WATER ACTIVITY INFLUENCE ON THE SAFE AGING PERIOD OF CONDENSED MILK

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Abstract
The majority of chemical and biological processes causing the change of nutrients and finally their spoilage are dependent on water. Microbiological growth is directly related to water activity. Water activity (a_w) was introduced by an Australian microbiologist W.J. Scott in 1952. He defined this concept as a "fundamental property of water solutions" and i.e. a ratio between pure water (p_0) and steam pressure solution (p). The water activity of the unsweetened condensed milk packed into canister remains unchanged during the storage period (a_w.= 0,902). The water activity in the sweetened condensed milk slightly increases after 18 months (a_w.= 0,784, after 18 months a_w = 0,787). Though water activity does not actually change the storage of such a product and does not create a possibility for the growth of microorganisms. However, milk is a system of array compounds and a limitless storage of such a product is impossible. It is determined that the allowed storage period of 12 months is justified as after this period a major part of milk changes become accelerated

Keywords: water activity, condensed milk, safe aging

1. INTRODUCTION

The majority of chemical and biological processes causing the change of nutrients and finally their spoilage are dependent on water. Microbiological growth is directly related to water activity. And this activity in turn is related to the safe aging period of food [1].
Water activity (a_w) was introduced by an Australian microbiologist W.J. Scott in 1952 [3]. He defined this concept as a "fundamental property of water solutions" and i.e. a ratio between pure water (p_0) and steam pressure solution (p):

$$a_w = \frac{p}{p_0}. \qquad (1)$$

Later on T. Hardman, D. Reid [3] made their thermodynamic correction for the definition of a_w:

$$a_w = \frac{p_{balance}}{p_o}, \qquad (2)$$

where $p_{balance}$ is the partial water steam pressure in balance with the solution;
p_0 is the water steam pressure at the same temperature and pressure as of the solution.
According to Raul's law, a_w depends on the molar concentration of dissolved substances in a solvent. Every dissolved substance reduces a_w, however, the reduction level depends on its chemical properties, dissociation, solubility, interaction of molecules and etc. Every solution is expressed by an osmotic coefficient (δ), and its ratio with a_w is according to the formula (3):

$$\ln a_w = - VmM\delta \qquad (3)$$

where: m is the molar concentration,
M is the water molar weight, kg/mol,
V is the number of ions,

Tables are made for electrolyte enriched solutions, and Equilibrium Relative Humidity (ERH) is applied in practice.
Other parameters that characterize and define the water state are osmotic pressure (OP), the ratio with a_w of which is expressed by:

$$OP = \frac{-RT}{V} \ln a_w \qquad (4)$$

where V is the partial molar water volume,

R is the universal gas constant,
T is the absolute temperature, ^{0}K.

a_w figure scale of the product ranges from 1,0 (distilled water) to 0,0 (no free water). No microbes can multiply if water activity is less than 0,6.

The aim of this paper is to define the water activity in unsweetened and sweetened condensed milk.

1. RESEARCH OBJECTS AND METHODOLOGY

Investigative objects: sweetened condensed milk produced and packed into canisters by Joint Stock Company "Marijampolės pieno konservai". The canister filled with the investigative product was stored at room temperature (18-20^{o}C) for 18 months (Table 1). Five batches of sweetened condensed milk in canisters produced at different time were analyzed. The analysis of stored samples was performed once in two months.

Method of defining water activity a_w.

Essence of the method. Water activity a_w of pieces of food is the value, which defines the ratio between steam pressures and water and the investigative product at the same temperature and is determined by a specific device TH200. Steam pressure over pure water is equaled to 1 (or 100% of relative humidity), and over absolutely dry substance 0 (or 0% of relative humidity).

Table 1. Composition of the product

Parameters	Values	
	Sweetened condensed milk	Unsweetened condensed milk
Humidity, %	26,5	74
Sucrose , %	43,5	-
Total amount of dry milk substances, % fat, %	31 9	26 8
Caloric value, kcal/100 g	341	139
100 g nutrition value, g: proteins fat carbohydrates	 7,9 9 57,2	 6,1 8,1 10,5

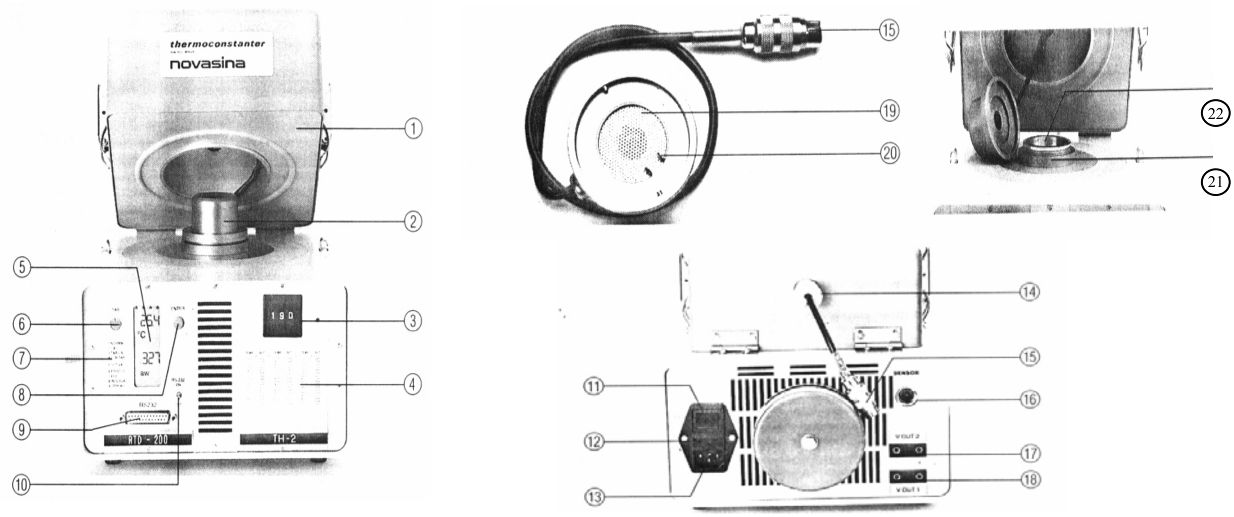

Fig. 1 Device. Thermoconstanter TH200, NOVASINA

1 – cover; 2 – meter with a sensor; 3 – temperature indicator; 4 – table for temperature evaluation; 5 – display for humidity and temperature data; 6 – operation selector button; 7 – table for possible operations; 8 – switch-on button for a selected operation; 9 – plug; 10 – RS 232 plug switch-on and switch-off button; 11 – device switch-on button; 12 – protection device; 13 – power supply socket; 14 – rubber plug; 15 – sensor; 16 – sensor plug; 17 – output of humidity register signal; 18 – output of temperature register signal; 19 – sensor protection; 20 – seal ring; 21 – test chamber; 22 – measuring vessel.

Table 2. Working conditions of Thermoconstanter TH200, NOVASINA

Parameters	Values
a_w measuring limits	0,05 to 1,00
measuring limits of temperature	0°C to 50°C
precision	±0,01a_w ±0,1°C
frequency	±0,005a_w

Working conditions of Thermoconstanter TH200, NOVASINA are presented in Table 2.

Analysis. A special measuring vessel 22 was filled with a sample (unsweetened or sweetened condensed milk) up to the vessel edges. Then, the vessel with the investigative sample was placed into chamber 21 at a selected constant temperature (in this case 25°C). After placing the vessel with the sample a measuring head is put on, the sensors of which measure a_W and temperature.

After the sample reaches the selected temperature, a_W value remains unchanged for a certain period of time (2-5 min.) and it is considered to be the result of the sample water activity $a_{W.}$

A repeated research is performed using another sample portion.

2. RESEARCH RESULTS AND THEIR DISCUSSION

The analysis of unsweetened and sweetened condensed milk stored for 18 months showed that the water activity didn't vary (Fig. 2).

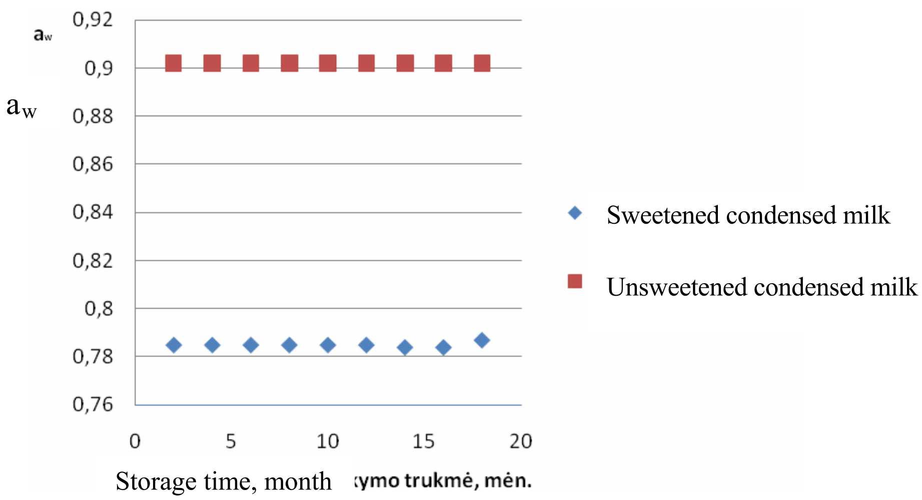

Fig. 2. Water activity in unsweetened and sweetened condensed milk depending on the storage period.

The derived data showed that the water activity of unsweetened condensed milk packed into canisters didn't change during the storage period in comparison to the sweetened condensed milk. The water activity in sweetened condensed milk slightly increases after 18 months. In our point of view, an increased amount of free water is related to the changes of milk proteins and lactose which are involved in the (Maillard) reaction of non-fermented browning. In the course of the reactions the reciprocity between the sugar lactose of reduced milk and milk proteins takes place, due to which the milk proteins polymerize and split in the final stage of the Maillard reaction. We suppose that the ratio of free and combined water changes simultaneously.

A different a_W values in the unsweetened and sweetened condensed milk is determined by a large sucrose additive (43 per cent) in the sweetened condensed milk, because sucrose increases osmotic pressure and reduces the possibility for microorganisms to grow. Sucrose is a water binder and it reduced the level of water activity.

3. CONCLUSIONS

The water activity of the unsweetened condensed milk packed into canister remains unchanged during the storage period (a_W.= 0,902). The water activity in the sweetened condensed milk slightly increases after 18 months (a_W.= 0,784, after 18 months a_w = 0,787).

Though water activity does not actually change the storage of such a product and does not create a possibility for the growth of microorganisms. However, milk is a system of array compounds and a limitless storage of such a product is impossible [2]. It is determined that the allowed storage period of 12 months is justified as after this period a major part of milk changes become accelerated.

5. REFERENCES

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