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RHEOLOGICAL PROPERTIES OF MALT CONCENTRATE DESIGNED FOR SPRAY-DRYING

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Summary. The effect of temperature and dry matter content on the viscosity of malt concentrate designed for spray-drying was studied. The viscosity coefficient values were determined by the viscosity meter Haake RS 50. Spray drying was carried out in drier Anhydro Lab 1. It was stated, that the decreasing of viscosity coefficient (η) of malt concentrate, caused by the raising of temperature (t), could be described by the exponential function $\eta = a+b \cdot \exp(-t/c)$. Simultaneously the drying process was accompanied by the proportional rate of evaporation and yield of powder production increase with the decrease of viscosity. It has also been found, that the viscosity of malt concentrate increases with the increasing of dry matter content (D), according to exponential function $\eta = a \cdot \exp(b \cdot D+c)$, while the rate of evaporation decreases and yield of powder production increases. For the intensification of drying process yield under industrial conditions it was suggested to transport the malt concentrate directly from the evaporator to spray-drier.

Keywords: malt concentrate, dry matter, temperature, viscosity, spray-drying.

INTRODUCTION

Malt wort is a water solution of the products of enzymatic hydrolysis of components of barley malt obtained in brewing plants by malt mashing and mash filtration. Malt wort is a water extract of carbohydrates (maltose, glucose and dextrins), proteins, (amino acids and peptides), enzymes from hydrolase group (amylolytic, proteolytic, cellulolytic and others), mineral components (sodium, phosphorus, iron etc.) vitamins (B_1, B_2, B_6, PP) and many other substances [4].

The malt concentrates are mostly produced in the form of highly concentrated wort with dry matter content in the range from 70% to 80%. Water content in malt concentrates in the amount from 20% to 30% is the factor, which limits the product stability. It requires to use preservatives like, for example, sodium benzoate. Another way to increase the stability of malt extracts is drying [5]. Despite the fact that the spray-drying process is quite expensive, it can offer, besides increasing of the product stability, many additional advantages, like expanding the application range of dried product. It can be used as an additive to dry soups, and refining agent in bakery industry, which is very convenient for mixing with other products [1].

Some physical properties of dried malt wort have been measured. Dried material obtained from the wort with the higher content of dry matter is more elastic than that obtained from the wort with lower content of dry matter [2]. Also lower pressures of air supplied to the nozzle of spray-drier cause higher values of elasticity modulus [3].

The viscosity of raw material is important magnitude, which significantly affects the spray-drying process. The viscosity coefficient depends on the dry matter content and the temperature of liquid [6, 7].

The purpose of the investigation was to determine the influence of dry matter content and temperature on the viscosity of malt concentrate as a raw material for spray-drying process.

MATERIAL AND METHODS

The malt concentrate produced by the Malt Extracts Factory in Wolsztyn was used as a raw material. It was diluted with water. The viscosity of seven solutions of malt concentrate containing 76.6, 66.4, 51.7, 39.7, 31.9, 15.4 and 11.6% of dry matter was measured in the viscosity meter of Haake RS 50 with the usage of measuring element – DG 41. For each solution the dependance between the viscosity coefficient and the temperature, in the range from 20 to 55°C, at the constant shear rate 250 1/s was determined. The dependence of viscosity coefficient on shear rate in the range up to 250 1/s was quasi-linear for all tested solutions. Malt concentrate solutions at temperature 50°C and containing 10, 20, 30, 40, 50% of dry matter and malt concentrate solution with 30% of dry matter heated up to the following temperatures: 10, 15, 20, 25, 30, 35, 40, 45, 50°C were dried in spray – drier Anhydro Lab 1. The power of heater was 3kW and the air pressure supplied to the nozzle was 0.8 bar. The yield of peristaltic pump was set up according to conditions in which was assured proper drying of solutions of different dry matter content and heated to different temperatures. The weight of dried product, of moisture content oscillated between 2 and 4%, was measured with the accuracy 0.01g.

RESULTS AND DISCUSSION

The relationship between the viscosity coefficient (η) of malt concentrate with different dry matter (*D*) contents and the temperature (*t*) was described by the exponential function $\eta = a+b \cdot \exp(-t/c)$ (Fig.1). The values of a, b and c depended on the dry matter content of the raw material (Tab. 1). Semilogarithmic scale was necessary to use because of the significant changes of viscosity coefficient in the range of low temperatures. It can be noticed, that the increase of the temperature affected more the decrease of solution viscosity at high content of dry matter. For example, the raising of temperature from 22 to 55°C affected the decrease of the viscosity value from 318 to 70 mPa·s for the concentrate contained 76.6% of dry matter and only from 1.82 to 0.90 mPa·s for the concentrate containing 11.6% of dry matter.

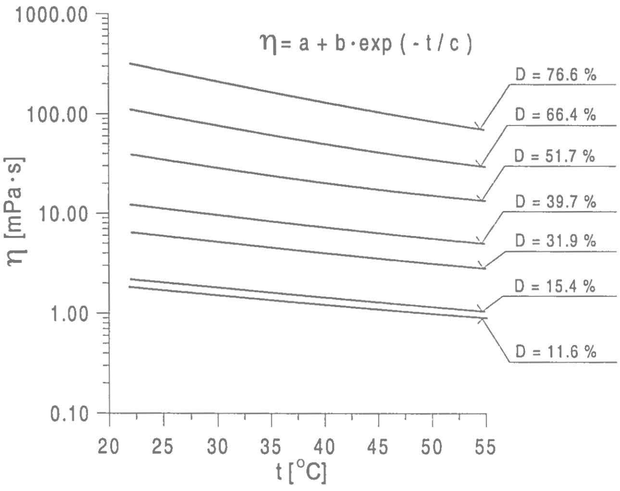

Fig. 1. Relationship between the viscosity coefficient *(η)* of malt concentrate and temperature *(t)*. Dry matter *(D)* is parameter.

Table 1. Coefficients of the equation $\eta = a+b \cdot \exp(-t/c)$, which describes the relationship between the viscosity coefficient *(η)* and temperature *(t)*

D [%]	a [mPa·s]	b [mPa·s]	*t* [°C]	R^2
76.6	21.46	998.8	18.10	0.99
66.4	12.80	317.3	18.66	0.99
51.7	7.149	94.97	20.20	0.99
39.7	1.713	22.97	28.09	0.99
31.9	0.8618	11.25	31.29	0.99
15.4	0.2241	3.487	38.02	0.99
11.6	0.2835	2.818	36.21	0.99

Correlation between the viscosity coefficient (η) and the dry matter content (D) of malt concentrate at different temperatures (t) was described by the exponential function $\eta = b \cdot \exp(b \cdot D + c)$ (Fig. 2, Tab. 2). It was found that the solutions of different dry matter content can have the same viscosity at appropriate temperatures. For instance, the values of the viscosity coefficient of solution with the dry matter content $D = 36\%$ at temperature 22°C and solution of dry matter content $D = 50\%$ at temperature 55°C were about 11 mPa·s. Therefore, it is concluded that it might be possible, in the limited range, to increase the dry matter content of the raw material without its viscosity change. However, must be adjusted to appropriate value the temperature of the raw material.

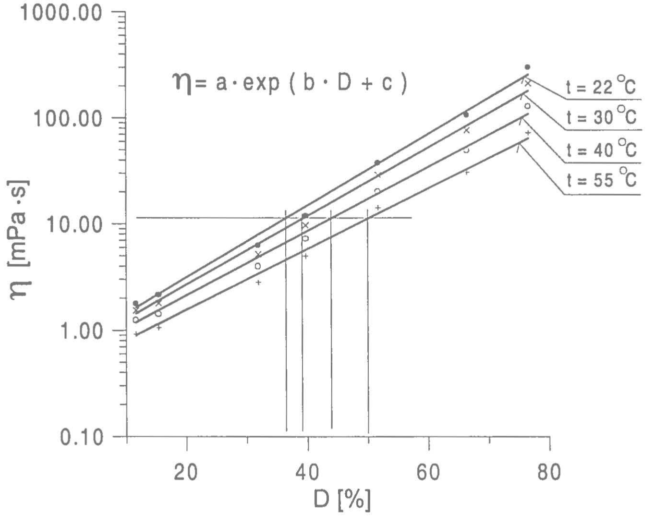

Fig. 2. Influence of dry matter content *(D)* on viscosity coefficient of malt concentrate *(η)*. Temperature *(t)* is parameter.

Table 2. Coefficients of the equation $\eta = a \cdot \exp(b \cdot D + c)$, which describes relationship between the viscosity coefficient *(η)* and the dry matter content *(D)*

t [°C]	a [mPa·s]	b [1/%]	c [-]	R^2
22	0.4526	0.07791	0.3818	0.98
30	0.4284	0.07443	0.3503	0.98
40	0.3943	0.06964	0.2963	0.99
55	0.3438	0.06573	0.2003	0.99

The results of drying experiments showed, that the increase of dry matter from 10 to 50% in raw material at temperature of 50°C reduced rate of evaporation from 87 to 13.1 g/min (Fig.3), but simultaneously increased the yield of powder production from 9.1 to 12.4 g/min (Fig.4). The raising of the temperature of the raw material containing 30% of dry matter, from 10 to 50°C,

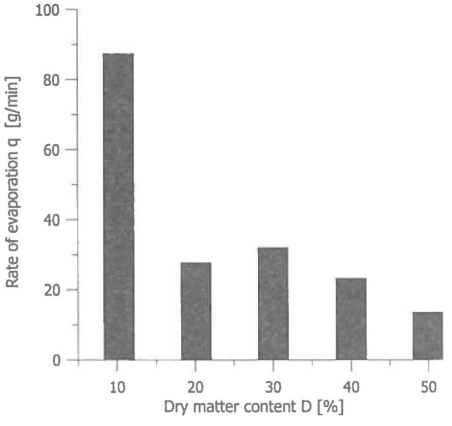

Fig. 3. Rate of evaporation *(q)* of malt concentrate at different dry matter contents *(D)*. Temperature of malt concentrate is 50°C.

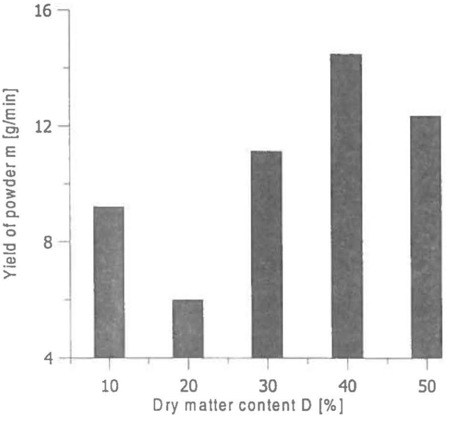

Fig. 4. Yield of powder *(m)* of malt concentrate at different dry matter contents *(D)*. Temperature of malt concentrate is 50°C.

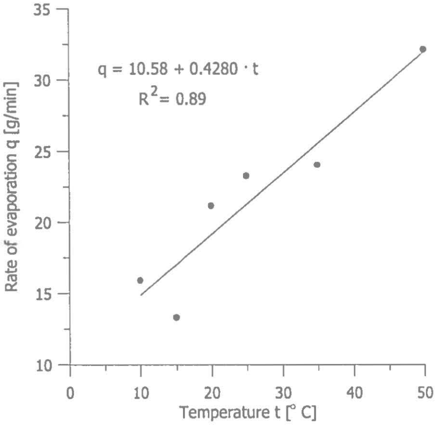

Fig. 5. Effect of malt concentrate temperature *(t)* on the rate of evaporation *(q)*. Dry matter content is 30%.

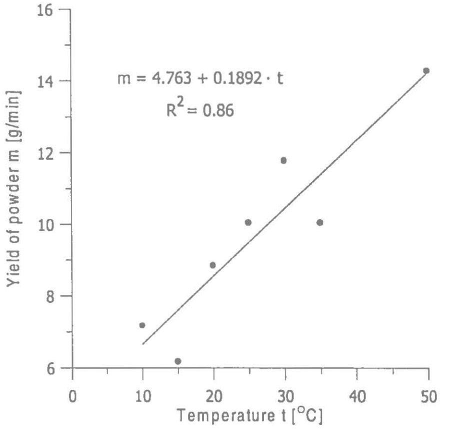

Fig. 6. Effect of malt concentrate temperature *(t)* on the yield of powder *(m)*. Dry matter content is 30%.

increased the rate of evaporation from 14.9 to 32 g/min (Fig. 5) and the yield of powder production from 6.7 to 14.2 g/min (Fig. 6). It is necessary to design processing in the way in which malt concentrate is directly pumped from the evaporator to spray-drier.

CONCLUSIONS

1. Increase of malt concentrate temperature *(t)* causes the decrease of viscosity coefficient (η), what can be described by the exponential function $\eta = a + b \cdot \exp(-t/c)$, and the decrease of the rate of evaporation. However yield of powder increases.
2. The increase of dry matter content of malt concentrate *(D)* causes the increase of the viscosity coefficient (η) value described by the exponential function $\eta = a \cdot \exp(b \cdot D + c)$, while the rate of evaporation decreases and yield of powder increases.
3. For the higher efficiency of drying in industrial conditions, malt concentrate should be pumped from the evaporator directly to spray drier.

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WŁAŚCIWOŚCI REOLOGICZNE KONCENTRATU SŁODOWEGO PRZEZNACZONEGO DO SUSZENIA ROZPYŁOWEGO

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Streszczenie. Badano wpływ temperatury i zawartości suchej masy na lepkość koncentratu słodowego w aspekcie suszenia rozpyłowego. Wartości współczynnika lepkości wyznaczone zostały za pomocą wiskozymetru rotacyjnego Haake RS 50, a suszenie rozpyłowe przeprowadzono przy użyciu suszarki rozpyłowej Anhydro Lab1. Stwierdzono, że spadek współczynnika lepkości koncentratu słodowego (η), spowodowany wzrostem temperatury (t), można opisać przy użyciu funkcji wykładniczej postaci $\eta = a+b\cdot\exp(-t/c)$, przy czym towarzyszy temu proporcjonalne zwiększenie współczynnika odparowania wody oraz wydajność otrzymywanego proszku. Wykazano również, że lepkość koncentratu słodowego rośnie wraz ze zwiększeniem zawartości suchej masy (D) zgodnie z funkcją wykładniczą $\eta = a\cdot\exp(b\cdot D+c)$, przy czym współczynnik odparowania wody ulega zmniejszeniu, a wydajność otrzymywanego proszku wzrasta. W celu zwiększenia efektywności suszenia w warunkach przemysłowych zaproponowano kierowanie koncentratu słodowego do suszarki rozpyłowej bezpośrednio z wyparki.

Słowa kluczowe: koncentrat słodowy, sucha masa, temperatura, lepkość, suszenie rozpyłowe.