**Таблица 2 – Фракционный состав помадной массы с использованием синбиотического комплекса**

| Размеры кристаллов, мкм | Содержание фракций кристаллов различных размеров, % | | | |
|---|---|---|---|---|
| | Контроль | 5 % лактулозы и пробиотические микроорганизмы | 7,5 % лактулозы и пробиотические микроорганизмы | 10 % лактулозы и пробиотические микроорганизмы |
| 0 – 5 | 31,5 | 42 | 45,5 | 54 |
| 5 – 10 | 22,5 | 30 | 34 | 38 |
| 10 – 15 | 14 | 16 | 17 | 6 |
| 15 – 20 | 8 | 9 | 3 | 2 |
| 20 – 25 | 7 | 2 | 0,5 | – |
| 25 – 30 | 6,5 | 1 | – | – |
| 30 – 35 | 5 | – | – | – |
| 35 – 40 | 3,5 | – | – | – |
| 40 – 45 | 2 | – | – | – |

Увеличение дисперсности помадных масс с добавлением синбиотической добавки по отношению к контрольному образцу можно объяснить тем, что в опытные образцы вводится лактулоза, которая является редуцирующим сахаром, в результате чего происходит замедление кристаллизации сахарозы. Лактулоза снижает скорость обмена молекул сахарозы на границе зародыш — раствор путем повышения энергии активации молекул.

Таким образом, в результате проведенных исследований можно сделать вывод, что использование в составе помадных конфет синбиотической добавки приводит к улучшению вязкостных свойств помадной массы, увеличивает дисперсность, что, в свою очередь, улучшает качество готовых изделий и способствует расширению ассортимента конфет. Также очевидно, что обогащение функциональных пищевых продуктов пробиотиками, пребиотиками и их синбиотическими комплексами представляет собой научно обоснованное и перспективное направление в индустрии функциональных кондитерских изделий.

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# COMPARATIVE RHEOLOGICAL CHARACTERISTICS OF WAFER FILLINGS WITH SUGAR AND FRUCTOSE

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*Viscosity is the main index characterizing the properties of fillings in wafers formation. The viscosity of fillings is defined to a great extent by the recipe composition, as well. In order to determine the effect of fructose upon this index, a comparative characteristics between the rheological properties of wafer fillings obtained by using crystal fructose and sugar, respectively, has been made. It has been established that fructose filling has a strongly expressed tixotropic properties, and at temperatures of 50°C its viscosity increases.*

Key words: Rheology, waffles, fructose, low-calorie products

**INTRODUCTION**

Diets have been and remain the primary method for treating diseases such as obesity, diabetes and others. Sugar-free diet is required, especially for people suffering from different types of diabetes (Type I and Type II). Its disruption leads to exacerbation of this disease. Since diabetes is defined as a disease of the century, it is important to insure prevention with creation of sweet taste foods without sucrose.

Currently, for the production of diet food are used sweeteners with different origin and chemical composition. It is considerate that between all alternative sweeteners fructose is one of the most perspectives sugar-alternatives. It has insulin independent metabolism and it is recommended for consumption for diabetes suffering people in amount of 0,5-1,0 g per kg of body weigh.

One of the main representatives of confectionary are dough waffles. Still today, in Bulgaria their production takes significant stake in the nomenclature of confectionery. The variety of assortment structure of these products is defined mainly by the use of different types of praline and oil fillings. Whatever is the type of filling, the basic raw material for its preparation is sucrose. (Sugar is still the most popular staple with sweet taste). Besides the sweet taste, principle reason for its application in production of sweet taste foods, are its specific technological properties. For example for preparation of praline felling in traditional waffles sucrose is the main-structure component.

Over the last 20-25 years in the manufacture of confectionery, including curtains types of wafer fillings crystalline fructose has been applied. Characteristics and composition of crystalline fructose intended for consumption are regulated by statutory food low [4].

Relative sweetness of fructose is 1,3-1,7 times higher than that of sucrose. Therefore, some experts recommend it for application in sweet taste food production in order to reduce the sucrose content [1]. Energy value of fructose (4 kcal/g) is equivalent of that of sugar, but its metabolism is insulin independent and can be used in production of sweets for diabetes suffering people. Crystalline fructose is very hygroscopic. In practice this quality may cause some technological problems [6], like agglomeration of crystals in production of chocolate mass with fructose.

Main indicators characterizing properties of wafer fillings in forming technological operation is viscosity. It depends on various factors (temperature, humidity, etc.). To certain extent viscosity of wafer fillings is defined by the recipe composition [2].

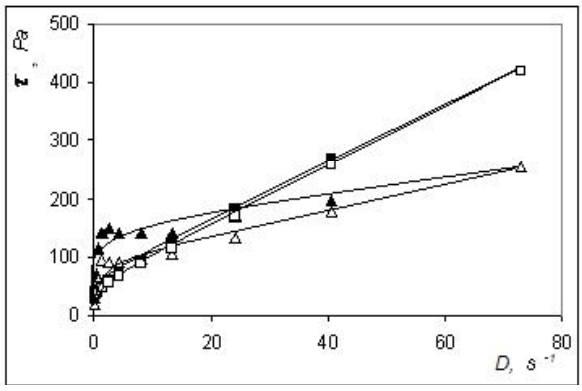
In this context aim of this study is to determine the influence of crystalline fructose on rheological properties, respectively on viscosity on wafer fillings.

**MATERIALS AND METHODS**

To determine the effect of fructose on rheological properties of wafer fillings, are used wafer filling prepared in manufacturing conditions. Comparative characterization is carried out between rheological properties of wafer fillings prepared with fructose and sucrose. Rheological behavior of molten wafer fillings was analyzed by «Rheotest 2» (Germany).

**RESULTS AND DISCUSSION**

On fig.1 are represented rheograms of wafer fillings at 40 °C.




▲ – *with fructose, in direction of increasing D;* △ – *with fructose in direction of D;*
■ – *with sucrose in direction of increasing D;* □ – *with sucrose in direction of reducing D*

**Fig.1 – Reograms of wafer fillings with fructose and sucrose**

Analyses were performed by determining the tangential stress ( $\tau$ ) in the direction of increasing values of the velocity gradient (D) in the range of 0,17 to 72,9 s-1 and in direction of reduction of D. Graphical correlation shows that the product with fructose demonstrates rheological behavior of non ideal plastic body which is also characteristic for wafer filling prepared with sucrose. Furthermore, curves of outflow for the sample prepared with fructose show significant hysteresis which indicates the presence of thixotropy.

Values of coefficients of thixotropy are calculated by the method proposed by Machihin and Birfeld [3] and are shown in table 1.

**Table 1 – Coefficients values of thixotropy of waffle fillings with different velocity gradients**

| Velocity gradient *D* ($s^{-1}$) | Coefficient of thixotropy according with type of filling | |
|---|---|---|
| | With fructose | With sucrose |
| 1,5 | 1,49 | 1,07 |
| 4,5 | 1,53 | 1,06 |
| 13,5 | 1,33 | 1,07 |
| 24,3 | 1,30 | 1,07 |
| 40,5 | 1,11 | 1,05 |

Results in table 1 show that the wafer filling prepared with fructose demonstrates higher values of the coefficient of thixotropy, compared with wafer filling prepared with sucrose which is perhaps due to structure forming processes.

On figure 2 are presented correlations between viscosity values of wafer fillings and their velocity gradient.

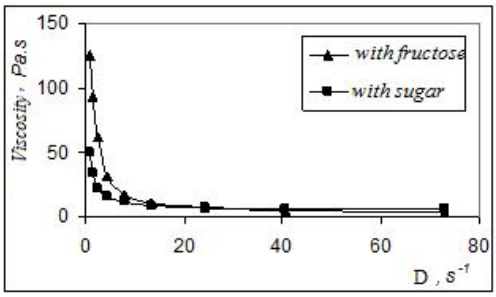



**Fig 2 – Viscosity of wafer fillings with fructose and sucrose depending the velocity gradient at 40 °C**

The data in Fig. 2 shows that at low values and in small changes in interval velocity gradient, the viscosity of fillings for wafers significantly reduced, while at higher values of D this change is negligible. This correlation is more demonstrative in wafer filling with fructose. For example, when amending the velocity gradient in the range of 1,5 to 8,1 s-1 the viscosity of the filling with fructose decreased by 81.5 %, and for this with sugar, the reduction was 65.2 %. When amending D in high values of 40,5 to 72,9 s-1, the decrease in viscosity of the filling with fructose is 28.5 % and with sugar is 13.6 %. This example shows that with increasing values of the velocity gradient, the degree of destruction of the filling with fructose is higher.

Correlation between viscosity at 40°C and velocity gradient is determinated by following equation [5]:

$$\eta = B.D^{-m} \tag{1}$$

where: $\eta$ – viscosity,*Pa.s;*

$B$ – viscosity, when $D = 1\ s^{-1}$, *Pa.s*;

$D$ – velocity gradient, $s^{-1}$;

$m$ – pace of destruction of structure

Calculated values of coefficients for different types of wafer filling (in the range of velocity gradient D from 0,9 to 72,9 $s^{-1}$) are presented in table 2.

Relatively high values of correlation coefficient (Table 2) show that the viscosity of the fillings is sufficiently subject to the mathematical model / 1 /. It has been determined also the relationship between viscosity and temperature for analyzed wafer fillings (Fig. 3). Samples were annealed at appropriate temperature for 20 min.

**Table 2 – Values of coefficients in equation 1 and values of coefficient of correlation (r)**

| Type of wafer filling | Coefficients | | |
|---|---|---|---|
| | *B* | *m* | *r* |
| With fructose | 21,230 | 0,8706 | 0,9947 |
| With sucrose | 37,964 | 0,4910 | 0,9808 |

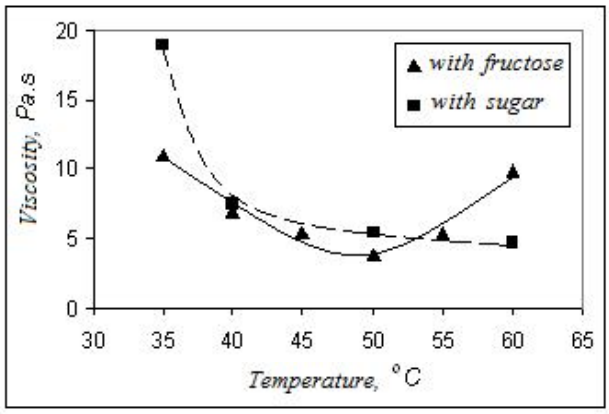



**Figure 3 – Correlation between viscosity and temperature of wafer fillings with fructose and sucrose in (D = 24, 3 $s^{-1}$ )**

Graphically strong correlation indicates that with increasing temperature ( in range 35 to 60 °C) viscosity of the filling for waffles with sugar decreases while that of fructose at temperatures above 50 °C began to increase. It is likely that in the process of equilibration of the sample occur changes in its structure, due primarily to crystalline fructose.

**CONCLUSIONS**

From the survey results following conclusions can be made:

1. It has been shown that the filling for wafers with fructose has considerably more pronounced thixotropic properties compared with those of sugar filling.

2. It was found that with increasing temperature ( in range 35 to 60 °C) viscosity of the filling for waffles with sugar decreases while that of fructose at temperatures above 50 °C began to increase.

3. It is recommended that during the various processes in the production of fillings for wafers with crystalline fructose to be used at temperatures higher than 50°.

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