THESES OF DOCTORAL DISSERTATION

Tekla Izsó

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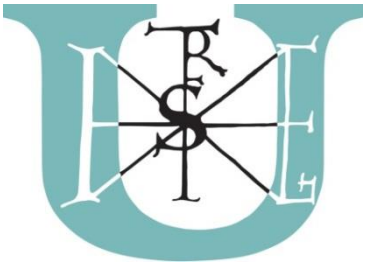

SZENT ISTVÁN UNIVERSITY

Consumer perception of sour cream imitations' quality in the comparison of the products regarding the aspects of food science and nutrition

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1. INTRODUCTION AND OBJECTIVES

The replacement of raw materials of animal origin with as many plant-derived ingredients as possible, or even the development of entirely plant-based foods, is one of the common ways of producing analogue products, but it is still a serious challenge for manufacturers. In the case of dairy products, such efforts are particularly prevalent. Initially, the creation of dairy-analogues was induced by factors such as the shortage of raw materials in times of crisis or the reduction of hunger in societies with a lower standard of living, but the provision of affordable food is still an important aspect. Besides, over time, analogue products that are sustainable and at the same time responsive to health problems (eg milk protein allergy) made from exclusively plant-based sources (containing soy, oats etc.), often at a higher price than the original, have survived, but foods that combine low-cost, dairy-derived ingredients with plant-based ingredients are also on the market.

The product category itself raises the issue of misleading consumers: behind the image of a product familiar to them, these foods hide a different composition from the traditional ones. Although dairy analogues or imitates are mentioned in some national and international regulations (Codex Alimentarius Hungaricus, FAO Codex Alimentarius), the current Hungarian and EU regulations contain only references to the product range, there is no clear and sufficiently detailed interpretation of them. As a result, the consumer may run into products of very different quality in the 'dairy imitation' category. Dairy imitation products are also a hardly interpretable area from the authority's point of view, as the borderline between counterfeiting, misleading consumers and products that are well distinguishable from traditional products but of different quality is thin.

The function of dairy imitations in the diet, the consumer behaviour towards them, or the criteria for their quality are less studied fields, mostly information on product development experiments, possible ingredients and related sensory critiques can be found in the Hungarian and international literature. However, careful mapping of these issues would be necessary to bring the views of producers, consumers and public authorities closer together.

Accordingly, in my research, I aimed at a comprehensive analysis of one of the most popular product substitutes, sour cream imitations, which will hopefully help to improve the perception of the product category, highlighting their benefits and potential.

The aims of this study therefore included:

1. Determination of the differences between sour cream and sour cream analogues based on analytical measurements: Survey of the range of dairy product analogues on the market, focusing on sour cream and its analogue variants. Exploring differences in composition, comparing quality parameters[1].
2. Nutritional evaluation of sour cream analogues: Comparison and evaluation of traditional and analogous products according to dietary guidelines, weighing their advantages and disadvantages.
3. Exploring the attitudes of Hungarian consumers towards dairy analogues: Getting to know the motivations and attitudes of consumers, assessing their knowledge of the topic. Exploring the reasons for purchase, gathering expectations and demands on products.
4. Getting to know the behaviour of consumers: Observing the decision-making process of consumers in a real shopping situation, examining their shopping habits. Assess the potentially misleading nature of the labelling and display of individual products.
5. Modernization of regulation: Formulation of a proposal for regulatory elements to facilitate informed consumer choice. Defining more precise product categories by considering the properties of analogue products.
6. Formulation of product development proposals: Exploring the composition, diet, consumer motivations and the development of product improvement ideas using the results of consumer needs assessment, taking into account consultation with manufacturers.

Based on my objectives and after processing the available relevant literature, as well as taking into account the materials published in the media and the platforms for disseminating knowledge, I formulated the following hypotheses:

H1: The calcium, fat-soluble vitamin and protein content of sour cream analogues are lower than the calcium, vitamin and protein content of ordinary sour cream.

H2: The composition of sour cream analogues is more favourable for consumers with high cholesterol levels.

[1] One of my goals was to evaluate the appearance of differences in the organoleptic properties of the products, however, the health regulations coming into force in connection with the COVID-19 epidemic did not allow the study planned for April 2020 to be carried out. The comparison of sensory characteristics is expected to take place in the second half of 2020, however, the present dissertation does not include the results.

H3: Dairy analogues are most often identified by consumers as consisting of only plant-based ingredients that do not contain any dairy ingredients.

H4: A) The majority of consumers do not consciously buy sour cream analogues, B) they make their choice due to the appearance and placement of the products.

H5: A) The level of knowledge influences the opinion and attitude of consumers towards sour cream analogues. B) Consumers with a higher level of knowledge have a more positive view of this product category.

H6: A) Price-sensitive consumers consciously choose sour cream analogues, B) as a substitute for sour cream.

In my dissertation, I presented my results established with the help of various methods suitable for both the realization of my objectives and the support (refutation) of the above hypotheses, which can also serve as a model for the study of other dairy analogue products.

2. MATERIALS AND METHODS

2.1 Mapping the product range in grocery stores at Budapest

The first step in the research, which laid the basis for further research, was to survey retail supply, which made it possible to review traditional and sour cream imitation products available to consumers and then to create a database. During November 2017, the characteristics of all sour creams and sour cream imitations made using milk and vegetable fat (including all presentations, different fat ratios and lactose-free products) found in the stores of 15 retail food chain chains in Budapest were recorded.

2.2 Laboratory measurements

Analytical tests were performed in the reference laboratories of the National Food Chain Safety Office using accredited, standard methods. For the analysis, I selected the 3-3 products of sour cream and sour cream imitation with a 20% fat content from three different Hungarian companies producing both traditional and imitation products. The items were purchased from grocery stores in Budapest in April 2018. The selected sour creams were made using cream and bacterial culture, while sour cream imitations were made using skimmed milk, palm fat and bacterial culture.

Table 1. Analysed parameters and methods for the evaluation of sour creams and sour cream imitations

Parameter/attribute	Standard	Method
Fat content	MSZ 9602:2018	Röse-Gottlieb method
Sample preparation for fatty acid determination	MSZ EN ISO 5509:2000 Chapter 5	Formulation of esters
Fatty acid composition	MSZ ISO 5508:1992	GC-FID
Amount of trans-fatty acids	MSZ EN ISO 15304:2002	GC-FID
Cholesterol content	MSZ EN ISO 12228-1:2014	GC-FID
Protein content	MSZ 1385:1987	Kjeldahl method
Number of lactic acid bacteria	MSZ ISO 15214:2005	de Man, Rogosa, Sharpe (MRS) agar
Vitamin A (all-trans-retinol)	MSZ EN 12823-1:2014	HPLC-UV
Vitamin D_3	MSZ EN 12821:2009	HPLC-UV-MS
Vitamin E (α-tocopherol)	MSZ EN 12822:2014	HPLC-UV
Calcium content	MSZ EN 15505:2008 Appendix B	Flame atomic absorption

For each analytical test, two replicates of the sampled products were prepared. The examined characteristics and the standards and methods on which the analyses were based are summarized in Table 1. For the analysis of the lactose content of dairy products, the laboratory developed an HPLC-RI technique based on the method published in 1979 by DUNMIRE and OTTO[2], for which the laboratory is accredited.

2.3 Quantitative consumer survey

I conducted personal interviews with the help of eight interviewers in the period between 2017 November 7 and 22, in seven different cities (Budapest, Dombóvár, Győr, Miskolc, Szeged, Szolnok and Veszprém). The structure of the questionnaire was basically aimed at a self-completion format, but in cases where the survey participant requested it, answers could be given orally, which the interviewer recorded on the questionnaire. I mostly used closed-ended, multi-choice and 5-level Likert attitude-scaling questions. 1,000 respondents took part in the survey, selected based on a so-called quota selection. The demographic ratios established for the Hungarian population during the micro census[3] conducted in 2016 - gender, age, place of residence according to the NUTS2 planning-statistical region - served as the basis for the monitored quotas. Quota tracking ensured that the data were representative of these three demographic variables.

2.4 Qualitative, exit-poll type consumer survey

In order to understand in-depth the product selection, the decision-making process, the influencing factors while shopping, I observed in a real decision situation how consumers choose sour cream and sour cream imitation products in grocery stores and then after the product got into their shopping cart (so the decision-making process was presumably over), I explored the reasons and aspects of product selection in a short interview. For the study, between 15 August and 20 September 2019, 11 stores of four retail chains hosted the survey[4]. The interview was conducted with the permission of retail chain leaders and store

[2] DUNMIRE D. L., OTTO S. E. (1979): High pressure liquid chromatographic determination of sugars in various food products. Journal of Association of Official Analytical Chemists, 62(1), p. 176–185.

[3] Hungarian Central Statistical Office (2017): Micro census 2016 2. Characteristics of the population. (Ed.) Kovács M. Budapest: Hungarian Central Statistical Office.

[4] During mapping the product range (November 2017), the customer could still encounter sour cream imitations in all four retailers' stores, however, during the period between the two sub-studies, this product category was removed from the shelves in one of the stores. This influenced the survey to the extent that I also included customers who chose sour cream in the given situation, but who had previous experience with sour cream imitations.

managers, with the involvement of 5 interviewers. The study included 60 customers who were selected by a non-probabilistic sampling procedure using a targeted sampling method based on the product they selected at the time of purchase.

2.5 Consultation with the producer side

In order to get a more complete picture for the evaluation of sour cream imitations, it was also necessary to map the views and aspects of the manufacturers. To this end, I sought the opinion of industry experts in an interview. The aim of the interviews was basically to support the formulation of relevant product development, communication and legislative proposals that work in practice. For the consultation, I asked the representatives of three Hungarian companies, which also produce sour cream and sour cream imitations, to participate in the research, of which only one person gave answers to my questions. The industry expert is a quality assurance specialist of a Hungarian dairy company, which produces dairy imitations in a wide range. I used the expert's feedback without indicating the name and manufacturer to supplement and support my results.

2.6 Statistical methods used for data analysis

Data collected using laboratory measurements, the quantitative consumer survey, and the qualitative survey combined with observation was analysed using SPSS statistical software[5]. I compared the average price of sour cream and sour cream imitations, searching for significant differences between the two product groups by one-way analysis of variance (ANOVA) with a 95% confidence interval. To compare the average price of the products, I supplemented the analysis of variance by performing a Duncan post hoc test. For the general characterization of the results of the quantitative and qualitative studies, I evaluated the indicators of frequency, mean and standard deviation. Correlations and differences between the individual variables were determined using cross-tabulations (in addition to Pearson's χ^2-test and z-test).

In the case of the quantitative survey, I also used a method called structural equation modelling (SEM), which is one of the second-generation multivariate data analysis techniques, to map the willingness to buy sour cream imitations and the effects of the factors influencing it. I used partial least squares (PLS) modelling using a reflective construct. PLS-SEM path analysis was performed using SmartPLS 3.2.7 software[6]. The significance of the path coefficients

[5] IBM Corp (2015): IBM SPSS Statistics for Windows. Armonk, NY: IBM Corp.
[6] RINGLE C. M., WENDE S., BECKER J. M. (2015): SmartPLS 3.'Boenningstedt: SmartPLS GmbH. http://www.smartpls.com

characterizing the routes was checked by the bootstrap process, which was performed with 1000 subsamples, and the predictive relevance was checked by the blindfolding procedure (omission distance value: 7).

Table 2. Hypothetical factors that affect consumers when choosing a sour cream imitation

Elements - Latent variables	Indicators (as manifest variables)
PRICE: Price sensitivity	**V1:** I always look first at the price of a food product.
VALUE: Experience and value based on choice	**V2:** In my experience, no difference exists between sour cream and its imitation product.
	V3: Because of the more favourable price, I might rather choose a sour cream imitate.
COOK: Culinary skills and openness	**V4:** I cook regularly.
	V5: I like to try new techniques or raw materials in the kitchen.
KNOW: Knowledge of dairy products and dairy imitations	**V6:** Scores of True or False questions on dairy imitations and dairy products.
	V7: In dairy imitations, the milk fat is replaced by other materials.
BUY: Willingness-to-buy sour cream imitations	**V8:** I have already bought sour cream imitations deliberately.
	V9: It is possible that I would buy a sour cream imitation product.
CONSC: Consciousness in product selection	**V10:** I always read food labels thoroughly.
	V11: I consciously choose brands or manufacturers when I buy food products.
NUTR: Nutritional awareness	**V12:** I pay attention to my nutrition.
	V13: I am interested in healthy nutrition.
SENS: The preference of the sensory properties of sour cream imitations	**V14:** I like the taste of sour cream imitations.
	V15: I like the texture of sour cream imitations.
SOUR: Liking sour cream	**V16:** I like sour cream and meals made with sour cream.
	V17: I often use sour cream for several meals.

The components of the model included in the PLS-SEM study were selected based on the factors established in the literature on consumer attitudes, motivations, and shopping behaviour, as well as my assumptions about sour cream imitations. The elements of the model and the observed variables explaining them are presented in Table 2.

To describe the relationships between latent variables, with which I aimed to characterize consumer behaviour (willingness to buy sour cream imitations), I defined six relationship paths. The adequacy characteristics of the factors (latent structures) in the model, the composition reliability index, the AVE (average variance extracted), the standardized factor weights, the standardized residual root mean square, and the results of the discriminant validity test all met the requirements specified in the literature. The adequacy of the constructed structures was also confirmed by the categorical principal component analysis (CATPCA) using SPSS.

3. RESULTS AND DISCUSSION

Based on a review of the types of dairy imitation products found in the literature, I considered that the imitations can be divided into three more homogeneous groups within each category according to their similarity to the original dairy product in terms of ingredients and manufacturing steps. Dairy imitation products can be selected for groups according to four aspects: what kind and how much milk-based raw material and plant-based raw material they contain, how much the production follows the traditional method, and how much and what type of additives and other ingredients the product contains. Accordingly, I defined three homogeneous groups within the category of dairy imitations. In the first, there are few differences between the ingredients compared to the original product, and the production process includes "traditional" steps that define the product character (eg coagulation by culture). The products of the second group already have fewer dairy ingredients and more additives, and even production is simplified, while the third type is made exclusively of plant-derived materials and food additives. The categorization defined here can be used later to assess the quality of each product and to determine the requirements to be set for the ingredients (such as the need for vitamin supplementation). I named the grouping method "Classification System for Dairy Imitations". The categorisation of sour cream analogues by this system presented in Table 3.

Table 3. Types of sour cream imitations compared to ordinary sour cream

Type of Product	Milk base	Fat source	Acidifying agent	Food additives	Other components
"Ordinary" sour cream	Cream	Milk fat	Culture	None	None
Type 1 sour cream analogue	Skimmed milk	Vegetable fat	Culture	None	None
Type 2 sour cream analogue	Skim milk powder	Vegetable fat	Lactic or citric acid	Emulsifier, thickening agents	Water
Type 3 (non-diary) sour cream analogue	None	Vegetable fat	Culture	Starch, calcium-lactate, thickening agents, flavourings	Water, inulin, "soymilk powder", proteins

3.1 Product range in grocery stores

Examining the retail supply of sour creams and sour cream imitations, I found a total of 157 traditional sour creams, 13 lactose-free sour creams and 24 sour cream imitations in different packaging sizes and fat content on store shelves. Comparing the prices of sour cream and imitation products with a fat content of 20%, there is a huge difference: the average price of imitations is only 66.96% of the traditional products. Although the average price of 20% sour cream imitations was lower than that of sour cream with 12% fat content, in this case, the difference was not significant. Based on their composition, the imitations in the range belong to the first imitation type.

Due to their potentially misleading nature, I also reviewed the names of the sour cream imitations and their packaging, as well as the graphic elements on them. The names of each imitation product met the specifications, with the word "milk" appearing only in the list of ingredients. The pictorial display raised several doubts as to compliance, as 2 products presented cows, 2 products presented milk/cream tubs, and 1 product presented milk jugs. Figure 1 shows an example of a sour cream imitation sour cream and a traditional sour cream pair that is likely to mislead consumers.

Another problem with packaging is that even if a graphic element referring to milk is not visible, sour cream and imitation products from the same manufacturer or brand are available in almost identical packaging and size, only the name and the list of ingredients are different.

Figure 1. Comparison of the potentially misleading packaging of a sour cream (left) and its imitation version (right) (own picture)

3.2 Results of analytical tests

My results show that protein, carbohydrate, more specifically lactose - the carbohydrate content of milk is almost entirely derived from lactose - and the amount of calcium do not differ significantly between the two product categories. The fat content of the examined products complied with the requirements of the Codex Alimentarius Hungaricus for dairy products, even though sour cream imitates do not qualified as "dairy products" according to Hungarian regulations. This is also the case for the number of lactic acid bacteria, the value of which was also not statistically significant, so the type 1 imitates also met the requirements for sour cream for this quality indicator.

The amount of all-trans-retinol in the sour cream samples was probably slightly higher than that in the imitations, but in the sour cream imitation samples it did not reach the limit of quantification in either case, so the statistical comparison was not possible. Vitamin D_3 and α-tocopherol also did not approach the limit of quantification in either the sour cream or imitation samples, so they are not substantially comparable.

However, the analysis of the fatty acid composition showed that the amounts of saturated and trans-fatty acids and cholesterol in the imitations were significantly lower, and therefore their consumption may be beneficial for those with cardiovascular problems[7]. It should be noted, however, that the digestibility of the two product types may be different, as conventional sour cream is rich in short- and medium-chain fatty acids through milk fat, which provides better absorption in the body. However, none of the products had an ideal ratio of omega-6 to omega-3 fatty acids.

3.3 Results of a quantitative consumer survey

According to the results of quantitative consumer survey, 51.13% of respondents had heard of dairy imitations or analogues before the survey. Most of them (59.93%) associated these products with substitutes made entirely of plant-derived materials, with only 35.21% of respondents identifying them as dairy-derived foods in which milk fat was replaced with vegetable fat.

More than half of the participants (59.69%) had previously purchased sour cream imitations, but only 30.24% of the purchases were purposeful. Further questions revealed that the main reasons for unintentional purchases were: the packaging of sour cream and imitation sour cream products is very similar to traditional sour

[7] WILLETT W. C. (2012): Dietary fats and coronary heart disease. Journal of internal medicine, 272(1), p. 13-24.

cream (34.50%), imitations are placed next to sour cream on store shelves (27, 89%) and 7.37% the lower price was so attractive that the nature of the product was not taken into account. Although a ranking of potentially misleading factors can be established based on frequencies, in fact, likely, all three of these factors (same appearance, misleading placement, and low price) contribute to random purchases at the same time. Random purchases of sour cream imitation were most annoying to consumers (51.93%).

Consistently with this, 44.68% of respondents believe that sour cream imitations are misleading. The perception of the products is related to the consumers' knowledge about imitation dairy products: according to the knowledge points formed based on the True or False section, there was a significant difference ($\chi^2 = 16.52$; df = 2; $p < 0.001$) among those who marked dairy imitation products as misleading. Fewer of those with a higher level of knowledge generally thought this type of food was deceptive.

To examine the relationships between the variables presented in Table 2, I performed a path analysis to set up the PLS-SEM model, and the graphical representation of the resulting model is shown in Figure 2.

The strongest relationship was observed between nutritional awareness and conscious product choice constructs (NUTR - CONSC), as well as between the perceived price-value ratio based on experience and the willingness to buy sour cream imitations (VALUE - BUY), both relationships were significant ($p \leq 0.001$). The path coefficient of the route between price sensitivity (PRICE) and VALUE latent constructs was also among the highest values, in addition to the fact that the relationship proved to be significant. In addition to the SENS latent variable, which includes the preference for sensory properties of sour cream imitates, all other structures showed a significant relationship with willingness to buy (BUY).

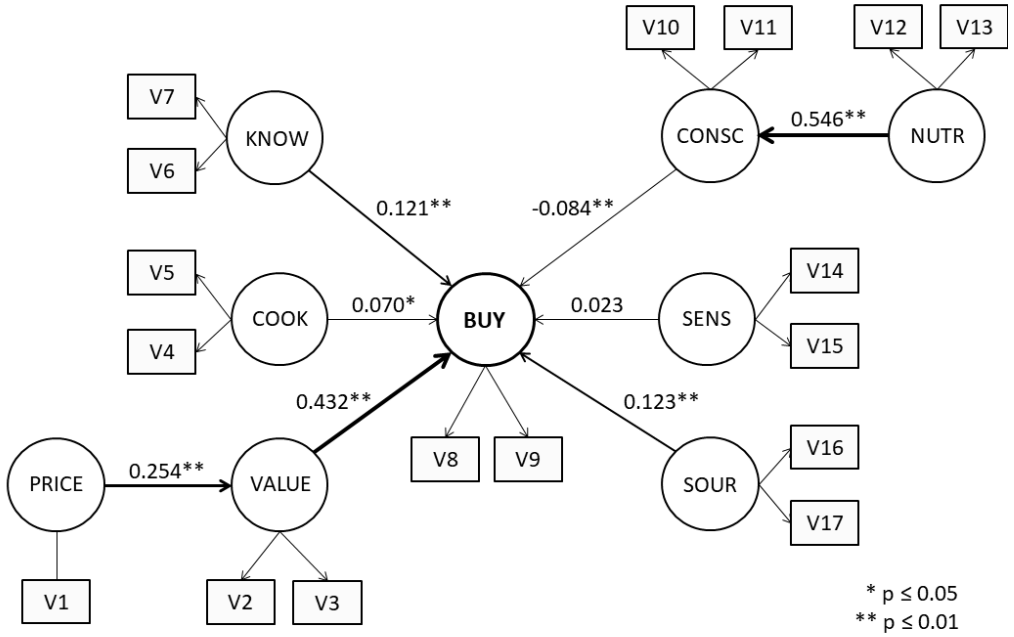

Figure 2. Factors affecting the willingness-to-buy sour cream imitations (the thickness of the arrows indicates the strength of the relationship between the structures)

Interestingly, conscious product choice (CONSC) has a negative relationship with the willingness to buy, i.e., customers who usually read product labels are less likely to choose sour cream imitation. This suggests that the willingness to buy is positively influenced by the fact that if the consumer already has information about the imitations before the purchase, in contrast if the consumer is confronted with the nature of the products only standing in front of the shelf, she/he will be more distrustful of the product. All in all, the VALUE, KNOW and SOUR latent variables were the most defining elements in the model.

The established model explains the variance of the target variable (BUY) in 24%. Considering the nature of the research, this is an acceptable value, besides, the 0.240 adjusted R^2 indicates a medium/large influencing effect of the latent variables. Also, based on the Q^2 indicator, the developed model has medium predictive relevance.

3.4 Qualitative consumer survey combined with observation

Concerning the monitoring of product placement in general, the segregation of sour cream imitations was not fully implemented in any of the shops examined. Typically, the sour cream imitations were located next to or among the 12% fat

sour cream, and the size of the packaging also played a role in the choice of placement, according to my observations.

Observing customer behaviour in stores revealed that the decision is made within just a few seconds, which is none of the observed cases did include reading the ingredients of the product. Along with these factors, it is not surprising that the purchase of sour cream imitations is often not conscious.

Despite the good awareness rate - 61.67% of the participants are already heard from sour cream imitations or analogues - more than half (55.81%) of the interviewees (n=43) who bought the sour cream imitation became aware during the survey about they have chosen non-traditional sour cream. Most of them were simply surprised to hear that the product they chose was in fact an imitation, some were accepting or were interested, others said they had already bought the product several times but did not notice the difference. In two cases, the interviewee put the sour cream imitation back on the shelf.

When we asked why the participant chose that very sour cream imitation product, most of them emphasized the favourable price, additionally, the appropriate product size and habit played a major role. Several interviewees have explained that this type of product is specifically preferred for cooking, as the taste does not prevail so much when used for cooking (for example, in pottages), so it is a cheaper alternative - but for other purposes, they usually buy traditional sour cream. This also supports the relevance of the COOK variable (frequent cooking, openness to new ingredients) in the PLS-SEM model.

Questions about previous sour cream imitation purchases confirmed the results of the quantitative survey: except 4 participants, all respondents (93.33%) had already purchased a sour cream imitation before this research, but 48.21% were not consciously looking for this product. In the past, intentional sour cream imitation purchases, as in the cases examined in the present research, were generally due to the lower price (78.13%). The perception of differences between the sensory properties of sour cream imitations and traditional sour cream was also reported by the interviewees based on their own experience: the majority (66.67%) said that there was no perceptible difference in this respect (taste, smell, texture) between the products.

Respondents clearly emphasized the low price among the benefits of sour cream imitations in the first place, followed only by claims about sensory properties and composition, such as taste, favourable composition and creaminess. At the same time, consumer expectations were much more diverse than this, although the price appeared here in the first place as well. Shortly after the good price, they look for

a sour cream-like taste or a "delicious" taste, good quality when consuming imitation sour cream.
As expected, similarly to the quantitative survey, the majority found dairy imitations misleading (57.14% of respondents), but some noted that "there is no problem with such a product, but it should be more recognizable, separable". Opinions were divided on the placement of sour cream imitations in shops, but more than half of the interviewees (51.67%) considered their place on the shelves to be very misleading. However, 16.67% considered that the placement was not misleading at all, as the imitation products' composition and names were different from those of traditional sour cream, and there were sour cream imitations of which the colour of the packaging made the product clearly identifiable.
Although participants in both the quantitative and qualitative surveys identified similar packaging as the most common reason for unintentional purchases, the method considered appropriate for differentiation would change the way it is placed. The next most frequently chosen solution, according to the interviewees, would be to change the colour of the packaging. In connection with this, a group of colour association questions was included in the interviews, in which the participants found that green and yellow/orange would be the most suitable for the "own" colour of sour cream imitations. The green colour indicates the presence of plant-derived ingredients, so it may be excellent for the separation.

According to the quantitative survey, the majority of those who had consciously bought imitation sour cream in the past were over 40-60 years old (65.19% in total), so when designing the questions in the qualitative survey, I took into account the needs of this age group. According to a recent study of the Hungarian population, concerns about digestive problems, high cholesterol, diabetes, and cardiovascular disease, dental problems and osteoporosis are important to be considered when designing functional foods with added value for older consumers[8]. It should be noted that the cholesterol content of sour cream imitates is much lower than of the traditional sour cream, so in connection with one of the problems of older Hungarian consumers, their consumption is more advantageous than traditional dairy products without further modification.
The Hungarian population is deficient in vitamin D and calcium[9], so concentrating on the problem of osteoporosis, sour cream imitation produced by adding calcium and vitamin D could be a particularly suitable product with relevant added value

[8] SZAKOS D., ÓZSVÁRI L., KASZA, GY. (2020): Perception of Older Adults about Health-Related Functionality of Foods Compared with Other Age Groups. Sustainability, 12(7), p. 2748
[9] National Institute of Pharmacy and Food (2014): National Nutrition Status Survey (OTÁP 2014). https://www.ogyei.gov.hu/otap_2014

for consumers. Therefore I tested the openness to this product development idea during the interviews. 58.33% of those surveyed thought they would be interested in a sour cream imitation product that was fortified with calcium and vitamin D if its price remained even lower than traditional sour cream. Respondents open to development would spend an average of 17.58 HUF more on such a value-added small size (175 g) product with a 20% fat content. Accordingly, respondents would sacrifice approximately 122 HUF for a 20% sour cream imitation product supplemented with calcium and vitamin D_3. Although some consumers would be interested in imitation sour cream with functional properties, it has become clear from the expert consultation that producers do not see enrichment as cost-effective or as a feasible path for development.

Although colour association issues were not included in the interview topics through the idea of product enriched with calcium and vitamin D, colours that can be appropriate for distinction from traditional products are also relevant here. The green and yellow colours mentioned most often remind consumers of healthy, vitamin-rich foods[10,11], so they would be especially suitable for packaging the enriched product and for positioning the product.

3.5 Lessons learned from the expert consultation

Although only one of the invited dairy industry representatives undertook to participate in the research, the answers in the interview shed light on the situation of sour cream imitation producers. According to the expert, sour cream analogues or imitations give benefits both consumers - as they offer a cheaper, acceptable quality alternative to sour cream as well as manufacturers as they can expand their range by producing a new product.

However, during the consultation, the expert emphasized that the production of type 1 sour cream imitations requires more steps, more attention: solid vegetable fat is usually used for substitution must be melted first and then homogenized with skimmed milk. After the product-dependent fat adjustment, another homogenization process is required to obtain a sufficiently stable product.

The representative of the producers said that as analogues are made for lower-income social strata, demand fluctuates with changes in the general standard of living - that is, if the standard of living improves, the volume of sour cream imitation production becomes lower. At the same time, the representative explained that these products in the cheaper price category can be found by

[10] KASZUBOWSKI R. (2004): How to use color in food packaging. http://www2.uwstout.edu/content/rs/2004/article07.pdf?origin=publication_detail

[11] MEAD J. A., RICHERSON R. (2018): Package color saturation and food healthfulness perceptions. Journal of Business Research, 82, p. 10-18.

consumers without targeted communication, the customers know the product range. About misleading packaging and the display of products in shops, the expert emphasized that manufacturers are obliged to comply with the requirements of Regulation (EU) No 1169/2011.

3.6 New scientific findings

1. During the processing of the literature on dairy imitations products, I found that there is currently no classification that clearly distinguishes imitation products based on the raw materials used and the production technology. Therefore, I was the first to develop a suitable classification system, which I named the "Classification System for Dairy Imitations".

2. With the support of laboratory tests I was the first to prove that there is no significant difference in the content of protein, lactose, lactic acid bacteria, calcium and fat-soluble (A-, D_3-, E-) vitamins between type 1 sour cream imitations and conventional sour cream. There has never been an example of such a comparison of products before, which is supported by the publication of the present result.

3. Through analytical measurements, I found that the fatty acid composition and cholesterol content of type 1 sour cream imitations are more advantageous for those with cardiovascular problems and high cholesterol levels than traditional sour cream. Imitation products have significantly lower, about 70%, saturated fatty acid content, one-tenth trans-fatty acid content, and about one-eighth cholesterol content as measured in conventional products. Therefore, for some consumers, the replacement of sour cream with type 1 sour cream imitations may be highly recommended, the relevance of which is also shown in the peer-reviewed article on the subject.

4. I also pointed out that the majority of Hungarian consumers (69.76%) do not consciously decide to buy sour cream imitations, they are chosen intentionally only in about every 3rd purchase. Unintentional purchases are due to the similar packaging, product placement and more favourable prices of sour cream imitations, which were supported not only by the quantitative analysis but also by the qualitative survey. Proofing of both findings is a novelty in the field.

5. I set up a PLS-SEM model suitable for describing the willingness to buy sour cream imitations, and I discovered that consumers' willingness to buy can be predicted based on their experience-based price-value ratio perception, knowledge about imitations and sour cream's popularity. The factors of the model I have created explain 24% of the variance of the target variable, the model has adequate explanatory power in terms of the nature of the research area. The

scientific value and novelty content of the model is also confirmed by the scientific article published on the topic.

6. Through the PLS-SEM model and consumer interviews combined with observation, I confirmed my hypothesis that price-sensitive consumers buy sour cream imitates as a cheaper alternative to sour cream. My finding provides new information to the field that Hungarian consumers do not treat these products as a separate product category, but as a cheaper, organically and kitchen technology-appropriate substitute for sour cream. Consumers nevertheless call for a better distinction between traditional products, as both quantitative and qualitative surveys show, consumers, find the packaging and in-store display of imitation sour cream misleading. Taking into account the opinions of the respondents, I identified opportunities to ensure better distinctiveness, which could help the activities of producers and distributors of dairy imitations in the future as relevant information.

7. Using the results of the product range, laboratory tests and quantitative and qualitative surveys, I determined the possible development direction of sour cream imitations with added value in nutritional science functionality for certain consumers, while estimating the willingness to pay for the fortified product. Taking into account the opinions of consumers and the results of previous research, I also proposed the appearance of the fortified product. For the food category of sour cream imitations, such information was not available before the research was conducted.

4. CONCLUSIONS AND RECOMMENDATIONS

The directions of development have now become sufficiently separable, so I considered it important to develop a classification system that promotes a uniform interpretation of the concepts in the field. The classification system set up in my dissertation defines three different groups of imitation dairy products, which should be distinguished in their names (not only from traditional dairy products), as their quality and differences are significant and their product development potential (eg supplementation). In the case of type 1, which is produced by traditional methods but by substituting one ingredient (typically milk fat), the name "*dairy analogue*" may be appropriate, as the meaning of the analogue includes "not identical but in some respects adequate" to the original product. This wording is also in line with the definition in the international FAO Codex Alimentarius. Type 2, in which almost any ingredient can be replaced or combined with dairy-derived substances, is better suited to the term "*synthetic dairy product*". This type only imitates the original product, its ingredients, production and quality are completely different from the imitated food. Type 3 does not contain any milk-derived material. For people with allergies and intolerances, these foods "replace" traditional dairy products, so the term "*dairy product substitute*" can be suggested here. Regulation of types 2 and 3 would in any case be appropriate for essential product characteristics such as protein, vitamin and mineral content or lactic acid bacterial count ensuring that good quality products are marketed.

Based on the laboratory examinations, it could be seen that the most typical type 1 sour cream imitates in the Hungarian product range and traditional sour cream differ almost exclusively due to the differences between the fats, in other respects their quality is slightly different. This result refuted my hypothesis H1, which states that "The calcium, fat-soluble vitamin, and protein content of sour cream analogues lags behind that of sour cream".

The significant differences in the content of saturated and unsaturated fatty acids, trans-fatty acids and cholesterol in milk fat and palm fat used as a substitute make the consumption of sour cream analogues recommended for people with cardiovascular problems and high cholesterol levels. This confirmed my hypothesis H2. I concluded that type 1 sour cream analogues stand out from a nutritional point of view as an alternative to traditional products even without further modification or enrichment.

Through the analysis of my results, it became clear in line with my hypothesis H5 that consumers' attitudes and opinions about dairy analogues, imitations and substitute products can be influenced by expanding their knowledge and

experience about products, and knowledge also affects their willingness to buy. In addition, the quantitative consumer survey showed that the terms “dairy imitation”, “dairy analogue” and “substituted dairy product” refer to foods of exclusively plant origin to the majority of consumers, which proved my hypothesis H3. In general, therefore, it can be stated that it is not clear to consumers what products these definitions cover.

The results of both quantitative and qualitative consumer studies allowed me to conclude, proving my hypothesis H6, that consumers do not treat sour cream analogues as a separate product category, but as a low-priced food that can replace sour cream in food preparation. Using a vivid analogy: if we look at sour cream as mustard and sour cream analogues as mayonnaise, we can see that they are products with a similar function as sauces, similar texture, packaging, etc., but still have completely different compositions. However, sour cream analogues are not identified by consumers as ‘mayonnaise’ but as ‘cheap mustard’.

Extensive communication from the food industry and retailers would be needed, for example, for blowing away the misconceptions surrounding the product category. In order to address consumers successfully, effective methods must be chosen in practice, such as in-store tastings, designing infographics to explain the differences between products and presenting the benefits, or even the preparation and distribution of recipe recommendations for the use of sour cream imitations.

The biggest problem of imitations revealed by the dissertation is the possibility of confusing type 1 sour cream imitations with traditional sour creams. Misleading packaging and the way products are displayed in stores often contribute to that the customers unintentionally choose the analogue product. Random shopping usually causes negative feelings and annoyance from the majority of people. All this confirmed my hypothesis H4. Taking into account the needs of consumers, the most effective way to improve distinctiveness is to provide their packaging with a different colour from traditional products (such as green) or to separate the category from traditional dairy products on the shelves and to indicate the different product character. However, the use of uniform colour on products can be difficult due to the diversity and wide range of market actors. In addition to increasing market transparency, a better distinction between traditional and imitation foods will also help to create a more positive perception of imitations.

To eliminate misleading, self-regulation for manufacturers and retailers is recommended: self-regulation could be a clear limitation of misleading product appearance for those involved in the production, for example, that the traditional and analogue products of the same brand do not receive packaging with the same colour scheme and graphics. For retailers, attention should be expected to be

placed on product placement; at present, product display does not comply with the legislation in force in most of the examined places. Retail chains with several units or organizations operating in a franchise system could also formulate their own internal requirements and expand the training of their employees in this area, thus ensuring that they do their utmost to avoid misleading.

Research findings have highlighted that sour cream imitations, created primarily to reduce costs, offer many new, broader opportunities for food product development in light of modern nutritional science findings.

This complex research using several different methods can be attributed to a case study that can serve as a model for the study of other dairy analogues and imitations and draws attention to the thin line between deception and product development. My findings can provide useful information on consumer behaviour for food producers, distributors, marketers and policy-makers concerning dairy imitations.

With my dissertation, I wanted to contribute to making imitation sour cream a legitimate food in all respects, for not to mislead the consumer, but to convince the consumer with its favourable properties (nutritional physiological, technological benefits, the addition of potentially functional ingredients, etc.), that it is also worth considering buying these products. I am confident that my results and suggestions will help restore the battered reputation of dairy imitations.

PUBLICATIONS RELATED TO THE RESEARCH TOPIC

Journal articles (IF journal article):

1. **Tekla Izsó**, Gyula Kasza, László Somogyi (2020): Differences between fat-related characteristics of sour cream and sour cream analogues. *Acta Alimentaria*, manuscript accepted for publication (expected publication: December 2020)

2. **Tekla Izsó**, Barbara Szabó-Bódi, László Somogyi, Gyula Kasza (2019): Consumers 'willingness to buy dairy product imitations (analogues) based on structural equation modelling. *British Food Journal*, 121 (3), p. 835-848.

3. **Tekla Izsó**, László Somogyi, Anita Soós, Ildikó Zeke (2018): The effect of foreign fats on the physical properties of anhydrous milk fat. *Periodica Polytechnica Chemical Engineering*, 62 (2), p. 182-187.

Book, a chapter of a book (book excerpt in Hungarian):

4. **Tekla Izsó**, László Somogyi, Gyula Kasza (2020): The function of colours in the consumer perception of dairy products' attributes. In: *Kutatás-fejlesztés-innováció az agrárium szolgálatában*. *II. kötet.* Mezőgazda Lap- és Könyvkiadó, Budapest, manuscript accepted for publication (expected publication: October 2020)

5. **Tekla Izsó**, Dávid Szakos, Gyula Kasza (2017): Consumer-focused supervision of the food chain. In: Péter Szabó (ed.): *Kutatás-fejlesztés-innováció az agrárium szolgálatában*. Mezőgazda Lap- és Könyvkiadó, Budapest. ISBN: 978-963-286-726-7. pp. 312-317.