Investigation of viscosity of whole hydrolyze sweetened condensed milk

Olena Kalinina, Oleksandr Kovalenko, Olga Kornilova

Luhansk national agrarian university, Lugansk, Ukraine

Keywords:

Milk
Viscosity
Hydrolyze
Stabilizer

Article history:

Received 20.01.2014
Received in revised form
14.02.2014
Accepted 16.04.2014

Corresponding author:

Olena Kalinina
E-mail:
kalinina-elena@mail.ua

Abstract

Introduction. Paper is aimed at developing of low-lactose (hydrolyzed) sweetened condensed milk products technology for lactose intolerant people and for the whole population.

Materials and methods: Rheological characteristics were determined on a Reotest device by the 2nd method of viscometry

Results and discussion. Reasonability of ß-galactosidase use for milk lactose hydrolyze during the production of canned products with sugar was proved in the previous works. This technology gives possibility to increase the quality of condensed canned foods, to reduce sugar concentration till 50 %, to increase dietary properties. Due to the reducing of saccharose mass part till 22 and 31 % the products had a liquid consistency that's why was a necessity to increase the viscosity properties of condensed products.

One of method to increase the product viscosity is inoculation of stabilization systems. Reasonability of the usage of stabilization system Bivicioc 1L was proved. The researches of viscosity determination in whole hydrolyzed sweetened condensed milk were shown in the work. Relations of viscosity of whole hydrolyzed condensed milk to the deformation rate were presented.

Conclusions Viscosity indices of experimental samples in the fresh produced products and during storage are determined and justified.

Introduction

Due to the high biological value and good storage ability condensed milk products with sugar are widely used in human nutrition.

However, the defects of consistency as "mealy" and "grainy" that reduce the quality of products are often seen. Surplusage of sugar can be a risk factor for predisposition to diabetes and lead to excessive weight.

A part of the world population cannot consume milk, which is associated with insufficient or lack of ß-galactosidase enzyme in the human digestive tract, which leads to disruption of its work and discomfort.

Enzymatic hydrolysis of lactose makes it possible to develop a technology of dairy products with reduced lactose content [1-4]. Low-lactose products are considered as functional food products for people with lactose intolerance and it allows you to extend the range of dairy products, improve the organoleptic characteristics of the product, excluding the possibility of crystallization of lactose in the hydrolysed sweetened condensed milk during storage. During enzymatic hydrolysis, lactose is split into monosaccharides glucose and galactose, the organoleptic characteristics are changed and depending on the level of lactose hydrolysis the increase of sweetness of milk is took place that makes it possible to reduce the concentration of sucrose in the formulations of condensed milk products with sugar. New samples of hydrolyzed sweetened condensed milk products were proposed and developed in the production laboratory of Luhansk National Agrarian University and the technological properties were studied, Table 1.

Table 1

Characteristics of skim milk and whole hydrolyzed sweetened condensed

A title of the product	**Mass part of sucrose,** %	**Mass part of dry materials of milk,** %	**Mass part of dry materials of product,** %	**Effective viscosity,** *Pa·s*
Whole sweetened condensed milk (control)	43,5	28,5	72,0	3,6±0,2
Whole hydrolysed sweetened condensed milk	31,0	28,0	59,0	1,2±0,1
Whole hydrolysed sweetened condensed milk	22,0	37,0	59,0	1,6±0,1

With decreasing mass part of sucrose in the formulation of condensed sweetened canned products the consistency of the product with a mass part of 59% dry materials had a liquid consistency. To increase the viscosity properties of hydrolyzed sweetened condensed milk the stabilizer systems MAKGEL 11 and Bivicioc 1L have been recommended and used in many sectors of the food industry and, in particular, for condensed sweetened canned milk products.

At the same time, several functions perform: to provide the formation of uniform, stable fat emulsion, which is protected from destruction; the ability to reduce the mass part of fat in the product without deterioration of quality; the chemical bonding of water molecules are provided that help to extend the shelf life of products and reduce the migration of moisture from the product into the packaging etc. The mechanism of action of stabilizers is based on the ability to bind the moisture at coming into the food system, as a result of which the latter loses its mobility and thus altering the viscosity and consistency.

At first, theirs technological properties were studied in the laboratory conditions, in a production laboratory of Luhansk National Agrarian University and then samples worked out on JSC "Troitsky MDZ" Luhansk region. Determination of rheological properties of hydrolyzed condensed products were performed at a storage temperature of 6-10 ºC.

Materails and methods

Rheological characteristics were determined on a Reotest device by the 2nd method of viscometry [5].

Before the measurements, an appropriate index of measuring device was selected. The required amount (30 cm^3) of product charged into the measuring cylinder. The principle of measurement was as follows: under the action of the rotor one layer of product is shifted relative to another one. Measurements began to conduct at low rates of speed deformation increasing it gradually, by increasing the frequency of rotation of the measuring cylinder. The required frequency rotor speed was asked by the switching drive and by installing lever in position stage 1a to 12 a. The rheological characteristics of the product were determined according to the rotor speed (velocity gradient) and the resistance force of its rotation.

Shift stress τ (Pa) was determined by the formula:

$$\tau = Z \cdot \alpha, \quad (1)$$

Z - constant of cylinder, Pa / unit. scale of the instrument;
α – indexes of device.

Effective viscosity of experimental samples is determined by the formula:

$$\eta_{эф.} = \tau / D \cdot 100, \quad (2)$$

τ – shift stress, Pa;
D – shift rate, s^{-1}

Research task - increasing the viscous properties of hydrolyzed sweetened condensed milk products by using stabilization systems.

Results and discussion

Stabilization systems - Makgel K11 and BIVICIOC 1L are created on the base of polysaccharides of natural origin, which fulfill a useful role related to their molecular architecture, size and the presence of intermolecular interactions due to hydrogen ties. And moreover, they are important (such as food fibers) for the normal functioning of the human organism.

The results of experiments have showed that 11 MAKGEL is poorly soluble in milk, with the changes the color of the product, giving it a grayish hue, which adversely affects the organoleptic characteristics and the products did not meet the regulatory requirements. When using Bivicioc 1L the adverse effects were not revealed in the final product (almost 100% of solubility is achieved and the color of the product is not changed). Therefore it was decided to continue to use the stabilization system Bivicioc 1L. The series of experiments have been conducted with whole milk to determine the mass part of Bivicioc 1L, wherein into the raw material prepared in advance, respectively with technological scheme of production of hydrolyzed milk the stabilizing system was inoculated at an amount of 0.2, 0.4, 0.6, and 0.8 % of weight of the finished product. Enzymatic hydrolysis was conducted under the influence of GODO-YNL2 preparation at activity of 5000

NLE/sm^3. Hydrolysed milk was headed for inactivation of the enzyme at a temperature of 75... 80 ºC [6-8].

As evidenced by the data shown in Fig. 1, the dependence of the effective viscosity of the products is non-linear: an increase in the mass part of the stabilizer increases the effective viscosity products. Effective viscosity of whole fresh hydrolyzed condensed milk with mass part 31% is sucrose and stabilizer is 0,2% - 2,9 ± 0,1 Pa·s (the product had a liquid consistency, not peculiar to the skim sweetened condensed milk during storage can occur stratified fractions), a further increase of the mass part of the stabilizer cause even more substantial increase of viscosity up to 5,5 ± 0,3 Pa·s, which is not typical for whole sweetened condensed milk (a sharp increase of viscosity is possible during storage, the product may have a " thickening " defect).

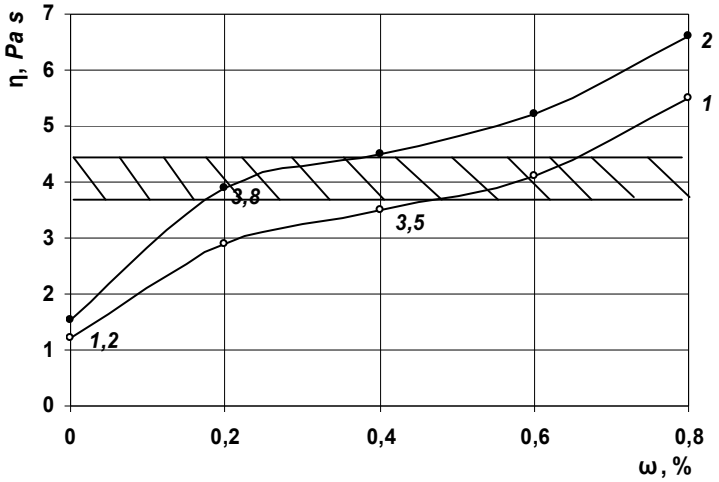

Fig. 1. Dependence of the effective viscosity of whole hydrolyzed sweetened condensed milk upon mass part of stabilizer:

1 - whole hydrolyzed sweetened condensed milk with mass part 59%, sucrose is 31%,

2 - whole hydrolyzed sweetened condensed milk with mass part of 59% dry materials, 22% is sucrose.

Dependence of the effective viscosity of the experimental samples of whole sweetened condensed milk and mass part of 59% dry materials of different amounts of the stabilizer on the deformation rate, Fig. 2 and 3.

As have been mentioned in the research, the recommended viscosity for the production - 3.5…4.1 Pa·s with a mass fraction of the stabilizer 0.4...0.6 % for whole hydrolyzed condenced milk with a mass part of sucrose 31% and 3.8...4.5 Pa·s and mass part of the stabilizer of 0.2...0.4 % by weight of the finished product to a whole hydrolyzed condensed milk with a mass part of 22% sucrose.

For further research the minimum mass part of stabilizer was selected.

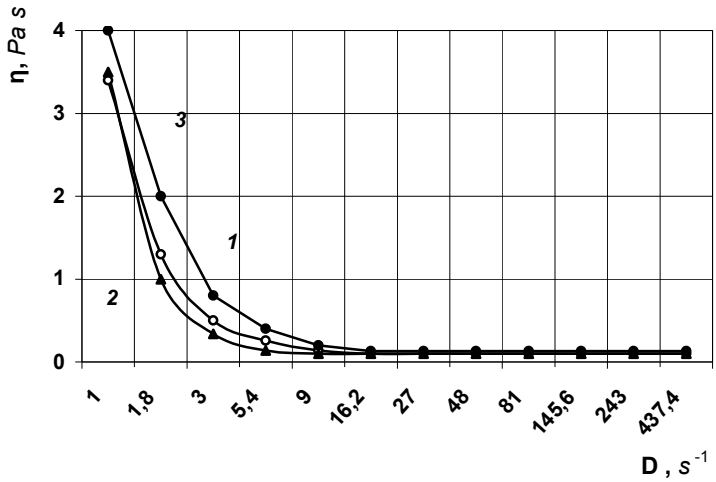

Fig. 2. Dependence of the effective viscosity of whole hydrolyzed sweetened condensed milk upon deformation rate:

1 – whole condensed sweetened milk (control);

2 - whole hydrolyzed sweetened condensed milk with mass part 59% of dry substances, 31% is sucrose, the mass fraction of the stabilizer is 0 4% by weight of the product;

3 - whole hydrolyzed sweetened condensed milk with mass part is 59% dry materials, 31% is sucrose, the mass part of the stabilizer is 0.6 % by weight of the product.

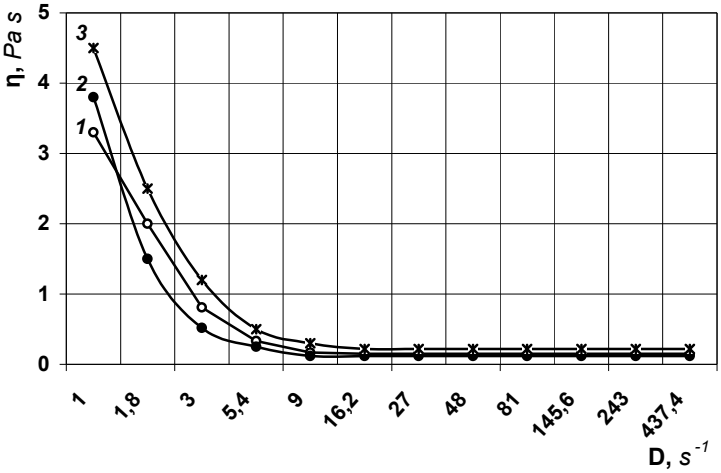

Fig. 3. Dependence of the effective viscosity of whole hydrolyzed sweetened condensed milk upon deformation rate:

1 – whole condensed sweetened milk (control);

2 - whole hydrolyzed sweetened condensed milk with mass part 59% of dry materials, 22% is sucrose, the mass part of the stabilizer is 0.2 % by weight of the product;

3 - whole hydrolyzed sweetened condensed milk with mass part 59% of dry materials, sucrose is 22 % mass part of stabilizer is 0.4% by weight of the product.

For all of experimental samples with increasing strain rate (from 1 to 16.2 s^{-1}) the effective viscosity decreases. And that particularly intensively the viscosity decreases in the range of low deformation rates up to 5.4 s^{-1}, while the structure of the product breaks down and shows the greatest strength. With increasing deformation rate the viscosity decreases sharply. At higher deformation rate of 5.4 s^{-1} a structure of the product is destroyed, the indexes of viscosity is lowering and changing inconsequently. According to the investigations which have been put into practice (Fig. 2 and 3) you can make specifications for hydrolyzed sweetened canned milk products, the results are presented in the Table 2.

Table 2

Characteristics of whole hydrolyzed sweetened condensed milk

A title of the product	**Mass part of sucrose,** %	**Mass part of dry milk material** %	**Mass of dry product materials,** %	**Mass part of stabilizer** %	**The effective viscosity of fresh condensed mixture,** *Pa·s*
Whole sweetened condensed milk (control)	43,5	28,5	72,0	–	3,6±0,2
Whole hydrolyzed sweetened condensed milk	31,0	28,0	59,0	0,4 0,6	3,5±0,2 4,1±0,2
Whole hydrolyzed sweetened condensed milk	22,0	37,0	59,0	0,2 0,4	3,8±0,2 4,5±0,2

It is known that during the storage the viscosity of sweetened condensed milk, is sharply increases [9,10].

They conducted investigations of structural and mechanical properties of hydrolyzed sweetened condensed products and stabilizer in fresh products and during storage. Results of the investigation of the effective viscosity of whole hydrolyzed condensed milk during storage are shown in Fig. 4

A series of experiments with whole hydrolyzed sweetened condensed milk were conducted, in the process to the beforehand prepared raw materials were added stabilizer Bivicioc 1L at the amount of 0.2, 0.4, 0.6 and 0.8 % by weight of the finished product [11]. For the whole hydrolyzed condensed milk mass part of dry materials of the product - 59 % including 31 sucrose and 22 %.

The facts of the studies (Fig. 5) testify that by increasing the mass part of the stabilizer from 0.4 to 0.6 % (for whole milk) during storage the indexes of effective viscosity and consistency of the products varies insignificantly. Further increase of the mass part of the stabilizer above 0.6 % (for whole milk) during storage causes more significant changes of indicators. For example, when adding a stabilizer at an amount of 0.8 % for the 8th month of storage the effective viscosity of the product increased to 10,2 ± 0,4 Pa·s with the product had a thick and dense texture.

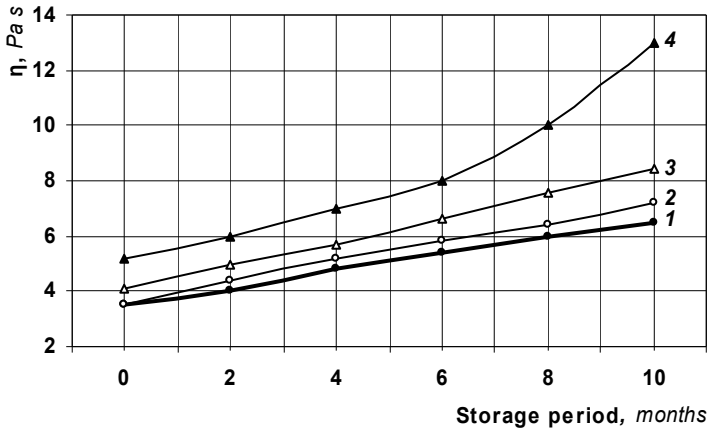

Fig. 4 . Change of the effective viscosity of whole hydrolyzed condensed milk during storage:
1 – whole condensed sweetened milk (control);
2 - whole hydrolyzed sweetened condensed milk mass part of 59% dry materials, 31% is sucrose, mass part of stabilizer is 0,4 % of the finished product;
3 - whole hydrolyzed sweetened condensed milk mass part of 59% dry materials, 31% is sucrose, the mass part of the stabilizer is 0.6 % of the finished product;
4 - whole hydrolyzed sweetened condensed milk mass part of dry materials 59 %, sucrose is 31%, the mass part of the stabilizer is 0.8 % by weight of the product.

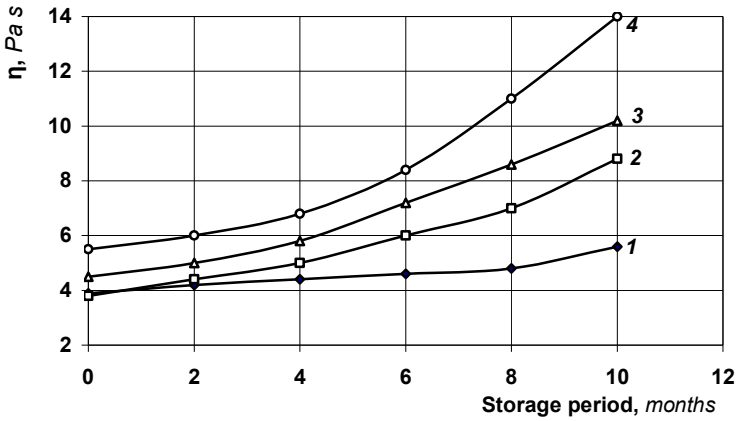

Fig. 5. Change of the effective viscosity of whole hydrolyzed condensed milk during storage:
1 - condensed milk with sugar (control);
2 - whole hydrolyzed sweetened condensed milk mass part of 59% dry materials, 22% is sucrose, mass part of the stabilizer is 0.2% of the finished product;
3 - whole hydrolyzed sweetened condensed milk mass part of 59% dry materials, 22% is sucrose, the mass part of the stabilizer is 0.4% of the finished product;
4 - whole hydrolyzed sweetened condensed milk mass part of 59% dry materials, 22% is sucrose, the mass part of the stabilizer is 0.6 % by weight of the product.

For whole hydrolyzed condensed milk with a mass part of 59 % dry materials, including 31% of sucrose, the optimum alternative of the mass part of the stabilizer became

samples with application of 0.4…0.6 % by weight of the product and the effective viscosity was 5.8 ± 0,3 to 6,6 ± 0,3 Pa·s, respectively (for 6 months storage).

For whole hydrolyzed condensed milk with a mass part of 59% dry materials, including 22% of sucrose (Fig. 4 b), the maximum amount of stabilizer became the samples with the introduction of 0.2…0.4% by weight of the product, and the effective viscosity was from 6,0 ± 0,3 to 7,2 ± 0,3 Pa·s (at the 6 months of storage period). At the mass fraction of 0.6 % stabilizer in 10 months the gelation process was seen, the effective viscosity have increased to 14,0±0,6 Pa·s, due to the peculiarity of the stabilizer (which is based on carrageenan), when the amount of stabilizer is overstated the consistency of the product become gelatinous (which is not typical for condensed sweetened milk products).

According to the obtained experimental facts (Fig. 4 and 5), the maximum mass part of stabilizer Bivicioc 1L for whole hydrolyzed condensed milk with a mass part of sucrose 31% and 22 is the quantity of 0.4...0.6% and 0.2...0.4 % by weight of the product, respectively [12].

Conclusions

1. Application of the stabilization system Bivicioc 1L for products with mass part of 59% dry materials is justified and the mass part of the stabilizer is determined:

- for whole milk with a mass part of dry materials (59% sucrose 31 % and 22) - 0.4...0.6 and 0.2 ... 0.4 % by weight of the product, respectively.

2 Viscosity of hydrolyzed condensed milk and sugar mixtures with the application of Bivicioc 1L stabilization system is established:

- for whole hydrolyzed condensed milk with mass part of dry materials (59% sucrose 31 % and 22) - 3.5…4.1 and 3.8…4.5 Pa·s.

3. Effective viscosity in the hydrolyzed sweetened condensed canned milk products with the application of Bivicioc 1L stabilization system in the process of storage is established:

- for whole hydrolyzed condensed milk with mass part of dry materials (59% sucrose, 31 and 22 %) - from 5,8 ± 0,3 to 6,6 ± 0,3 and from 6,0 ± 0,3 to 7,2 ± 0,3 Pa·s., respectively.

References

1. Vrese M., Sieber R., Stransky M., (2006), Lactose in human nutrition, *Milk processing*, 10, pp. 50.
2. Sinelnikov B., Hramtsov A., Evdokimov I. and other (2007), Lactose and its derivatives, *Scientific. ed. acad. RASHN*, Sankt-Peterburg.
3. Hramtsov, A. (2008), Lactose and its derivatives, *Food Industry*, 3, pp. 18-19.
4. Haryu M. (2005), Removal of lactose from milk, *Dairy industry*, 4, pp. 52-54.
5. Messia M., Candigliota T. and Marconi E. (2007), Assessment of quality and technological characterization of lactose-hydrolyzed milk, *Food Chemistry*, 104(3), pp. 910-917.
6. Hertzler S., Savaiano D., Jackson K. and other. (2013), *Nutrient Considerations in Lactose Intolerance, Nutrition in the Prevention and Treatment of Disease (Third Edition*).

7. Harjuc M., Kallioinen H. and Tossavainen O. (2012), Lactose hydrolysis and other conversions in dairy products: Technological aspects, *International Dairy Journal*, 22(2), pp. 104-109.
8. Kalinina E., Afanasenko S., Shalevskaya V. (2006), Study of the influence of temperature modes for the enzyme preparation ß-galactosidase, *Collection of scientific works of Luhansk National University*, *issue: Tehnichnical sciences,* 64/87, pp. 135-138.
9. Kalinina E. (2008), Study of hydrolyzed condensed milk viscosity during storage, *Collection of scientific works of Luhansk National Agrarian university*, pp. 74-79.
10. Kalinina O. (2010), Researches of effective viscosity of hydrolyzed milk canned products, *Ukrainian Scientific Conference of young scientists, theses of the report*, Uman.
11. Kalinina E., Minorova A. (2009), Researches of effective viscosity of hydrolyzed milk canned products, *Naukovy Visnyk of Lviv National University of Veterinary Medicine and Biotechnology "S.Z. Gzhitskii",* 11(2), pp. 43-45.
12. Mykhaylo Arych, Olena Gnatenko *(2014),* Financial and economic performance of the dairy industry of Ukraine, *Ukrainian food journal*, 3(1), pp. 9-18.