the value of the average moisture flux from the unit volume of the drying chamber were determined.

Keywords: potato protein, height of bed, spouted bed dryer

NOMENCLATURE

A, B – coefficients of equation;
H_0 – static thickness of raw material film in drying chamber, m;
u – water fraction in raw material, kg H_2O (kg d.m.)$^{-1}$;
$u_{(\tau)I}$ – water fraction in raw material in the first period of drying, kgH_2O (kg d.m.)$^{-1}$;
v – flow rate of air, m s^{-1};
t – drying air temperature, °C;
q_v – average volumetric moisture flux, kgH_2O m^{-3} h^{-1};
$du/d\tau$ – drying rate, kgH_2O (kg d.m.)$^{-1}$ min^{-1};

INTRODUCTION

In countries where starch production from potatoes (occurring also in Poland) is developed, a large amount of effluent is formed during potato processing; this is a considerable menace for the natural human environment, mainly because of the protein content. Protein recovery from potato starch waste by heat coagulation leads to an increase in BOD_3, COD and suspended solids of about 40-60% [4]. The protein obtained is a valuable constituent in feed. In 1990-1997, about 1.5-3.5 thousand tons of protein concentrate were produced annually in Poland [1], which contained about 80% of pure protein in dry matter.

Potato protein is characterized by its relatively high nutritional value, higher than many other proteins of plant origin. For example, the EAA index for potato protein has a value of about 82, for cereal protein about 62 in comparison to the protein of a whole egg, which is the protein standard. The amino acid composition of potato protein is well balanced in spite of an insufficiency of methionine and cysteine, whereas potato protein is a good resource of amino acid [2,3].

Annually in the world, 270-280 million tons of potatoes are produced, which supply about 5 million tons of protein. This constitutes about 4% all of accessible protein resources. Waste starch effluent is mostly acidified and heated which leads to protein precipitation. Protein precipitate is usually centrifuged on sediment centrifuges up to 25-40% of d.m. Less watered protein precipitate, with the consistency of cream (about 25% d.m.) can be dried by atomization or by the "add-back" system (mixing the ready product with the wet protein mass before drying) in conjunction with the flash drying method. More dehydrated protein precipitate (about 40% d.m.) – after homogenization can be (without the "add-back" system) dried in a flash drier – which method is used in most factories producing potato protein concentrate for feed purposes.

Practice has shown that the main fault of flash dryers is their high air and energy consumption. Moreover, they need dusters with high efficiency, because of the big differences in particle sizes. It seems that for more dehydrated protein precipitate (about 40% d.m.), fountain dryers working at lower speeds may be more suitable than flash dryers.

The aim of the work was an investigation of the drying process with potato protein precipitate centrifuged up to 60% d.m – in fountain bed conditions, independently of the bed height of the raw material.

MATERIALS AND METHODS

The drying of the potato protein concentrates was carried out in a laboratory stand shown in figure 1. The centrifugal fan (1) forced air through the heater (3) to the transparent, drying chamber (5) with a capacity of 0.00213 m^3.

At the fan inlet a damper (2) was located to control the air volume. An RK32 temperature controller maintained the set value of the temperature within the ±1°C limit. The thermo-element (4) measured the temperature of the medium, just below the screen film, with an accuracy of ±1°C. The hydraulic resistance of the raw material bed was measured with a U-pipe, filled with water, with an accuracy within ±1 mm for the column of water. As a raw material, potato protein with 1.4 kg H_2O (kg d.m.)$^{-1}$ produced by the Niechlów Potato Processing Company was used. Before drying, the potato protein was broken up into particles of ca 0.005 m dimension.

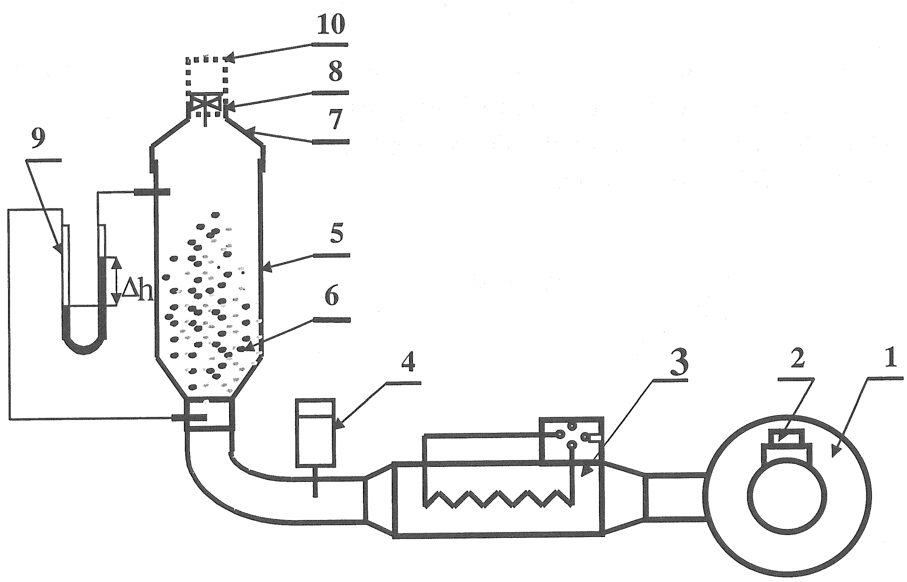

Fig. 1. Scheme of measuring stand: 1 – fan, 2 – control damper, 3 – heater with temperature controller, 4 – thermo-element, 5 – drying chamber, 6 – spouted bed, 7 – measuring pipe, 8 – anemometer, 9 – U-pipe, 10 – sack filter.

After breaking up, the potato protein sample was put into the chamber and dried until a water content of about 0.11 kg H_2O (kg d.m.)$^{-1}$ was achieved. The measurement of mass loss in the dried protein was carried out with a WP4000 electronic weight within an accuracy limit of ±0.1 g, by weighing the chamber (which had been previously tarred) together with its content. The drying process was carried out at the height of the static bed of the raw material $H_0 = 0.07$ m; 0.1 m; 0.12 m; 0.15 m. A constant drying medium temperature $t = 70°C$ was used. The rate of the drying medium $v = 0.8$ m s^{-1} (measured for empty cross – section of cylindrical part of drying chamber) was chosen after careful observation of the bed. The moisture of the raw material was evaluated by the drying method. Relative moisture and ambient temperature were measured with an Assman psychrometer within an accuracy limit of ±2%, and with a mercury thermometer, respectively. Time was measured with a stopwatch. The average volumetric moisture flux q_v was calculated on the basis of the water loss in the raw material in respect to 1m^3 of the volume of the drying chamber and 1h of drying time. Each measuring cycle was repeated three times.

RESULTS AND DISCUSSION

In figure 2 the drop of the water fraction u, versus the time τ, under the influence of the change of bed height of the potato protein is presented. In the experiment, the constant rate of the drying medium $v = 0.8$ m s^{-1}, and constant temperature $t = 70°C$ were assured.

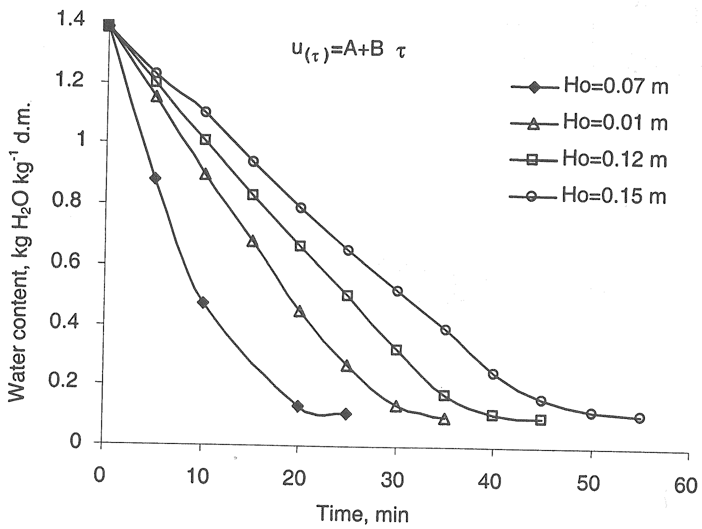

Fig. 2. Drop in the water fraction versus time at different heights of the static bed of the raw material

As follows from the graph, the dependence on height of the static bed of the raw material and the drying period of the sample from the water content of 1.4 to ca. 0.11 kgH_2O (kg d.m.)$^{-1}$, ranged from 25 to 55 min. The course of the drying curves suggests that the change of moisture content in the dried material, in the predominant parts of the time of the drying process, has a near linear character; the relationship can be approximated in the following form:

$$u_{(\tau)}=A+B\tau \tag{1}$$

Table 1 contains coefficients A, B for various height of bed H_0 of raw material.

The drying rate graph shown in figure 3 confirms the influence of the height of the static bed of raw material H_0 on the dynamics of water loss.

Table 1. The values A, B and R^2 in equation 1 – for different H_o

H_o	0.07 m	0.10 m	0.12 m	0.15 m
A	1.3265	1.3454	1.3449	1.3606
B	–0.0796	–0.0424	–0.0346	–0.0275
R^2	0.98	0.99	0.99	0.99

On the basis of figure 3 it can be stated that the period with the nearly constant drying rate (I period) included the range from 1.4-0.25 kgH_2O (kg d.m.)$^{-1}$ for H_0=0.1m; 0.12m; 0.15m. With regard to H_0=0.07m, the I period included the range from 1.4 to ≈0.9 kgH_2O (kg d.m.)$^{-1}$.

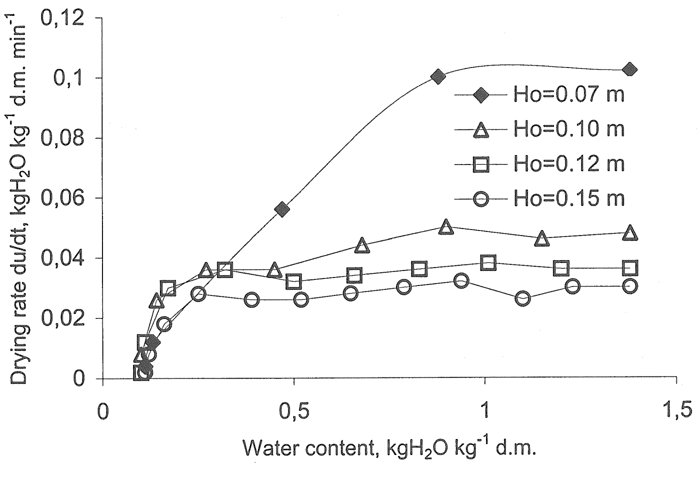

Fig. 3. Drying rate versus water content for different height of the static bed of raw material

On average, in the I drying stage, the growth of the height of the static bed of raw material from 0.07 m to 0.15 m caused a decrease in the drying rate from ca 0.1 to ca 0.03 kg H_2O (kg d.m.)$^{-1}$ min^{-1}.

In figure 4, the influence of the height of the static bed of the raw material on the value of average volumetric moisture flux q_v, related to 1 m^3 volume of drying chamber and 1h of drying time is presented.

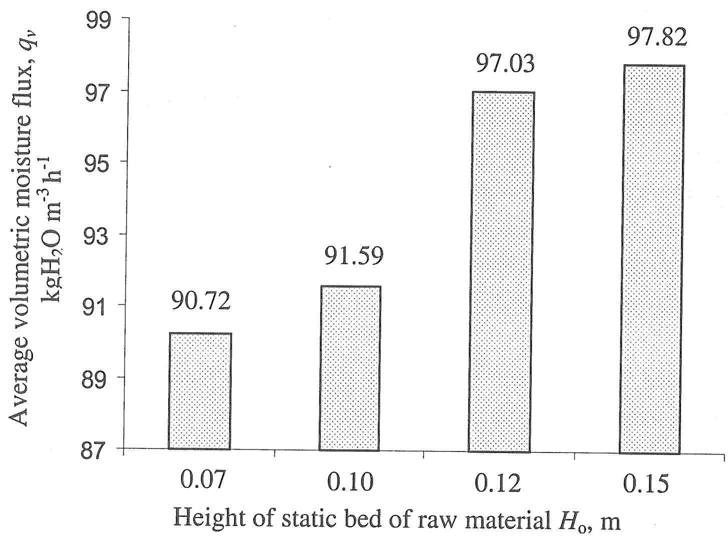

Fig. 4. The influence of the height of the static bed of the raw material on the value of average volumetric flux of moisture

The value of q_v was negligibly growing with the growth of the height of the static bed of the raw material. For example the value was ca 90 kg H_2O m^{-3} h^{-1} at the height H_0= 0.07 m, and for H_0= 0.15 m the value of q_v was ca 98 kg H_2O m^{-3}h^{-1}. Together with the increase of H_0 (for H_0 from 0.1 to 0.15) intensification of bed "bubling" phenomena was observed. This "bubling" made drying conditions worse.

The drying rate was kept in line with the mass of dry matter and depended on the raw material mass introduced into the chamber. However, in the q_v calculation, the constant volume 0.00213 m^3 of drying chamber was established. So, the higher drying rate (for H_0 = 0.07 m) could be accompanied by lower values of q_v.

This was the reason for the different character of the dependence q_v on H_0 in comparison with the course du/dτ = f(H_0).

CONCLUSIONS

1. Changes of water content in fountain bed dried potato protein concentrates versus time (in the predominant part of the time of the drying process) can be described by the equation in the form:

$$u_{(\tau)} = A + B\tau$$

2. Increasing the height of the static bed of the raw material caused a decrease of the average drying rate and a negligible increase of the average volumetric flux.

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Słowa kluczowe: białko ziemniaczane, wysokość warstwy, suszarka fontannowa