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«The experimental data on the density, viscosity, and boiling temperature of the coffee extract»

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Problem statement

One of the main stages of soluble coffee production is the coffee extract drying. The previous stage of soluble coffee production is the coffee extract evaporation. The evaporation stage allows to reduce the energy consumption of soluble coffee production and to increase the product quality. It is important to know the physical properties of coffee extract for the extract evaporation equipment design. Also, it is necessary to know the coffee extract density and viscosity to drying equipment sprayer type choose. Thus, the obtaining of the experimental data on the coffee extract rheological and thermophysical properties is an important applied task.

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Solution methods

- We the coffee extract with the dry substances mass fraction in the range of 15-70% at the temperature in the range of 20-80 °C.
- The coffee extract boiling temperatures for the dry substances mass fraction in the range of 15-70% at atmospheric pressure were measured using the Swietoslawsky-type ebulliometer. The error of the boiling temperature measurement was not more than 0.5%.
- For the coffee extract density measurement, we used the set of aerometers with a measuring range of 1000-1300 kg/m^3. For the density measuring of the extract with the dry substances mass fraction less more 50% we used the pycnometer method. The measurement error was not more than 0.15% for extract with the dry substances mass fraction less than 50% and not more than 0.5% for the extract with the dry substances mass fraction more than 50%.
- For the coffee extract viscosity measurement, we used the capillary viscometers with capillary diameters 0.99 and 1.47 mm for the extract with dry substances mass fraction less than 50%. The viscosity measurement error was not more than 0.5% for this range of the dry substances mass fraction. For the viscosity measuring of the extract with the dry substances mass fraction more than 50%, we used the capillary viscometers with capillary diameters 0.99 and 1.47 mm for the temperature 50 °C and more. For the temperatures less than 50 °C we used cup viscometer with the nozzle diameter 4 mm. The viscosity measurement error was not more than 2.5% for this range of the dry substances mass fraction.

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Conclusions

- We have obtained the experimental data on the coffee extract boiling temperature at atmospheric pressure and on the coffee extract density and viscosity for the dry substances mass fraction in the range of 0.15-0.70 and the temperature in the range of 20-70 °C.
- We found that the coffee extract boiling temperature changes slightly for the dry substances mass fraction in the range of 0.15-0.70 at atmospheric pressure. The maximum thermal depression is 3.2 °C in the considered range of the dry substances mass fraction.
- It was shown that the coffee extract density increases with the dry substances mass fraction growth and decreases with the temperature rising. In the considered ranges of the temperature and dry substances mass fraction the minimum and maximum values of the measured coffee extract density are 1030 kg/m^3 and 1350 kg/m^3, respectively.
- The regressive equations of the dependences of the coffee extract boiling temperature and density from the dry substances mass fraction and temperature were obtained.

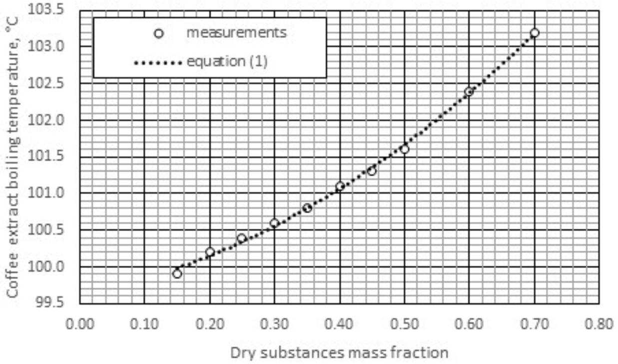

Figure 1. Dependence of the measured coffee extract boiling temperature from the dry substances mass fraction at atmospheric pressure.

$$T_b = 4.9395 \cdot f^2 + 1.6099 \cdot f + 99.633. \quad (1)$$

There T_b is the boiling temperature, °C; f is the dry substances mass fraction.

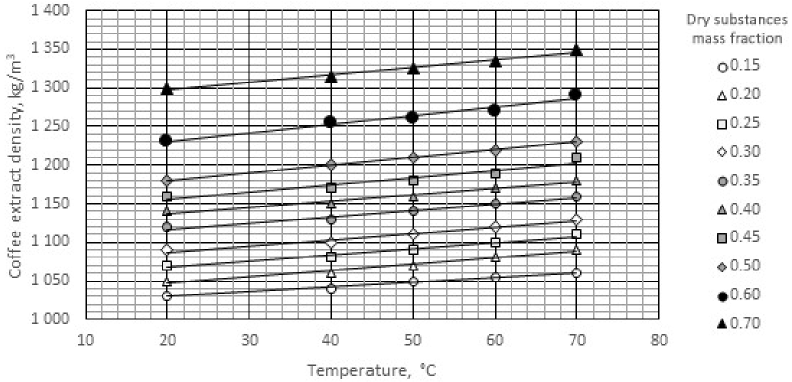

Figure 2. Dependence of the measured coffee extract density from the dry substances mass fraction and the temperature.

$$\rho = 932 + 0.8 \cdot t + 509 \cdot f. \quad (2)$$

There ρ is the coffee extract density, kg/m^3; t is the temperature, °C; f is the dry substances mass fraction.

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Conclusions

- It was found that the coffee extract viscosity increases nonlinearly with dry substances mass fraction growth and depends on temperature by the power law. For the dry substances mass fraction in the range of 0.15-0.70 and the temperature in the range of 20-80 °C the coffee extract viscosity minimum and maximum measured are 0.769 mPa·s and 27481 mPa·s, respectively.
- It was found that the coffee extract is foaming in the considered range of dry substances mass fraction. The foaming temperature is decreasing with the dry substances mass fraction increasing. For the temperatures close to the boiling temperature the foaming significantly decreases.
- The regressive equations of the dependences of the coffee extract viscosity from the dry substances mass fraction and temperature were obtained.

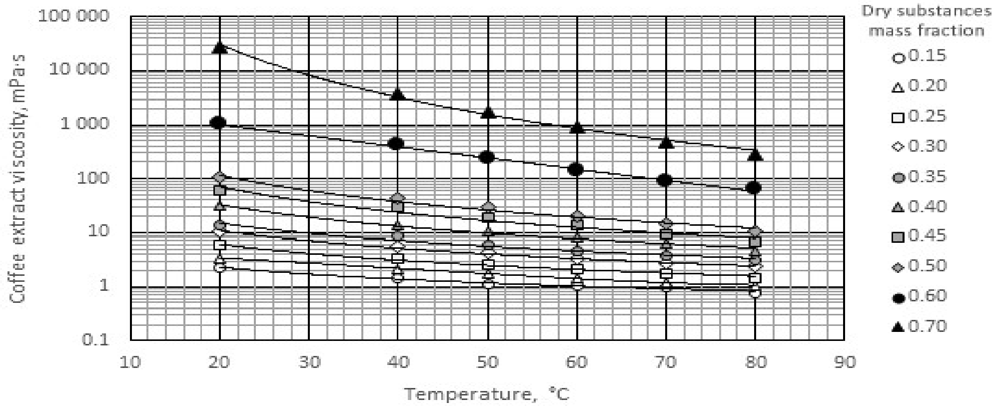

Figure 3. Dependence the dynamic viscosity of the coffee extract from the dry substances mass fraction and the temperature.

$$\mu = a\left(\frac{t}{100}\right)^{b}. \quad (3)$$

There μ is the viscosity, mPa·s; *a* and *b* are regression coefficients; *t* is the temperature, °C.

Table. Values of regression coefficients and the approximation errors of the coffee extract viscosity regressive equations

Dry substances mass fraction	Regression coefficient a	Regression coefficient b	Equation average approximation error
0.15	3.85	-0.741	4.0%
0.20	6.50	-0.851	4.8%
0.30	12.10	-0.984	4.6%
0.35	32.80	-1.090	4.1%
0.40	84.79	-1.084	8.6%
0.45	215.27	-1.335	5.6%
0.50	363.86	-1.590	13.8%
0.60	4931.00	-1.637	9.2%
0.70	300557.00	-2.004	16.2%

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