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EFFECT OF EXSTRACT CONTENT ON THE KINETICS OF DRYING OF BARLEY MALT CONCENTRATE DROPLETS*

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Summary. Experiments on drying of single droplets of malt wort at the extract content of 10, 20, and 30 wt%, at a constant velocity (v = 1,6 m s^{-1}) and temperature (t = 80^{0}C) of drying medium – have been carried out on an experimental stand. The influence of extract content on drying rate and the value of average moisture flux from a unit area of droplets was determined. The „thin filament method" displayed good accuracy and repeatability.

Keywords: malt concentrates droplets, extract content, drying.

NOMENCLATURE

A, B	- constants	
d	- diameter of droplet	[m]
u	- water fraction in dried material	[kgH_2O kg^{-1} d.m.]
$u_{(\tau)}$	- water fraction in dried material in the second period of drying	[kgH_2O kg^{-1} d.m.]
v	- flow rate of air	[m s^{-1}]
t	- drying air temperature	[^{0}C]
q_a	- average superficial moisture flux	[kgH_2O m^{-2} h^{-1}]
ρ	- density of malt extract	[kg m^{-3}]
η	- viscosity coefficient of malt extract	[m Pa s]
s	- extract content	[wt%]
τ	- drying time	[min]
$du/d\tau$	- drying rate	[kgH_2O kg^{-1} d.m. min^{-1}]

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INTRODUCT1ON

Malt wort is a water extract of carbohydrates (maltose, glucose and dextrins), proteins (amino acid and peptides), enzymes from hydrolases group (amylolytic, proteolytic, cellulolytic and others), mineral components (sodium, phosphorus, iron etc). vitamins (B_1, B_2, B_6, PP) and many other substances contained in malt [3].

The malt extracts are mostly produced in the form of highly concentrated wort with dry mas content ranging from 70% to 80%. Water content in malt extracts (20%÷30%) is the factor limiting the stability of the product. It makes the producers to employ preservatives like for example sodium benzoate. Another way to increase the shelf-life of malt extracts is their drying [4]. Despite of the fact that the spray-drying process is quite expensive, it can offer, besides increasing of the product stability, many additional advantages such as extending of applications range of dried product. It can be used as an addition to dry soup mixes and refining agent in bakery industry, which is very convenient for metering and mixing with other products [1].

The process of drying of concentrated malt extract is not well known in Poland. Communications in this field are rather limited.

The aim of the work was to investigate the course of drying process of malt extract droplets at various dry mass contents.

MATERIAL AND METHODS

Drying of single droplets of malt wort concentrates was carried out in an experimental stand shown in Fig. 1. The current experimental method is similar to that described in [2,7].

At the inlet of the fan a damper (2) was located to control the air flux. The RK 32 temperature controler was keeping the set value of temperature within $\pm 1^0$C limit. The thermoelement (4) measured the temperature of drying medium, just bellow a droplet with an accuracy of $\pm 1^0$C. As raw material the malt wort concentrates produced by Wolsztyn Company was used.

Droplets of malt wort concentrate (10, 20, 30% d.m.) were suspended at the ends of fine filaments (5 filaments, $\phi = 0.1$ mm). The filaments were ended with small balls. The filaments were attached to a small cylinder (6). The cylinder with filaments and droplets (5) was placed in the drying tube as is shown in Fig. 1 . All droplets were about 0,002 m in diameter.

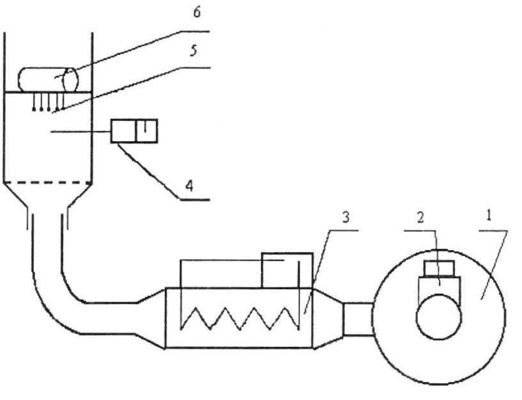

Fig 1. Scheme of measuring stand: 1 - fan, 2 - control damper, 3 - heater with a temperature controller, 4 - thermoelement, 5 - filaments with droplets, 6 – cylinder.

The volumetric diameter d of droplets was calculated on the basis of density of malt wort extract and the initial weight of droplets. The measurment of mass loss of dried droplets was carried out (frequency 2 min.) with WPA 60/C electronic balance with accuracy $\pm 0{,}0001$g, by weighing the cylinder with filaments.

In the experiment constant temperature ($t = 80^{\circ}$C) of drying medium was assured. The flow rate of drying medium (calculated for empty cross section of drying tube) was $v = 1.6$ m/s. Dry mass content of raw material was measured by refractometric method. The viscosity of solutions of malt concentrate with 10, 20, 30% dry matter content, was measured with the Haake RS 50 viscosity meter.

Relative humidity (40% - 50%) and ambient temperature (close to 25°C) were measured with Assman psychrometer with accuracy of $\pm 2\%$ and with a liquid thermometer ($\pm 0{,}2$°C). Time was measured with a stopwatch. Average superficial flux of moisture q_a was calculated on the basis of water loss in respect to 1 m^2 of the surface of dried droplets and 1h of drying time. Each measuring cycle was repeated three times.

RESULTS

The decrease of water fraction versus time, for different extract contents in the drying droplets of barley malt are shown in Fig. 2.

The course of the curves shows that the drying process of the barley malt droplets takes place at the decreasing drying rates. The dynamics of water loss at the initial stage of drying was significantly higher at 30% d.m. than that of less concentrated solution ($s = 10\%$).

As the extract content was increasing, from s = 10% to s = 30%, the time of droplets drying decreased gradually (up to the final water fraction $u \approx 0.1$ kgH_2O kg^{-1} d.m.) from 14 to 10 min.

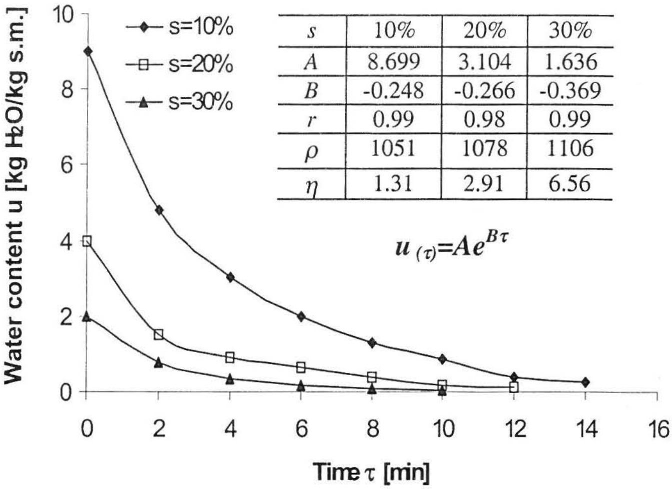

Fig. 2. Relationship between water content and time

The dependence of water fraction decrease in the concentrated droplets, with different initial dry mass content, on the drying time can be described with an exponential function of the form:

$$u_{(\tau)} = Ae^{B\tau} \tag{1}$$

The values of A and B coefficients versus dry mass content are presented in Table (Fig. 2).

The effect of extract concentration in malt droplets on the dynamics of water evaporation is confirmed by the plot of drying rates, shown in Fig. 3. As it follows from Fig. 3, at the initial stage of drying process (first 2 min) for the extract content in the malt concentrate of s = 10%, the drying rate was about 2 kgH_2O kg^{-1} d.m. For the concentration of solution of s = 30%, the initial rate was lower by about three times.

The influence of the extract content in the droplets of raw material on the value of average superficial stream of moisture q_a, for the whole process is illustrated in Fig. 4.

The drop of dry mass content in the raw material from 30% to 10% resulted in the increase in q_a value from about 1.8 to about 3 kgH_2O m^{-2}h^{-1} under the experimental conditions.

The differences in drying rates among the malt droplets with similar diameter but different extract content result probably from the different intensity of inner circulation in the malt droplets. As long as such circulation exists, the formation of dry coating on the droplet surface is hindered [5,8]. It has a crucial effect on the rate of mass transfer. On the droplets with higher extract content, the dry coating was formed faster.

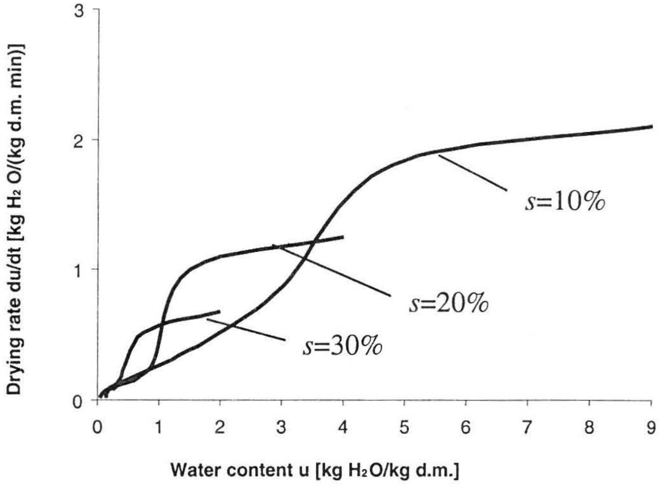

Fig. 3. Drying rate versus water content for different extract content in concentrates of barley malt extracts.

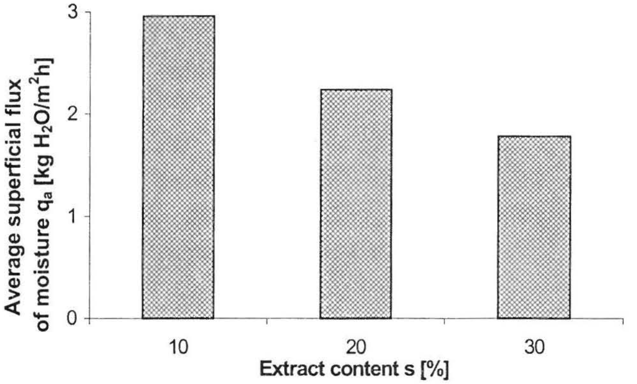

Fig. 4. The influence of extract content on the value of average superficial flux of moisture.

CONCLUSIONS

1. Changes in water content in drying droplets of malt wort concentrates can be described by the equation on the form: $u_{(\tau)} = Ae^{B\tau}$
2. The increase in extract content in the droplets of malt wort from 10% to 30% results in the lowering of drying rate by three times at the initial stage of drying process and about two-times lower the average superficial stream of moisture during the whole process.

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WPŁYW ZAWARTOŚCI EKSTRAKTU NA KINETYKĘ SUSZENIA KROPEL KONCENTRATU SŁODU JĘCZMIENNEGO

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Streszczenie. Na stanowisku badawczym przeprowadzono doświadczenia nad suszeniem pojedynczych kropel koncentratu słodu jęczmiennego o zawartości ekstraktu 10%, 20%, 30% przy stałej prędkości (v = 1,6 m s^{-1}) oraz temperaturze (t = 80^0C) czynnika suszącego. Określono wpływ zawartości ekstraktu oraz wartość średniego strumienia wilgoci z jednostki powierzchni kropel. Metoda "suszenia na cieńkich włóknach" wykazała dobrą dokładność i powtarzalność wyników.

Słowa kluczowe: krople koncentratu słodu, zawartość ekstraktu, suszenie.