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Investigation of syneresis of agar jellies with sorbitol

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In the process of storing jellies, an effect called syneresis occurs, which appears as a separation of low-molecular-weight liquid on their surfaces. As an index characterising the quality of jelly-like systems, the syneresis of agar jellies has been investigated with the purpose of creating a suitable composition for the production of jelly products, designed for diabetic patients and nutrition.

The influences upon syneresis of storage duration, dry-matter quantity, and agar in the jelly have been investigated. A regression equation of an exponential type has been obtained, expressing syneresis-dependence on dry-matter content and agar in the jelly. An optimal composition has been determined in which agar jellies made with sorbitol show the least tendency towards syneresis.

INTRODUCTION

As a sugar-substitute in sugar products, sorbitol is widely used by diabetics. The difficulty created by sorbitol in the process of jelly-formation is one of the reasons that limit the production of agar-jelly products.

According to Marshalkin *et al.* (1978) etc. jellies represent concentrated solutions of high-molecular-weight compounds that possess the properties of semi-solid bodies. These properties result from a space-network formation built from the chain macromolecules.

It has been established that the formation of the space network of agar jellies depends on the sweetener type, some types considerably hindering this process (Dodson & Wright, 1982).

In the process of jelly storage, there appears a separation of low-molecular-weight liquid on the surface, the so-called syneresis (Marshalkin *et al.*, 1978). It is supposed that the main reason for syneresis lies in the lack of equilibrium in the structure, owing to the formation of new connections among macromolecules.

Up to the present, there have been hardly any data quantifying agar jellies' tendencies to syneresis. This is even more true for the agar jellies that contain sugar substitutes. The syneresis is one of the indices that give an accurate characteristic of the jelly-like system.

The purpose of this study is to investigate the syneresis of agar jellies with sorbitol, with the purpose of creating a suitable composition for jelly products designed for diabetics and nutrition.

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MATERIALS AND METHODS

There are different methods for the quantitative determination of syneresis. In most of them, the value of syneresis is determined by the quantity of water separated on the jelly surface, whether stimulated or spontaneous.

In the first group of methods, a definitive type of loading (static or centrifugal) is applied, after which the quantity of the liquid separated is measured (Grau & Hamm, 1953; Hermanson & Lusisano, 1982). The product is deformed, and it is not known whether syneresis stimulation is due totally to equilibrium establishment or partially originates from the internal-structure change within the product investigated.

In the second group of methods, the quantity of the separated water can be determined by using the capillary effect in pumping liquids from porous bodies (Hoffmann, 1975; Labusa & Lewicki, 1978; Panchev, 1990).

In order to determine the agar jellies' syneresis with sorbitol, the method of Panchev (1990) is used, in which the water separated on the surface of the jelly is absorbed by a cellulose acetate filter called Filamen and is determined by weighing. The quantitative measure of the syneresis determined by means of this method is the ratio between the quantity of separated water and the weight of the jelly expressed as a percentage.

Jellies have been prepared with 98·7% pure sorbitol and a moisture content of 2·6%.

A mathematical model of the quantitative expression of syneresis after five days has been compiled by using

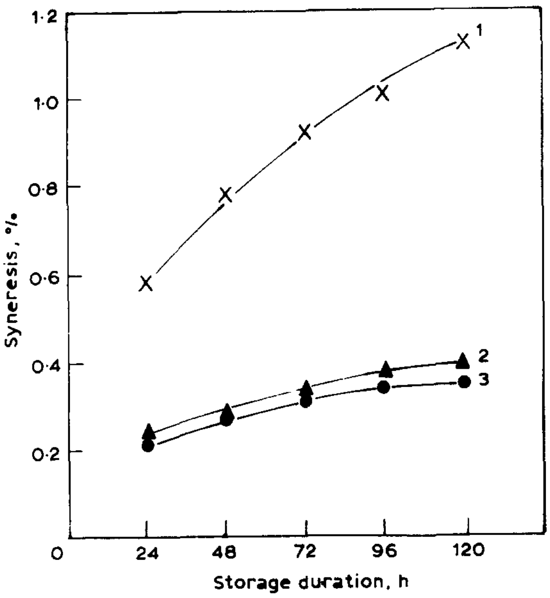

Fig. 1. Dependence of syneresis value on storage duration of jellies with 55% dry matter and prepared with: (1) 1·0%; (2) 1·5%; and (3) 2% of agar.

the composition plan of Box-Wilson (Vuchkov & Stoyanov, 1986).

RESULTS AND DISCUSSION

Syneresis is a process that basically depends on the structure of the jelly (i.e. on the quantity and type of the gelling agent and the dry-matter content). With the purpose of creating a suitable composition for the production of agar jelly (with sorbitol) of high quality, the influence of agar quantity and dry matter upon syneresis value, as an index, was investigated. A functional dependence of the syneresis value, y, on the independent factors x_1 and x_2 has been obtained, where

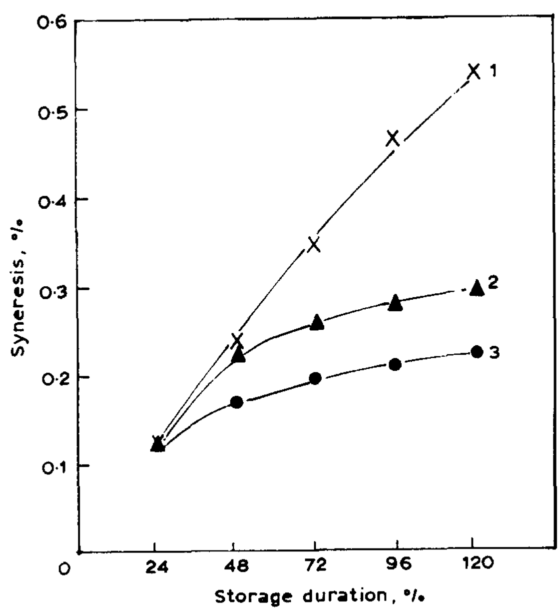

Fig. 2. Dependence of syneresis value on storage duration of jellies with 65% dry matter and prepared with: (1) 1·0%; (2) 1·5%; and (3) 2% of agar.

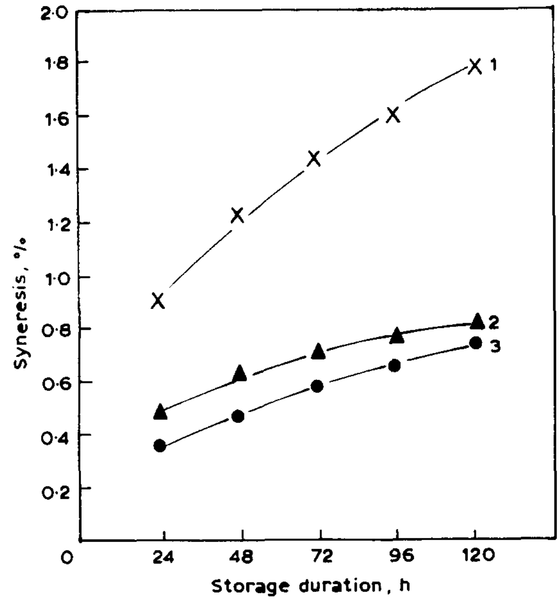

Fig. 3. Dependence of syneresis value on storage duration of jellies with 75% dry matter and prepared with: (1) 1·0%; (2) 1·5% and (3) 2% agar.

x_1 = dry-matter content (%), and x_2 = agar content (%).

Practice has shown that sugar jellies of high quality can be produced in agar (0·8–2·0%) with a dry-matter content of 75–77%. On this basis, agar jellies with sorbitol have been prepared and analysed. The following levels of factors: x_1 = 55–75%, modulus 10, x_2 = 1·0–2·0%, modulus 0·5, have been accepted.

The results obtained expressed graphically are shown in Figs 1, 2 and 3.

From the data in Fig. 1, it can be seen that, by increasing the agar quantity, the jelly's tendency to syneresis decreases. A comparatively high syneresis is shown by the sample containing 1% agar, and jellies prepared with 1·5 and 2·0% of agar have values close to these. This dependence is also characteristic of the samples with dry-matter contents of 65 and 75% (Figs 2 and 3).

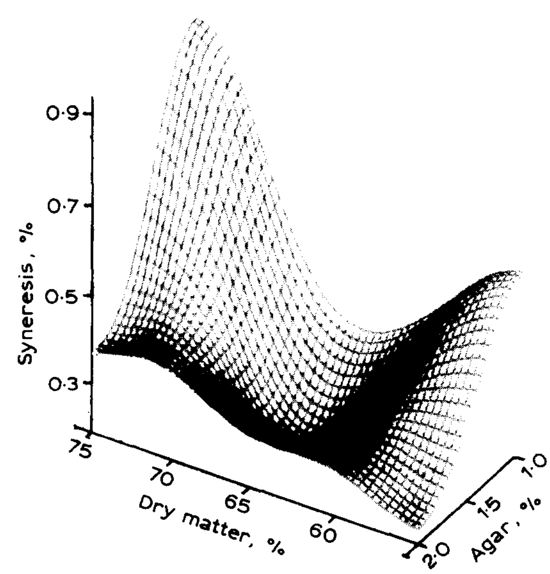

Fig. 4. Relationship between syneresis value, dry-matter content, and agar after one day.

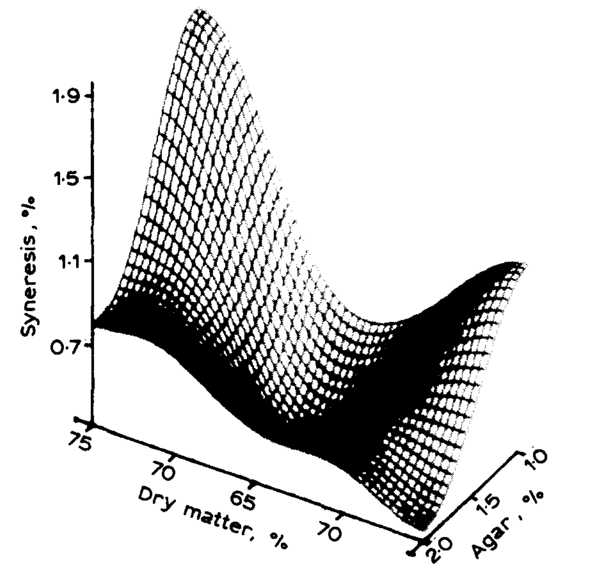

Fig. 5. Relationship between syneresis value, dry-matter content, and agar after five days.

The dependence of syneresis on dry-matter content and different quantities of agar is shown in Figs 4 and 5. The graphs show a strongly expressed tendency to syneresis in jellies with a dry-matter content of 75%. From the figures, it can be seen that jellies having a dry-matter content of 65% show the lowest syneresis values.

From the connection between syneresis and dry-matter content and agar in the jelly and by using the matrix of experimental planning (Table 1) and the results from the statistical processing of experimental data for the syneresis after five days, the following equation has been obtained:

$$y = \exp(35{\cdot}5873 - 1{\cdot}0074x_1 - 5{\cdot}9438x_2 + 0{\cdot}0153x_1x_2 - 0{\cdot}0078x_1^2 + 1{\cdot}3196x_2^2)$$

By means of Student's t-test the dependence of all coefficients has been verified. The adequacy of the equation obtained has been checked by Fisher's test, the value f_h being 0·92. At a confidence level of α = 0·05 and degrees of freedom of $k_1 = 3$ and $k_2 = 5$, the statistical criterion of Fisher is $f_{kp} = 5{\cdot}41$, and consequently the equation is adequate.

In investigating the equation according to the classical procedure for finding the extreme of a function, it has been determined that the absolute minimum value is $y_{min} = 0{\cdot}198\%$ and can be obtained at $x_1 = 62{\cdot}7\%$ and $x_2 = 1{\cdot}9\%$.

Theoretically, the optimal values determined for both factors have also been experimentally checked. The jelly prepared for that purpose with a dry-matter content of 62·50% and agar of 1·8% shows a quantitative value of syneresis of 0·21%. By using the values for both of these factors , the calculated syneresis (by the equation) is 0·20%.

Table 1. Matrix of experimental schedule and experimental results of syneresis after five days

N	x_0	x_1	x_2	x_1x_2	x_1	x_2	y	$\hat{y}$
1	+	+	+	+	+1/3	+1/3	0·745 4	0·756 2
2	+	+	−	−	+1/3	+1/3	1·778 2	1·750 0
3	+	−	−	+	+1/3	+1/3	1·122 9	1·062 7
4	+	−	+	−	+1/3	+1/3	0·346 8	0·338 3
5	+	+	0	0	+1/3	−2/3	0·826 4	0·827 1
6	+	−	0	0	+1/3	−2/3	0·398 3	0·431 1
7	+	0	+	0	−2/3	+1/3	0·229 1	0·231 3
8	+	0	−	0	−2/3	+1/3	0·581 2	0·623 6
9	+	0	0	0	−2/3	−2/3	0·296 8	0·273 1

CONCLUSIONS

1. The regression equation obtained can be used for forecasting the quantitative expression of syneresis in agar jellies with sorbitol.
2. An optimal composition has been determined at which the jelly-like system shows the least tendency towards syneresis, and it can be obtained with a dry-matter content of 62·7% and an agar of 1·9%.

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