

# Sweetened condensed milk with acorn coffee, a time-forgotten product revival

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## Abstract

Sweetened condensed milk is a long-storable concentrated product that can be found worldwide. It is used both directly in food and as a raw material for the production of other food products. Canned milk plays an important strategic role in the food stock reserves of many countries. Mostly canned milk is consumed by countries with poorly developed farming or dairy processing industries or regions where the existence of such branches is not possible. Worldwide, condensed milk is mostly produced in large milk processing plants due to the complexity of technology and the need for large amounts of raw milk and energy for its processing. Nowadays, there are many varieties of condensed milk available on the market, where the most interesting examples are present in post-Soviet regions. This is explainable due to the significance of condensed milk as one of the most strategically important food products of the USSR (especially during the Cold War period), and also due to the cultural impact on its citizens as canned milk was the easily available sweet tasting product. Soviet canned milk production specialists upgraded and developed other varieties, such as sweetened condensed full cream or skimmed milk or cream with coffee or cocoa. Also, there were other taste varieties in development, but due to different factors, only a few of them got to the mass production stage. Most interesting is the use of coffee substitutes for adding to sweetened condensed milk, where you get a coffee-taste-like product, but without caffeine in it. In mass production, there is only one such product available – sweetened condensed milk with chicory, and unfortunately, its selling market is very limited. The objective of this article is to reveal the use of oak tree acorns as a caffeine-free additive for sweetened condensed milk, reinventing it for the modern world market, where demand for traditional and biological food is growing. The article contains sweetened condensed milk with acorn coffee explanation with a historical review, production theory, and prototype creation steps, that were based on original, but time-forgotten technology from 1939, and similar, but still used, sweetened condensed milk with chicory technology.

*Keywords: sweetened condensed milk, acorns, coffee substitute, canned milk, forgotten food products and technologies*

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## 1. Introduction

Canned milk (condensed or evaporated milk) is a long shelf life dairy product, that is made by vacuum evaporation of excess water and further adding of sugar or high temperature sterilization. Because condensed milk is a concentrate, it has more nutrients than regular whole milk, and adding additives only increases its nutrient value. The canning industry helps to make good use of all processed milk and its by-products, especially in the summer period, when it is not possible to process all milk in the form of whole milk products and sell it to consumers (Mahfuza et al., 2024; Nieuwenhuijse, 2011). There are several industries where condensed milk is widely used: sweets/confectionery, pastry and bread, ice cream and processed cheese production, etc. Canned milk is in demand in regions where animal husbandry is not developed or is not possible. Also, sailors, expeditions, armies, and strategic reserves of various countries are supplied with canned milk. The ordinary end consumer uses this product both directly for food and also for preparing various dishes and desserts (Stern et al., 1971).

The historical reason for the emergence of canned milk can be explained by the need for a high-quality milk product that can be stored for a long time above +6°C, can be easily transported, and used easily (Paludetti et al.,



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2018). The basis of modern condensed milk production was laid in the 19th century thanks to Nicolas Appert, who developed technologies for the preservation of various food products for the Napoleon army (food sterilization), as well as Gail Borden, who, struggling with high child mortality, developed the technology and equipment for the production of condensed milk with sugar, after which he created the first canned milk factory in the world (Barbano, 2017; Ramesh et al., 2016; LaikaPaka, 2023). In Latvia, from 1957 to 2001, canned milk was produced by Rēzeknes Piena Konservu Kombināts (RPKK), which during more than 40 years processed around 8.2 million tons of milk, from which around 3 billion cans of different variety condensed milk were produced. RPKK products were exported all over the world, thus highly appreciated, regularly awarded and nowadays becoming a legend. Nowadays, in Latvia, only one small-scale producer of condensed milk exists – SIA Vajars, but the local market is mostly filled with canned milk from Lithuania, the Netherlands, and Ukraine (LaikaPaka, 2023).

Despite the ancient origin of the product, it still does not lose its relevance and demand (Henchion et al., 2021). Since the 19th century, not only the production technology, equipment and packaging have been improved, but also the varieties of condensed milk have been expanded. Since the use of sweetened condensed milk differs from countries and nations, there is potential for taste variety expansion, but this field is stagnated due to passivity of nowadays condensed milk producers to experiment with new product development (Barbano, 2017). There are small scale producers in Ukraine, Belarus and Russia that present their sweetened condensed milk with different flavourings (banana, peach, strawberry, cherry etc.), but it is usually is obtained by using artificial flavourings and colourings (LaikaPaka, 2023). Modern trends show that there is demand for sugar, lactose free, or plant based milk products, and canned milk producers start to fulfill that demand (Bolshakova et al., 2024; Fang et al., 2023; Guimaraes et al., 2012). Currently existing assortment of condensed milk products consists of:

TABLE 1 VARIATIONS OF CANNED DAIRY PRODUCTS

Sweetened condensed milk (SCM) and other canned milk variations (LaikaPaka, 2023)	
SCM full cream (8-10% fat)	Boiled/caramelized SCM (+cocoa) (5-8.5% fat);
SCM skimmed (1-5% fat);	Sweetened condensed cream (+cocoa or coffee) (19% fat)
SCM with natural additives (cocoa, coffee, chicory)	Evaporated or concentrated milk (without sugar) (7.8-8.6% fat).
SCM with artificial flavorings and colorings or sweeteners	Plant based sweetened canned milk (coconut, oat, palm oil)

Since the article author has free access to historical milk processing and milk product production technology literature, mostly soviet period literature and state standards were used as a base:

TABLE 2 RPKK PRODUCED CANNED MILK CONTENTS

Indicator	RPKK produced canned milk contents (Skrebinska et al., 1999)				
	Full cream sweetened	Skimmed sweetened	Sweetened with cocoa	Sweetened with coffee or chicory	Sweetened cream
Max. water content %	26,5	30,0	27,5	29,0	26.5
Min. sucrose content %	43.5	44.0	43.5	44.0	38.0
Min. dry matter content of milk and additives %	28.5	24.5	27.5	26.0	34.0
Min. fat content %	8.5	-	7.5	7.0	19.0
Max. dynamic viscosity for fresh product (Pa*s)	2-10	1-10	2-10	2-10	2-10
Max. dynamic viscosity of the product at the end of life (Pa*s)	15	15	17	15-17	17
Max. acidity (°T)	48	60	-	-	40
Max. lactose crystal size for fresh product (µm)	10	15	-	10	10
Max. size of lactose crystals for product at expiration (µm)	15	15	-	15	15

Considering the growing demand for locally produced products, which are mainly produced from local raw materials and materials, as well as the revival of traditional recipes and technologies, it would be useful to develop this direction for the restoration of condensed milk production in Latvia (Pinto-Correia et al., 2021; Henchion et al., 2021). In the territory of Latvia, it is possible to obtain high-quality milk and produce sugar from locally grown sugar beets (historically Latvia had 3 sugar factories) (LaikaPaka, 2023). However, in the production of condensed milk with additives, it will be necessary to abandon cocoa and natural coffee, since it is impossible to grow it freely in our climatic conditions. However, it is possible to use alternative products such as chicory, acorns or cereals, which not only can be grown in our climate, but have become traditional substitutes for coffee (Pouille et al., 2020; Indzere et al., 2018).

Acorn coffee, which is a mixture of roasted, finely ground, sifted and homogeneously mixed acorns, chicory roots and cereals (barley, wheat, rye) (Pasqualone et.al., 2019). Historically, even before coffee and cocoa were brought to the territory of Latvia, our ancestors made acorn coffee from local raw materials, which according to its organoleptic properties is not only similar to natural coffee, but also healthier because it does not contain caffeine. This is especially important for people who are not advised to use caffeine, which is actually considered a very weak poison-stimulant. Caffeine-containing products should be excluded from children's, pregnant and breast-feeding woman diet.al.together, as it can negatively affect child health and development (Reichert et al., 2021). There are several hundred different types of oaks in the world, which are mostly found in the temperate climate zone. For this reason, they are widely found in the territory of Latvia, becoming an integral part of Latvian culture and history. Not only excellent wood and beautiful leaves can be obtained from the oak tree, but also nuts (acorns), which both animals and humans consume. Acorns have always helped people to survive in times of war and famine when the usual food supplies are scarce (Indzere et al., 2018; Pouille et al., 2021; LaikaPaka, 2023).

Condensed milk with sugar and acorn coffee is produced in exactly the same way as condensed milk with sugar and coffee or chicory. Uses the same parameters of raw materials and finished products, as well as calculation formulas. This was concluded after the author discovered the standard OCT-HKMMII 2 adopted by the USSR on May 4, 1939, and the technical conditions, where condensed milk with sugar and acorn coffee or chicory is described as an alternative product to condensed milk with sugar and natural coffee. It is possible that the beginning of the Second World War did not give a further future for the development of this product, but in the post-war years, natural coffee was already more available and popular. Condensed milk with acorn coffee was mentioned a little in the post-war literature only in a few books published in the USSR on the production of canned milk, but upgraded national standards or technical conditions related to this product were never developed (Kazansky et al., 1955). However, after many years, only condensed milk with sugar and chicory was released in the early 1980s thanks to the Rēzeknes Piena Konservu Kombināts specialists, creating local production standard (TY 49 Латв.ССР 1362-85) which later were adopted by other milk canning plants of the USSR (TY 10-02-02-9-86) for further mass production (LaikaPaka, 2023).

## **2. Materials and Methods**

Sweetened condensed milk with acorn coffee was experimentally prepared in the food processing laboratory of Rezekne Academy of Technologies using the author's own made small volume vacuum evaporator-crystallizer prototype "Fig. 1". Also, other available inventory and equipment was used, such as:

- Digital kitchen scales (accuracy +/- 1g, max 5000g);
- Digital thermometer with probe (accuracy +/- 1°C, 0-250°C);
- Refractometer for honey or syrup (accuracy +/- 0,5%, 12-27% water content);
- Induction stove, refrigerator, pots, dishes, spoons, cups and sieves of various sizes.

For experimental sweetened condensed milk with acorn coffee further ingredients and materials were used:

- Pasteurized and normalized milk "Latgale" 3,5% - 4 L; (Latvia);
- Sugar beet refined sugar "Marijampoles"- 880 g; (Lithuania);
- Ground acorn coffee "Zīleja" - 334 g; (Latvia);
- Fine lactose powder - 35 g; (Spain);

- 40 ml glass jars with screw-on metal lids – for packaging and final product storage.



Fig. 1. Small volume vacuum evaporator-crystallizer prototype (authors own designed and made).

The next sequence of operations consists of pre-preparation of 2 main components – sweetened condensed milk and acorn coffee extract. For sweetened condensed milk production, it is necessary to calculate the correct amount of needed ingredients. As mentioned previously, technology of sweetened condensed milk with chicory is taken as a basis because it is most suitable for such coffee substitute variation production (Ozola, 1988; Stern et al., 1971; Kazansky et al., 1955).

The main idea of sweetened condensed milk production is to create a long shelf life dairy product, where an unsuitable environment for microbiological activity must be created. In that case, water removal from the product plays the most important role. To remove excess water, vacuum evaporators are used, as it allows to evaporate water at much lower temperatures, preserving most nutrients in the product. Also, the addition of sugar creates a high osmosis pressure environment, which hinders further life processes of microorganisms (Renhe et al., 2018; Martinez et al., 2017; Park and Darke, 2016). Correct calculation of ingredients is very important, to achieve the desired result in the final product, and it is calculated by equation (Ozola, 1988; Stern et al., 1971; Kazansky et al., 1955):

$$T_{pr}/(BS_{pr}) = T_m/(BS_m) \text{ or } C_{pr}/(BS_{pr}) = C_m/(BS_m) \quad (1)$$

Where:

- $T_{pr}$ - fat content in the product;
- $T_m$ - fat content in the mixture;
- $BS_{pr}$  - fat-free content of the product;
- $BS_m$ - fat-free content in the mixture;
- $C_{pr}$ - sugar content in the product;
- $C_m$ - sugar content in the mixture.

Based on these equations, all calculations in the production of condensed milk are made. However, ready-made normalization tables with the necessary data and parameters exist to facilitate calculations (Stern et al., 1971).

TABLE 3 PRODUCT TYPE

Product Type	Mixture contents %		Mixture amount (kg for 400kg ready product)	
	Fat	Non fat solids	Summer season	Winter season
Sweetened condensed milk	3.52	8.29	1005	1007

Product Type	Mixture contents %		Mixture amount (kg for 400kg ready product)	
	Fat	Non fat solids	Summer season	Winter season
Sweetened condensed milk with cocoa	4.22	8.24	686	686
Sweetened condensed milk with coffee or chicory	4.36	8.23	682	684

Also, other equations are used for determining necessary parameters (Ozola, 1988; Stern et.al., 1971):

$$B = P(1 - S_m/S_g) \quad (2)$$

**The amount of water to be evaporated from the mixture**, where:

- B - amount of water to be evaporated (kg);
- P - Weight of raw materials to be thickened (kg);
- S<sub>m</sub> - Solids content in the mixture %;
- S<sub>g</sub> - Solids content in finished product %

$$G = (S_m * A)/S_g \quad (3)$$

**Amount of condensed milk to be obtained**, where:

- G- Quantity of condensed milk (kg);
- S<sub>m</sub>- Solids content in the mixture %;
- Total amount of raw materials for thickening (kg);
- S<sub>g</sub>- Solids content in finished product %;

$$C = (M * A * S_p)/(100 * S_g) \quad (4)$$

**The required amount of sugar for the mixture**, where:

- C - Amount of sugar required for processing (kg);
- M - Amount of mixture required for thickening (kg);
- S<sub>p</sub> - Solids content of normalized milk %;
- S<sub>g</sub> - Required solids content in the finished product %;
- A - The required amount of sugar in the finished product (kg).

$$E = (P * K * S)/(100 * G) \quad (5)$$

**Determination of dry coffee or chicory extract amounts**, where:

- E - Amount of dry coffee or chicory extracts needed for cooking (kg);
- P - Amount of normalized milk required for cooking (kg);
- K - The dry extract substance is contained in coffee or chicory %;
- S - Dry matter content in normalized milk %;
- G - Dry matter content in the finished product %

As only 30% of the total amount of dry extracts of coffee or chicory enters the extract. Therefore, the total amount of coffee or chicory is determined by (Stern et.al., 1971):

$$K_k = (100 * E)/30 \quad (6)$$

where:

- E - Amount of dry coffee or chicory extracts needed for cooking (kg);
- S - Dry matter content in normalized milk %;

- P - Amount of normalized milk required for cooking (kg);
- K - The dry extract substance is contained in coffee or chicory %;
- G - Dry matter content in the finished product %.

Using previously mentioned equations, correct proportions of ingredients were determined, for starting point taking accessible amount and quality of milk. As ready to use pasteurized and normalized milk was used, no detailed explanation of raw milk processing technology and quality indicators is needed (Ozola, 1988; Stern et al., 1971; Kazansky et al., 1955).

Further processing contained preparation of sweetened condensed milk, where prepared mixture of milk and sugar were evaporated to 26% water content at 20 inHg or 508 mmHg vacuum and 75°C +/- 5°C temperature of mixture. During milk-sugar mixture evaporation, acorn coffee extract was prepared according to equation, where dry ground acorn coffee was mixed with required amount of water. Acorn-water mixture was heated to boiling point, where it was further heated and continuously stirred for 5 more minutes. After heating, acorn-water mixture was left to settle and cool down for 30 minutes. After settling, the acorn coffee extract was separated from the solids with the help of a sieve or cheesecloth, repeating the filtration several times. The resulting extract was added to pre-prepared but still hot sweetened condensed milk and mixed together. Complete mix was evaporated to required water content (less than 26%) “Fig. 2” and cooled down to 35°C with active mixing in order to achieve correct crystallization process by adding 0.02% of fine lactose powder (from total product mass). Overall evaporation and crystallization process took around 6 hours. Ready sweetened condensed milk with acorn coffee was filled in pre-sterilized and still hot glass jars and closed with pre-sterilized screw-on metal lids. Completed product was stored in refrigerator at 4°C.

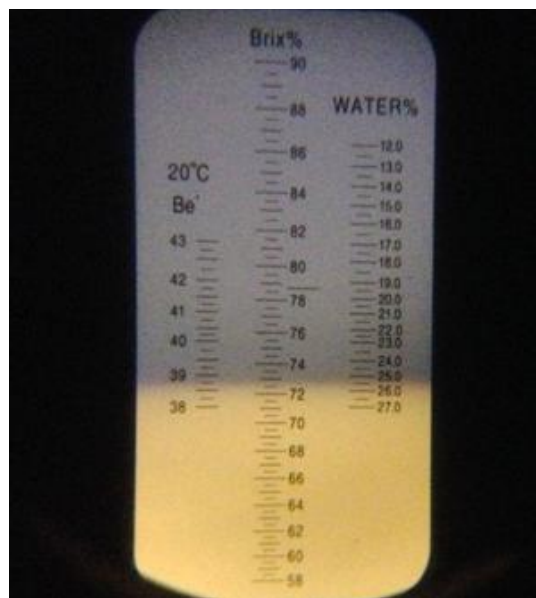


Fig. 2. Water content of sweetened condensed milk with acorn coffee (25,5%).

### 3. Results and discussion

- Despite certain risks and possibility of failure, as original technology of sweetened condensed milk with acorn coffee from 1939 was not used and developed further, also, complications with seasonality of acorn harvest, research resulted in quite promising new product prototype, that after some more improvements could be used for further mass production.
- From 4 litres of milk, 880 g. beet sugar and 334 g. ground acorn coffee - 1736 g. sweetened condensed milk with acorn coffee was obtained.
- For ease of use, all ingredient amounts for sweetened condensed milk production were calculated using authors own made automatic calculation tables (using Microsoft Excel), that are based on equations, that are mentioned in this article.

- Due to limited product amount, prototype was presented for close circle tasting, where participants (12 woman and 9 man of age 20-75) using method similar to “Hedonic scaling”, valued product organoleptic qualities, emphasizing that it is quite similar to sweetened condensed milk with coffee. Overall, participants enjoyed prototype taste and showed interest to purchase such product when it would be available for sale.
- Product was put in long term shelf life testing (2019-2024), with periods from 1 to 5 years, storing it all this period in refrigerator at 4°C. Product remained its organoleptic features for 12 months without changes (as required in sweetened condensed milk with chicory standard). Further in time, product started to become more viscous with noticeable feeling of sugar grains, but still remained its pleasant taste, no visible or sensible microbiological spoilage was detected (mould, fermentation).
- Visitors of “LaikaPaka” museum show interest in sweetened condensed milk with acorn coffee, as remaining prototype sample and its creation story is a part of exhibition.
- Sweetened condensed milk with additives topic may be a field for further researches, new discoveries and creation of new market product niche.

**Obtained sweetened condensed milk with acorn coffee prototype organoleptic features “Fig. 3”:**

- Colour - Light brown with small dark dots (fine coffee grounds), uniform throughout the mass;
- Consistency - viscous, homogeneous throughout the mass with small organoleptically felt coffee grounds, without lumps;
- Smell - pleasantly sweet with a pronounced aroma of sweet cream and acorn coffee aromas;
- Taste - moderately sweet with a distinct taste of sweet cream and acorn coffee, pleasant mild aftertaste.
- When dissolved in hot water - the colour and smell remain a little less pronounced.



Fig. 3. Sweetened condensed milk with acorn coffee (prototype).

#### 4. Conclusions

This research shows that the use of oak tree acorns as a coffee substitute for flavouring sweetened condensed milk is possible. Moreover, the organoleptic qualities of the experimental batch of sweetened condensed milk with acorn coffee were pleasurable for persons who tasted it. Since the original 1939 technology of sweetened condensed milk with acorn coffee is time forgotten, and acorn coffee itself is an old Latvian traditional beverage, it could be a potentially new and uncial national product of Latvia, that could be produced from 100% locally producible ingredients and used for other new food product creation (sweets, ice cream etc.). Using biological ingredients may be more challenging, but more attractive for those customers, who care about their and their close one health.

It is clear, that some more prototypes of sweetened condensed milk with acorn coffee should be made for future examination and testing to optimise its production technology. After optimisation and marketing campaign, the product should be produced in considerable amounts (approximately 1500 standard tin cans or 600 kg of product itself) for customer testing, which would determine its liveability on the Latvian market.

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