ORIENTAL JOURNAL OF CHEMISTRY
An International Open Access, Peer Reviewed Research Journal
www.orientjchem.org
ISSN: 0970-020 X
CODEN: OJCHEG
2024, Vol. 40, No.(4):
Pg. 1087-1090

Brief communication

Investigation Rheological Behavior of Chocolate

IOANA STANCIU

University of Bucharest, Faculty of Chemistry, Department of Physical Chemistry,
4-12 Elisabeta Blvd, 030018, Bucharest, Romania.
*Corresponding author E-mail: istanciu75@yahoo.com

http://dx.doi.org/10.13005/ojc/400420

(Received: July 13, 2024; Accepted: August 15, 2024)

ABSTRACT

In this article we studied chocolate with 100% cocoa without lecithin and traces of milk in the form of chips. The data obtained are in accordance with those obtained from the specialized literature. This article proposes two relations of dependence of log dynamic viscosity on log shear rate. The relations determined by second-order polynomial and exponential fitting can be successfully applied to confectionery products because the obtained correlation coefficients are close to unity.

Keywords: Rheological, Chocolate, Viscosity, Investigation.

INTRODUCTION

Chocolate was discovered in the years 250-290 after Christ in Central America. Although it is possible that other explorers had discovered chocolate in America long before, Europeans did not learn about this delicious drink until 1521. Chocolate even became a reason for war with the arrival of the Spanish conquistadors on April 21, 1519, led by their leader Hernán Cortés that allows access to the sources of the use of cocoa powder: the Aztec king believed that he was dealing with the god Montezuma, whose return was predicted by legends for this very day and he welcomed the conquistadors by offering them to drink from a cup of gold, a bitter drink "Xocoatl" with refreshing virtues. Hernán Cortés imposed this drink on his army, noting that "one cup of this precious drink lasts the people for a whole day's march, without the need for other food"[1-9].

The first Colombian chroniclers tell that the drink consisted of a liquid in which crushed cocoa beans, carob powder, vanilla, whole cloves, hazelnuts, almonds, pistachios, orange blossom and rose water, pepper powder, hot peppers were mixed., cinnamon and corn puree. Everything was connected by successively pouring the drink from one container to another, then by repeated mixing, which produced a lot of foam. Later, honey, musk and amber are added to suppress the bitterness of the mixture.

Hernán Cortés decided to bring the famous seeds with him, along with other treasures, on his return to Spain. The first load of cocoa leaves with a "vento chocolatero", the name given in Mexico to the northern breezes that favored

navigation. The Italian poet Pietro Andrea Forzoni summarized its virtues: "A sweet ambrosia, source of health, spiritual support of a life full of weakness, so coveted by the immortal inhabitants of the celestial heights!". From the tonic to the aphrodisiac, it was only one step, easily surpassed by the historian Bernard Diaz. According to him, Emperor Montezuma used to drink a cup of the precious elixir before crossing the threshold of his harem. Even Casanova and the Marquis de Sade did not forget this elixir.

Chocolate is a special group of sugary products made from cocoa beans, sugar, milk, hazelnuts, nuts. It is distinguished by a particularly fine and pleasant taste and aroma. Chocolate has a higher nutritional value (500-600 calories per 100 g) than other sugary products whose value is between 300-400-500 calories per 100 g. In addition to the fatty substances, carbohydrates and proteins that constitute the basis of food, chocolate also contains small amounts of theobromine, caffeine, organic acids, among which the oxalic one is in greater quantity, tanning substances, pigments, essential oils, lecithin, substances minerals[9-13].

Basic raw materials and auxiliary materials are used in the manufacture of sugary products (chocolate). So:

(a) The basic raw materials are: sugar, glucose, invert sugar (a mixture of equal parts of glucose and fructose), used for the total or partial replacement of glucose, powdered milk, concentrated milk (used to obtain milk candies and caramels), fats (cow butter, cocoa butter, margarine).

(b) Auxiliary raw materials are the following: starch, fruit (in the form of jams or pastes for fillings, in the form of candied fruit, fruit in alcohol), fatty kernels of some fruits (walnut kernels, hazelnuts, apricots, peanuts), seeds oleaginous (sunflower, sesame) used to obtain halvah, lecithin (used in the manufacture of chocolate, as an emulsifier), agar-agar (gelling substance extracted from certain seaweeds, used to obtain jellies), food acids (citric, tartaric), flavors (natural and synthetic) used for flavoring sugary products[13-20].

MATERIAL AND METHODS

In this article we studied pure chocolate with 100% cocoa without lecithin or traces of milk in the form of chocolate chips. The chocolate was heated in a water bath with a TC-650 type thermostat and the viscosity was determined with the DV-3P rotary viscometer.

RESULTS AND DISCUSSION

Figures 1-5 represent linearization of rheograms of chocolate samples in the range of temperatures at which they were studied.

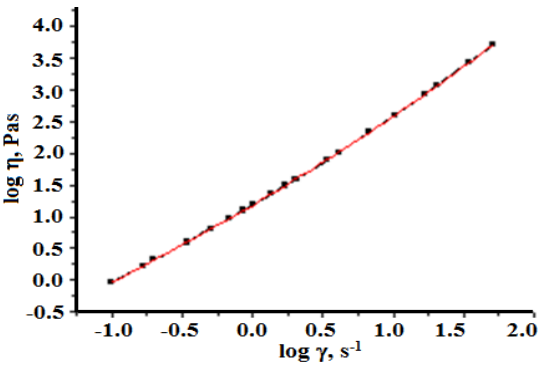

Fig. 1. Linearization of curve at temperature of 36°C

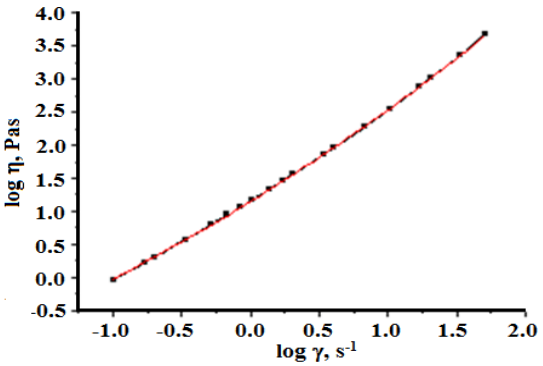

Fig. 2. Linearization curve at temperature of 38°C

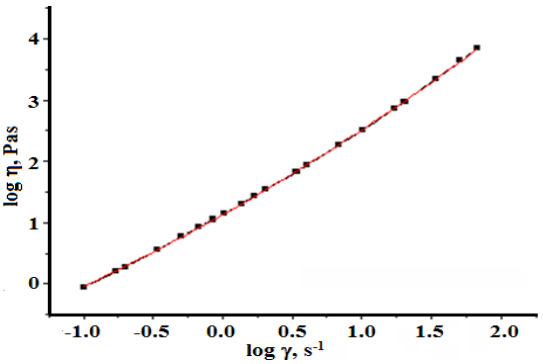

Fig. 3. Linearization of curve at temperature of 40°C

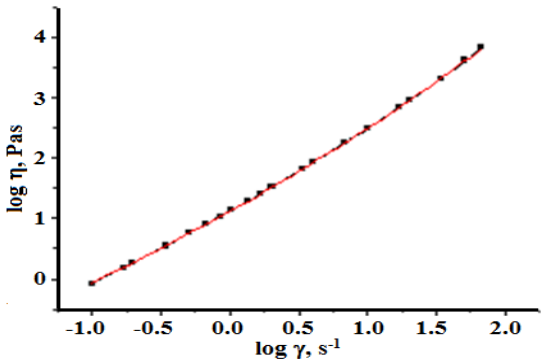

Fig. 4. Linearization of curve at temperatureof 42°C

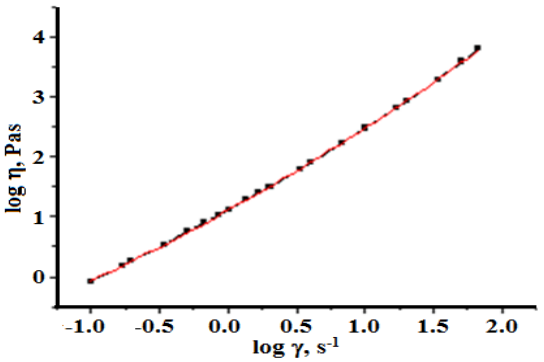

Fig. 5. Linearization of curve at temperature of 44 °C

By linearizing the rheograms at a temperature of 36 degrees Celsius, a second-order exponential equation is obtained with the parameters A, B, C, D and the correlation coefficients r^2:

$$\eta = 0 + A\exp(-\log\gamma/-B)-C\exp(\log\gamma_0/-D) \quad (1)$$

The parameters of the formula by η=0+ Aexp(-logγ/-B)-Cexp(logγ_0/-D) are given in Table 1.

Table 1: Parameters formula $\eta = 0+A\exp(-\log\gamma/-B)-C\exp(\log\gamma_0/-D)$

Temperature,°C	Parameters formula $\eta = 0+A\exp(-\log\gamma/-B)-C\exp(\log\gamma_0/-D)$					
	η	A	B	C	D	r^2
36	0	8.97702	-6.90885	-7.79546	-6.77266E98	0.99998
38	0	8.01267	-6.26559	-6.86225	-8.13906E128	0.99997
40	0	7.97132	-6.25213	-6.83903	-6.01613E126	0.99996
42	0	8.10352	-6.36933	-6.98847	-7.98198E125	0.99995
44	0	8.40778	-6.61737	-7.30339	-3.64452E132	0.99992

By linearizing the rheograms at a temperature of 36 degrees Celsius, a polynomial formula is obtained with the parameters A, B and C and the correlation coefficients r^2 [13]:

$$\log\eta = A+B\log\gamma+C\log\gamma^2 \quad (2)$$

The parameters of the formula log η A+B logγ+C logγ^2 are given in Table 2.

Table 2: Parameters formula log $\eta = A+B\log\gamma+C\log\gamma^2$

Temperature, °C	Parameters formula log η = A+Blogγ+C logγ			
	A	B	C	r^2
36	1.18027	1.30368	0.09853	0.99996
38	1.14892	1.28409	0.1074	0.99994
40	1.1303	1.28027	0.10845	0.99992
42	1.1132	1.27747	0.10598	0.99991
44	1.10281	1.27560	0.10138	0.99988

CONCLUSION

Chocolate has a non-Newtonian behavior in the temperature range in which it was studied. The two equations that describe the rheological behavior of chocolate have correlation coefficients close to unity. In this article we studied chocolate with 100% cocoa without lecithin and traces of milk in the form of chips. The data obtained are in accordance with those obtained from the specialized literature.

ACKNOWLEDGMENT

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interest

The author declare that we have no conflict of interest.

REFERENCES

1. Wells M., *Science and Technology of Enrobed and Filled Chocolate, Confectionery and Bakery Products*, **2009**, 255-284. Woodhead Publishing.

2. Bahari A., & Akoh C.C., *Lwt.*, **2018**, *97*, 349-354.
3. Garti N., & Aserin A., *Cocoa butter and related compounds.*, **2012**, 275-305). AOCS Press.
5. Manasi I., *Structural basis for the rheology of molten chocolate: a multi-technique approach* (Doctoral dissertation, University of Edinburgh)., **2019**.
6. Stanciu I., Some methods for determining the viscosity index of hydraulic oil, *Indian Journal of Science & Technology.*, **2023**, *16*(4), 254-258.
7. Stanciu I., Rheological behavior of corn oil at different viscosity and shear rate., *Orient. J. Chem.*, **2023**, *39*(2), 335-339.
8. Stanciu I., Rheological characteristics of corn oil used in biodegradable lubricant, *Orient. J. Chem.,* **2023**, *39*(3), 592-595.
9. Stanciu I., Effect of temperature on rheology of corn (Zea mays) oil., *Orient. J. Chem.,* **2023**, *39*(4), 1068-1070.
10. Afoakwa E. O.; Paterson A., & Fowler M., *European Food Research and Technology.*, **2008**, *226*(6), 1259-1268.
11. Stanciu I., *Oriental Journal of Chemistry.*, **2021**., *37*(1), 247-249.
12. Stanciu I., Orient. J. Chem., **2021**, *37*(2), 440-443.
13. Stanciu I., Orient. J. Chem., **2021**, *37*(4), 864-867.
14. Ziegler G. R.; Mongia G., & Hollender R., *International Journal of Food Properties.*, **2001**, *4*(2), 353-370.
15. Maheshwari B., & Yella Reddy S., *Journal of the Science of Food and Agriculture.*, **2005**, *85*(1), 135-140.
16. Blanco E.; Hodgson D. J.; Hermes M.; Besseling R.; Hunter G. L.; Chaikin P. M., & Poon W. C., *Proceedings of the National Academy of Sciences.*, **2019**, *116*(21), 10303-10308.
17. Afoakwa E. O.; Paterson A.; Fowler M., & Vieira J., *International Journal of Food Science & Technology.*, **2009**, *44*(1), 162-167.
18. Stanciu I., *Journal of Science and Arts.*, **2019**, *3*(48), 703-708.
19. Stanciu I., *Journal of Science and Arts.*, **2019**, *4*(49), 938-988.
20. Stanciu I., *Journal of Science and Arts.*, **2011**, *1*, 55-58.
16. Stanciu I., *Journal of Science and Arts.*, **2018**, *18*(2), 453-458.