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Development of a low-fat lactose-free dairy spread containing viable lactic acid bacteria – Part 2: Texture analysis and sensory evaluation

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SUMMARY

The objective of our work was to compare the main texture characteristics of the low-fat (30%), lactose-free dairy spread developed by us, containing viable lactic acid bacteria, and those of commercially available dairy spreads by an objective, reproducible, instrumental test, and then to assess the expected market reaction to our new product. The results of the rheological tests have shown that, in terms of its texture, our lactose-free dairy spread is similar to currently commercially available similar dairy products of adequate quality. Compared to 25 to 39% fat products, it is neither softer, nor stickier, its spreadability is close to that of usual dairy spreads. The judges (250 people) found the flavor and texture of the developed product significantly better ($P<0.05$) than those of one of the traditional dairy spreads that has been available in stores for a long time. However, in terms of spreadability, the latter dairy product was found to be superior ($P<0.05$). It was found that our new product could be received well when placed on the market, however, it should be emphasized during its introduction that, in addition to the ideal texture characteristics and nutritional physiology properties of the well-known and popular dairy spreads, it also has added functional benefits since it is lactose-free and contains viable lactic acid bacteria.

Introduction

According to their original definition, dairy spreads are *„natural or spicy, post-heat-treated products with the rheology of butter and a fat-in-water type structure, prepared with the addition of pasteurized and homogenized cream acidified with lactic acid bacteria, butter, natural stabilizers, table salt, possibly spices (for example, ground paprika, caraway seeds, mustard, celery stripe, celery leaves, etc.) and a healthy coloring agent (β-carotene), enriched with milk substitutes (for example, milk powder, milk concentrate, milk protein concentrate, caseinate)"* **[8]**. Their structural characteristics are determined by the key step of their manufacturing process (homogenization) and the properties of the emulsifying and/or stabilizing agents used **[1] [8]**.

Already in the 1970s, intensive research was carried out in the Hungarian Dairy Research Institute (MTKI) on the possibilities of using homogenization in the dairy industry (for example, eliminating creaming, increasing yields, improving the texture of the finished product, inhibiting syneresis, developing a full flavor, etc.) **[12]**. This groundbreaking research has helped MTKI develop dairy spread, which is still in the leading position in the domestic market of spreadable dairy products. However, products similar to the "classic" dairy spread produced by the researchers of MTKI, which has been enjoying considerable domestic business success since 1984, are now rarely found on store shelves. The prices dictated by the big supermarket chains are often significantly lower than the market prices of the raw materials (cream, butter), therefore, manufacturers are trying to meet market demand by reducing nutrient content and using cheaper technological solutions, which has an adverse effect on the quality of dairy spreads.

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Since dairy spreads inherently contain lactose, their consumption can be a problem for people with lactose intolerance. Although the proportion of people with lactose intolerance is typically below 10% among the Western and Northern European and North American populations **[13]**, lactose-free dairy products are experiencing a renaissance in countries with developed dairy industries, thanks to consumer loyalty to these products and their willingness to pay up to 50 to 100% more for them. In Hungary, more than one third of the adult population is affected by lactose intolerance **[2] [9]**, thus, lactose-free foods have a significant market potential, which fortunately has been recognized by dairy companies recently.

In the first part of our two-part communication, our successful efforts to develop the manufacturing technology for a new type of functional dairy product, a low-fat, lactose-free dairy spread containing viable lactic acid bacteria were presented **[5]**, while here we report the results of our research during which our new dairy product was compared, via instrumental texture analysis, to commercially available dairy spreads, while the expected market reaction to our experimental product was also assessed.

Materials and methods

Production of a low-fat (30%), lactose-free dairy spread containing viable lactic acid bacteria

The production of the low-fat, lactose-free dairy spread containing viable lactic acid bacteria necessary for the preliminary sensory testing, the subsequent instrumental texture analysis and the tasting to assess the expected market reaction was carried out according to the manufacturing technology described in the first part of this study **[5]**.

Sensory testing of commercially available dairy spreads and the low-fat, lactose-free dairy spread containing viable lactic acid bacteria

Commercially available product distributed as dairy spreads were marked with the letters *A*, *B*, *C* and *D*, while our experimental dairy product was marked *LM* (lactose-free). The average composition of the different products is shown in ***Table 1***.

Sensory testing was carried out using the conventional 20-point system. Evaluation criteria and the corresponding point limits are listed in ***Table 2***.

Instrumental texture analysis commercially available dairy spreads and the low-fat, lactose-free dairy spread containing viable lactic acid bacteria

Texture characteristics of the dairy spreads with the compositions listed in ***Table 1*** and marked with the codes *A*, *B*, *C*, *D* and *LM* were analyzed in five replicates using a TA.XT2 Texture Analyser (Stable Micro Systems, Godalming, United Kingdom), and the average curves were calculated from the results using the Texture Expert 1.22 software (Stable Micro Systems) of the instrument.

The forces between the probe and the sample during entry into the sample, at a constant speed and for a well-defined distance, of either a self-made probe or the one that is an accessory to the instrument with a well-defined geometry, or during its return to the starting point at a constant speed are measured by the instrument as a function of the time or, optionally, the distance. Thanks to the preset, constant probe speed, the rate of relative deformation is constant. Describing the deformation in the sample and interpreting the curves is a complex task, because the results are also affected by factors, such as, for example, the compression exerted by the probe moving downward, the shear along the edges of the probe during its penetration (which (may) result in arch formation on the probe), forces due to frictional resistance between the sample and the probe, or the forces required for the lateral flow of the sample **[3]**.

When comparing the samples, the geometry of the sample holder and the thickness of the sample are particularly important, since pressure waves are generated by the penetrating probe during the measurement. It should be avoided that these affect the probe, since they may cause disturbances in the measurement. In the case of spreadable products, care also should be taken when comparing samples that the surface of the probe at the time of immersion is parallel to the surface of the sample, and so the surface is intact and smooth. In addition to the force acting on the probe moving to the set depth at the set speed, various parameters are generated by the instrument software by computing the area below the curve between the two points defined by us and by comparing the areas, as well as the slopes of the curves, if appropriate, which can then correlate with organoleptic properties such as hardness, spreadability, stickiness or tackiness.

All samples were analyzed using the same probe at the same immersion and return speed and depth at the same temperature, as follows:

- test mode: compression mode;
- option: return to starting position, 1 cycle;
- probe: P/20 20 mm diameter aluminum cylinder;
- probe immersion speed: 1 mm/s;
- immersion depth: 10 mm;
- starting force and type: 5.0 g*, auto;
- sample temperature: 6 °C.

Due to the setting of the instrument, the force is given in grams.

* The weight of 1 g is 9.81x10-3 N (the editor)

The following data were used to evaluate the dairy spreads (for easier understanding of these, see ***Figure 1***):

- 1^f = maximum compression force (maximum force required to penetrate to a depth of 10 mm at a speed of 1 mm/s, dimension: g); a value indicating the hardness of the sample, the force required for a certain deformation of the sample.
- $A_1 : A_2$ = area under the curve (g × s) from the moment the starting force of 5.0 g is reached (threshold value, „anchor 1" on the ordinate) until the maximum compression force 1^f (2) is reached; the hardness or softness of the sample can also be inferred from this value.
- $A_2 : A_3$ = area under the curve between the peak indicating the maximum compression force (2) and the return of the curve to the abscissa (3); decompression work (g × s). The elastic stress in the sample, exerted on the probe after the compression tends to level off as the function of the resulting "counter-force", i.e., time. By dividing the decompression work by the compression work, a dimensionless ratio is obtained, providing information on the elasticity of the product.
- 2^f = the maximum force (-g) required for the probe to return from its maximum depth (10 mm), the peak in the negative area (4). It is the maximum adhesive force, which gives information about the adhesiveness or "doughiness" of the sample (in this case, the spreadable dairy product).
- $A_3 : A_4$ = adhesion work (–g × s). Its magnitude refers to adhesiveness, „pastiness", „doughy" texture, but may also be influenced by the weight of the sample arched on the probe.

Comparison of the low-fat, lactose-free dairy spread containing viable lactic acid bacteria with traditional dairy spreads and assessment of the expected market reaction to it

Tasting of the product was carried out with the help of the staff of the Szocio-Gráf Market Research and Polling Institute (Pécs) and using its infrastructure. Information on the products tasted during the sensory tests was obtained with the involvement of 250 persons, through quantitative, personal questionnaire data collection, using the blind test method and filling out containing both closed and open questions. 62% of the respondents (155 persons) were female, 38% (95 persons) were male. Their age distribution was as follows: 35% were 18 to 30 years old, 29% were 31 to 45 years old, 16% were 46 to 59 years old and 20% were 60 years old or older. We sought to find the answers to the following questions:

- Which of margarine, dairy spread and butter do they consume at any frequency?
- Which one do they consume most often?
- How often do they consume butter or dairy spread?
- When tasting products *„B"* and *„LM"*, how satisfied were they with their taste, texture and spreadability?
- Do they recognize the tasted products?
- Do they feel any difference between the two products (which one tastes better)?
- What difference do they feel (how is the better tasting product better)?
- If it were commercially available, would they consume the product at some frequency?

Mathematical–statistical analyses

Texture data were processed, analyzed and plotted by Texture Expert 1.22 (Stable Micro Systems), results by Microsoft Excel 2010 (Microsoft, Budapest) and Minitab Statistical Software (Minitab, State College, PA, USA), while questionnaires filled out during the sensory tests by Microsoft Excel 2010 (Microsoft) and IBM SPSS Statistics Base (Statistical Products, Budapest).

Results and their evaluation

Organoleptic properties of commercially available dairy spreads and the low-fat, lactose-free dairy spread containing viable lactic acid bacteria

Results, in the 20-point sensory testing system, of four types of commercially available dairy products sold as dairy spreads (*A–D*) and our lactose-free product (*LM*) prepared as described in the first part of our paper **[5]** are shown in ***Table 3***.

Commercially available products marketed as dairy spreads have significantly different nutritional values and fat contents. This is mainly due to the fact that since the abolition of the 2nd edition of prescription 1-3/51-1 of the Hungarian Food Codex **[7]** practically no domestic (Hungarian) regulation on the production and composition of dairy spreads exists. Products are classified by certain manufacturing companies as belonging to the so-called „spreadable butter product" category, but marketed under the positive-sounding "dairy spread" name.

However, this practice is in contradiction with the requirements of Regulation (EU) No 1308/2013 **[4]**, according to which dairy spreads should be made

exclusively from milk and/or certain dairy products, with the following fat contents: less than 39%; more than 41% but less than 60%; or more than 62% but less than 80%. At the same time, the Regulation prohibits the use of stabilizers in the manufacture of dairy spreads **[4]**. However, the „classic" Party dairy spread and all the other dairy spreads currently manufactured are made with a stabilizer. In the absence of a stabilizer, the fatty phase would separate from the aqueous phase already in the cutter during the manufacture, and casein would precipitate at a pH below 4.6 due to the intensive heat treatment (75–85 °C). The situation is further complicated by the fact that higher VAT rates apply to dairy spreads with a fat content of less than 39%. It also follows from the above that there are numerous inconsistencies and confusing requirements in the regulations governing the production and distribution of dairy spreads.

Fat contents of the products tested in our laboratory are shown in ***Table 1***. It is apparent that the previous requirements were met by dairy spreads *A* and *B*, while product *D* could be best described as post-heat-treated sour cream. The manufacturer of product *C* chose the middle ground regarding fat content.

In terms of the organoleptic characteristics, product *A* was severely overstabilized: its surface cracked and separated from the wall of the cup. Its texture did not meet the „spreadable between 5 and 20 °C" characteristic, it was slightly crumbly and overall proved to be hard. Its taste was slightly "tired" because of the overstabilization.

Product *B* was shiny, butter yellow, homogeneous, but still with a slightly soft texture, which was probably also due to stabilization deficiencies. Nevertheless, this product was the closest to Party dairy spread, which is considered to be the standard. Its taste was particularly buttery.

The upper layer of product *C* was slightly dehydrated, therefore, it lost its luster, however, its texture, despite its lower fat content, was closer to that of the standard, in fact, it was almost the same. On the other hand, its taste lacked the „pleasantly sour" character and, moreover, it had a somewhat „cooked" taste.

Product *D* was given the lowest scores; it was already predestined for this by its 25.0% fat content. Its texture was soft, however, its taste almost reached the desired level.

As for our experimental product (*LM*), its appearance lacked the luster and color reminiscent of butter, but met the „uniformly bone white" criterion. Its texture was slightly softer than the usual texture of dairy spreads. Its smell was characteristically aromatic and sour, which is not surprising because of the viable bacteria, its taste was found to be pure, fresh and aromatic, which is characteristic of the product.

Based on our laboratory sensory test results, it was decided which dairy spread should be included in the sensory tests to be conducted by the market research and polling company. It was decided that, in addition to the experimental product (*LM*), one of the 39.0% fat content products, closest to the original concept, would be chosen. Since product *A* was severely overstabilized, product *B* was chosen.

Instrumental comparison of commercially available dairy spreads and the low-fat, lactose-free dairy spread containing viable lactic acid bacteria

The physical properties of dairy spreads were also tested by objective, reproducible instrumental analysis. We wanted to compare the texture characteristics of our developed product to those of commercially available dairy spreads and, based on this, to determine where it is located in relation to the other ones, into which niche a potential future manufacturer would best fit it. The results of our measurements with the TA.XT2 texture analyzer (Stable Micro Systems) are shown in ***Table 4***, while the mean curves prepared on the basis of these results are shown in ***Figure 2***.

Based on the results shown in ***Table 4*** and ***Figure 2***, the following conclusions can be drawn:

- *Compression force, hardness:* In accordance with the experience of the sensory testing, the texture strength of dairy spread *A* was significantly higher than that of all other dairy spreads, including the experimental product: six times that of *B*, one and a half times that of *C*, more than four times that of *D* and the experimental product *LM*. The fat contents of products *A* and *B* were the same and their dry matter contents were nearly identical, and their technologies were the same as well; these two products were still manufactured using the „classic" dairy spread technology **[8]**. The significant difference between their F_1 values was probably due to the differences in the composition and concentration of their stabilizers. The decisive role of the stabilizer in determining the texture was also demonstrated by the fact that the texture strength of dairy spread *D* with only a 25% fat content, also prepared by the classic technology, was 28% higher than that of product *B* with a fat content of 39%. The hardness of dairy spreads *D* and *LM* were practically the same, but the hardness of *LM* was higher than that of product *B* with a fat content of 39%.

- *Compression work:* According to the measured values of this parameter, the texture strength of the dairy spreads tested decreased in the order *A>C>D=LM>B* as well.

- *Decompression work and elasticity:* Both the figures and the curves clearly show that product

C exhibited the most elasticity, the extent of which could be described organoleptically by the attribute „rubbery" or overstabilized. This was probably due to stabilization, and not technological deficiencies. Least elastic was the texture of dairy spreads *A* and *LM*. The elasticity of the products decreased in the following order: *C>B=D>A=LM*.

- *Adhesive force and adhesion work, adhesiveness:* Based on the results and taking into account texture strength it can be stated that dairy spread *B* adhered to the probe the most (45%) when it was returning to its starting position, and dairy spread *A* adhered the least (33%). The adhesiveness of products *C* (37%), *D* (35%) and *LM* (38%) were nearly the same.

Although the samples were prepared at the same time (on the same day), based on the standard deviations listed in ***Table 4*** it can be concluded that they were probably not from the same batch.

COMPARISON OF THE LOW-FAT, LACTOSE-FREE DAIRY SPREAD CONTAINING VIABLE LACTIC ACID BACTERIA WITH TRADITIONAL DAIRY SPREADS AND ASSESSMENT OF THE EXPECTED MARKET REACTION TO IT

Of the 250 persons surveyed in our consumer preference tests, the so-called lay judges **[10]**, butter was named by 183 people (73.2%), margarine by 165 people (66.0%) and dairy spread by 171 people (68.4%) as a food consumed by them at any frequency, meaning that two thirds of the respondents occasionally consume all three products. When answering our question *„Which product do you consume most often?"*, 47.6% answered margarine, 28.4% butter and 24.0% dairy spread. It is clear that the effect of the „counter-industry" campaign **[11]** is still in effect, but the attractiveness of lower margarine prices cannot be overlooked. It is obvious that far more people consume margarine than butter or dairy spreads, but even these data do not explain why the per capita consumption of margarine in Hungary is four times higher than that of butter and dairy spreads together.

Consumption frequency data of butter and dairy spreads are summarized in ***Table 5***. According to the data, about one quarter of the respondents consume butter and/or dairy spreads every day. Given that nearly 70% of people consume these products at least once a week, it is obvious that our results cannot be considered representative.

Considering each category as a nominal variable, a statistical indicator was created, which can also be interpreted as a frequency scale (1: daily … 6: never). Based on this, it was found that women consume butter and dairy spreads more often (2.88) than men (3.57), and that 31–45 year old people (2.14) and 46–59 year old people (2.50) consume butter and dairy spreads more often than members of the youngest (3.33) and the oldest age group (3.40).

During the taste test, dairy spread *B* with a fat content of 39.0% and experimental product *LM* were tasted by the participants, and then taste, texture and spreadability were evaluated by giving school grades. Results are summarized in ***Table 6***.

It is apparent that the taste and texture of our lactose-free dairy product were judged to be significantly better ($P<0.05$) than those of the commercially available dairy spread *B*; however, the situation was reversed when considering the spreadability of the products (***Table 6***). A more detailed analysis of the data also revealed some additional phenomena:

- All of the properties of product *B* were rated higher by men than women (taste: 4.22 vs. 3.71; texture: 4.71 vs. 4.28; spreadability: 4.95 vs. 4.78), however, there was no difference between the genders when rating dairy spread *LM*.

- Those aged 31–45 and 46–59 years old (3.71 and 3.75) were less satisfied with the taste of product *B* than younger (4.22) and older (4.60) people. 18-30 year-olds were less satisfied with the texture (4.0) and spreadability (4.67) of dairy cream *B* than older people (between 4.43 and 4.75, and above 4.8, respectively). In the case of dairy spread *LM*, 18-30 year-olds were less satisfied with spreadability (4.22) than older people (4.71–4.90).

- Those who consume mostly dairy spreads were less satisfied with the taste (3.83) and spreadability (4.67) of dairy spread *B* than those who consume mostly margarine (4.17 and 4.83) or butter (4.14 and 4.95). In the case of dairy spread *LM*, those who consume mostly margarine were less satisfied with the spreadability (4.25) than those who mostly consume dairy spreads (4.83) or butter (4.95). In contrast, those who consume mostly butter were less satisfied with the texture of experimental product *LM* (4.29) than those who consume mostly margarine (4.58) or dairy spreads (4.67).

When asked, *„Do you recognize what product you have tasted?"*, more than three quarters of respondents answered correctly for both products (*B*: 77.6%; *LM*: 75.9%). Dairy spreads were thought to be cheese spreads by 9.0% of those surveyed, some thought the experimental dairy spread to be „Danish butter-like product", and there was even someone who described product *B* as „too soft cheese". All of the respondents (250 people) found some difference between the products tested: 88.0% in taste, 30.0% in texture, 7.2% in color and 3.6% in spreadability.

To the question *„Which one did you like more?"*, 51.2% indicated our *LM* product, 41.2% dairy spread

B, while 7.6% of the judges could not distinguish between the taste of the two dairy products. Men preferred dairy spread *B* (61.4% *B*, 28.4% *LM*, 10.2% identical), women liked dairy spread *LM* more (61.1% *LM*, 27.8% *B*, 11.1% identical). 31-45 year-olds preferred *LM* (75.7% *LM*, 14.3% *B*, 10.0% identical), those over 60 preferred *B* (60.0% *B*, 29.5% *LM*, 10.5% identical), while the other two age groups found no difference between the dairy spreads in terms of taste. Those who consume mostly margarine (58.3% *LM*, 33.3% *B*, 8.4% identical) and dairy spreads (50.0% *LM*, 34.3% *B*, 15.7% identical) preferred dairy spread *LM*, while those who consume mostly butter liked product *B* more (55.1% *B*, 37.8% *LM*, 7.1% identical).

The answers to the question *„How is the product that tastes better superior?"* showed that the lactose-free dairy spread, to quote the tasters, had a taste that was "more intense", „more like home-cooking", „more sour" and „more natural", that is why they chose it. In the case of product *B*, its „more aromatic flavor" was mentioned by most. Almost the same number of respondents considered the texture of their preferred product better (*B*: 9.2%; *LM*: 8.6%).

The most important question for potential manufacturers is *„If the product were commercially available, how often would you consume it?"*. Answers of the judges are shown in ***Table 7***.

The results of our survey, despite being non-representative, have shown that the product developed by us has a place in the dairy market. The ever-growing number of health-conscious Hungarian consumers is indicated by the fact that when it was announced at the end of the product tasting that the abbreviation *LM* meant lactose-free, and that the product also contained viable bacteria, then many people who preferred dairy spread *B* during the survey said that had they known this information before, they would have preferred the experimental product. This is entirely plausible given the phenomenon that the uniformly favorable perception of functional foods positively influences the sales opportunities for these products all over the world **[6]**.

Conclusions

Based on the results of instrumental texture analyses and tasting tests aimed at determining the expected market reaction to the product it can be stated that our newly developed low-fat (30%), lactose-free dairy product containing viable lactic acid bacteria is expected to have a positive reception if it becomes commercially available, however, during the introduction it should be emphasized that in addition to the beneficial nutrition physiology and texture properties characteristic of traditional dairy spreads, it has additional functional benefits: it contains viable lactic acid bacteria and is lactose-free.

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