European Journal of Technical and Natural Sciences 2026, No 4
ISSN 2414-2352

PREMIER Publishing
ppublishing.org

DOI:10.29013/EJTNS-26-4-130-138

FOOD COMPOSITIONS BASED ON BUTTER (Fundamental Differences Between the Churning Process of a Butter-Based Food Composition and Conventional Processes Intended for the Same Purpose)

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Cite: *Vorobiova K. (2026). Food Compositions Based on Butter. (Fundamental Differences Between the Churning Process of a Butter-Based Food Composition and Conventional Processes Intended for the Same Purpose). European Journal of Technical and Natural Sciences 2026, No 4.* https://doi.org/10.29013/EJTNS-26-4-130-138

Abstract

This article examines the development of innovative food technologies based on the dynamic processing of liquid and semi-consistent multicomponent food systems intended for the production of butter-based food compositions and other combined food products with enhanced nutritional properties. Particular attention is devoted to the analysis of technological, nutritional, environmental, and regional factors that influence the development and commercialization of innovative food products intended to comply with increasingly stringent public health and environmental requirements while taking into account established dietary traditions, climatic conditions, and cultural characteristics of different regions. The article substantiates the feasibility of applying dynamic processing technologies to the preparation of composite, compound, and homogeneously combined food products using dairy-based components as the primary technological medium. The proposed concept integrates the development of specialized technological equipment with nutritional algorithms aimed at producing food compositions characterized by reduced fat content, increased concentrations of vitamins and biologically active compounds, and improved functional and consumer properties. It is concluded that the proposed technological approach represents a promising direction in modern food engineering, creating new opportunities for the production of health-oriented functional food products while supporting the integration of innovative processing technologies into the food industry.

Keywords: *Butter-based food compositions; Food composites; Churning apparatus; Dynamic processing of food composites; Dynamic treatment of butter-based food compositions; Combined food products; Functional food products; Nutritional algorithm design; Vitamin-enriched food compositions; Food compositions enriched with biologically active compounds; Reduced-fat food compositions; Fat content minimization; Health-oriented food technologies*

New food products compositions

Food products, similarly to pharmaceutical products and, to a certain extent, cosmetic products, represent a highly quality-controlled sector of the innovation landscape in which inventors operate.

First and foremost, this field is characterized by the necessity for complete compliance of new products and manufacturing technologies with public health standards and increasingly stringent environmental regulations.

It should also be recognized that this technological field is strongly influenced by established traditions, as well as by the climatic and cultural characteristics of the region in which an innovative product is introduced to consumers.

At the same time, it is important to acknowledge that the most successful local innovative solutions and inventions, although initially developed for the food industry, may subsequently find applications in broader fields of engineering and technology, thereby serving as effective drivers for the progressive development of integrated multidisciplinary innovations.

The present paper introduces one such promising technological approach.

The proposed technology is based on the hydrodynamic mixing of different liquid components combined with simultaneous churning under a dynamic, periodically repeated, highly developed kinetic regime involving the regeneration of accumulated kinetic energy and its sequential transfer into the processing system.

The proposed innovative process represents a method of dynamic treatment applied to mixed and churned liquid or semi-consistent food components.

To date, the most extensively investigated and frequently applied materials within this process are components derived from various dairy products.

The startup company to be established by the author of this publication is conducting research and development in this field, including the design of specialized technological equipment. The objectives of these scientific investigations, engineering and industrial design activities, as well as the development of nutritional algorithms and dietary programs, are to identify new technological approaches for producing composite, compound, and homogeneously combined food products characterized by the absence or substantial reduction of fat content together with an increased concentration of vitamins and biologically active compounds.

An additional objective of the proposed process is to obtain, without thermal treatment or any other aggressive technological impact on the product, primarily dairy or fermented dairy products, homogeneous mixtures or whipped multicomponent systems that under conventional processing conditions either do not mix at all, mix only poorly, or fail to remain stable over time.

To enable the implementation of the proposed technology under modern industrial production conditions and in accordance with current food quality and safety standards, a further objective of the company is to develop stable and homogeneous food systems composed exclusively of basic food ingredients while maintaining their physicochemical properties and uniformity over extended storage periods.

The final products obtainable using the proposed technology include:

- butter churned from sour cream with an unusually low fat content of no more than 13%;
- butter churned from sour cream enriched with multivitamin additives in the form of a sour cream–carrot juice composition;
- butter churned from sour cream enriched with multivitamin carotenoid additives obtained through the company's proprietary deep-processing technology for chicken eggs;
- butter churned from sour cream with tomato juice;
- butter churned from sour cream with various fruit syrups;
- butter churned from sour cream with honey;
- butter churned from sour cream with garlic and dill;
- butter churned from sour cream modified with ultra-pure egg oil produced using the company's proprietary technology;
- butter churned from sour cream modified with alpha-lecithin obtained

through the company's proprietary deep, waste-free processing technology for chicken eggs;
- butter churned from sour cream modified with albumin obtained through the company's proprietary deep-processing technology for chicken eggs;
- butter churned from sour cream modified with lysozyme obtained through the company's proprietary sequential deep, waste-free processing technology for chicken eggs;
- butter churned from sour cream modified with cocoa butter;
- butter churned from sour cream modified with avocado paste;
- butter churned from sour cream modified with vegetable pastes;
- butter churned from sour cream modified with fruit pastes.

The direct processing of milk and its modification through mixing with other components makes it possible to create new modified combined dairy composites possessing novel functional characteristics and exceptionally high consumer value.

First and foremost, the technology enables the production of a whipped mixture of milk and honey. The formulation employs low-fat milk containing 1% fat, cooled to a temperature of 2–3°C, and natural bee honey in a proportion of 75% milk and 25% honey. The resulting product is homogeneous, stable, possesses an exceptionally delicate and pleasant taste, and exhibits high nutritional value.

Owing to the extensive capabilities of the hydrodynamic mixing and churning apparatus developed within the company's research and development program, it is possible to prepare a wide variety of mixtures based on numerous combinations of liquids, viscous materials, food pastes, and syrups.

The apparatus implementing the proposed technology can be manufactured in a wide range of production capacities. One configuration, designed to produce approximately 1 liter of mixture or approximately 850 g of butter per churning cycle, is intended for use by farmers and may be employed for processing surplus milk.

The apparatus is based on a patented invention utilizing the principle of generating hydrodynamic linear reciprocating kinetic pulsations within the closed volume of a vessel containing the mixed and churned components. The induced hydrodynamic movements are highly efficient, enabling both intensive mixing and churning within a comparatively short processing time while producing an exceptionally homogeneous mixture or composite butter.

The apparatus may be manufactured as a consumer product equipped with a relatively small processing vessel having a capacity of approximately 1 liter. It may be powered either by an electric drive or by a manual drive, the latter significantly reducing manufacturing costs while increasing market accessibility and sales potential.

The apparatus may also be manufactured as auxiliary equipment for cafés and restaurants. In this configuration, the vessel capacity may be increased to approximately 2 liters, and the delivery set may include several interchangeable processing vessels to improve operational efficiency and versatility.

Another configuration may be designed as specialized technological equipment for dairy processing enterprises, where it can be employed for the production of small batches of innovative dairy food composites.

The apparatus may also be manufactured as an automated technological system intended for large-scale and mass production of modified dairy products.

Figure 1. *Illustrates a food composite based on a naturally fermented lactic acid–fat matrix obtained by adding a fermenting agent, such as kefir, to cream separated from whole milk, where the kefir itself is likewise produced through the fermentation of whole milk*

The structural design and operating principle of the proposed apparatus are based on the proprietary inventions developed by the company (Photo 1).

Figure 2. *Illustrates a food composite based on a naturally fermented lactic acid–fat matrix blended with carrot paste in a proportion of 60 parts of the lactic acid matrix to 40 parts of the remaining composite components*

Figure 4. *Illustrates an integrated food composite based on a naturally fermented lactic acid–fat matrix that has been dynamically and homogeneously blended with natural tomato paste and a natural garlic paste sauce in an initial proportion of 70 parts of the lactic acid–fat matrix to 30 parts of the remaining composite components*

Various additives may be incorporated into the matrix, including, for example, nut pastes, garlic-based sauces, and similar ingredients that do not alter the color of the resulting food composite.

Figure 3. *Illustrates a food composite based on a naturally fermented lactic acid matrix blended with a natural dill–garlic–olive sauce in an initial proportion of 70 parts of the lactic acid matrix to 30 parts of the remaining composite components*

Figure 5. *Illustrates a food composite based on a naturally fermented lactic acid matrix dynamically blended with natural bee honey supplemented with nut paste, in an initial proportion of 70 parts of the lactic acid matrix to 30 parts of the remaining composite components*

Of particular importance is the capability to homogenize the food composite simultaneously with the process of mechanical - hydrodynamic churning. This technological feature makes it possible to incorporate components that would otherwise be difficult to disperse uniformly, including products obtained through the company's

proprietary deep, waste-free processing of chicken eggs.

These ingredients may be introduced in the form of finely dispersed ultra-pure albumin powder, highly purified liquid alpha-lecithin, gel-like multivitamin carotenoid formulations, or highly purified liquid lysozyme, a natural preservative that imparts unique storage stability and significantly enhances the shelf life of the final product.

Sensory evaluation of the developed food compositions demonstrated exceptionally high organoleptic characteristics across a wide range of component combinations. (Photo 2.)

Figure 6. *Illustrates a food composite based on a homogeneous blend of a naturally fermented lactic acid matrix, prepared exclusively from natural ingredients and containing no additives, preservatives, or stabilizers, dynamically and uniformly mixed with a homogeneous mixture of poppy seeds that had been pre-homogenized with natural bee honey and natural nut paste*

Figure 7. *Illustrates several representative examples from the wide variety of lactic acid–based food composites and integrated food composites that can be produced, even under household conditions, while maintaining a high level of product quality and hygienic safety*

Fundamental Differences Between the Proposed Churning Process for Butter-Based Food Composites and Conventional Churning Technologies

The proposed butter churning process differs fundamentally from existing technologies of the same purpose in several essential structural and technological aspects.

- Churning is performed within a vessel consisting of a cylindrical body closed at both ends by hemispherical end caps provided with centrally located conical openings;
- The churning vessel is assembled from a cylindrical shell with conically machined end surfaces and two hemispherical end caps incorporating matching conical seating surfaces and coaxial conical openings. During assembly, the end caps are aligned with the cylindrical shell through the mating conical interfaces. The complete structure is secured and hermetically sealed by clamping devices mounted within threaded openings of the drive frame. Each clamping device contains a central through-hole equipped with a closure mechanism and incorporates a conical tip aligned with the axis of the opening. During assembly, these conical tips engage the corresponding conical openings of the hemispherical end caps, thereby simultaneously positioning, fixing, clamping, and sealing the internal working volume of the vessel;
- Owing to these design features, the proposed apparatus provides not only

substantial structural differences from conventional churning systems but also significant technological advantages, resulting in improved product quality and a considerably expanded technological operating range for the butter churning process.

Additional Functional Capabilities of the Proposed Process

The proposed apparatus additionally provides several technological advantages that are unavailable in conventional systems.

- The working chamber in which butter churning is performed is fully detachable and reconfigurable;
- During operation, authorized access to the internal processing chamber is possible, allowing additional ingredients to be introduced, processing by-products to be removed, or portions of the product mixture to be withdrawn without compromising the overall operation;
- The conical openings incorporated into the hemispherical end caps enhance disruption and redistribution of the churning mass as it impacts the inner hemispherical surfaces. These openings simultaneously perform multiple functions, including activation, alignment, positioning, sealing, fixation, and, most importantly, serving as technological gateways that permit either the introduction or removal of material, depending on the spatial orientation of the vessel;
- The proposed design allows multiple interchangeable vessels to be used with a single churning apparatus. Consequently, different formulations may be processed sequentially with minimal interruption, including variations in the composition of the lactic acid matrix, fat content, and other formulation parameters;
- The hydrodynamic characteristics of the proposed process are significantly enhanced by the geometry of the vessel. At the end of each linear displacement, the churning mass encounters a hemispherical cavity incorporating a central activating cone. During every impact occurring after each half-rotation of the drive frame, the product undergoes rapid transformation from a cylindrical to a spherical configuration within an extremely short time interval. Thus, deformation and churning occur simultaneously, substantially increasing process efficiency;
- This unique mode of mechanical action creates a kinetically diverse regime of forced deformation in which the product experiences repeated changes in both volume and geometry under the combined influence of multiple dynamic forces. These forces arise from the interaction between the vessel geometry and the kinematic characteristics of the butter-churning apparatus, resulting in highly efficient hydrodynamic processing.

Experimental Evaluation of the Hemispherical End Caps

Testing of prototype hemispherical end caps demonstrated that:

- their design is highly manufacturable;
- they possess excellent mechanical strength;
- they are convenient to operate and maintain;
- they satisfy stringent hygienic requirements;
- they can be manufactured from a wide variety of engineering materials; and
- multiple interchangeable versions of the hemispherical end caps, differing in spherical curvature and the depth of the central conical opening, may be used with the same cylindrical shell while maintaining complete compatibility of all mating interfaces.

Apparatus for Churning Food Composites, Including Composite Butter: Description of the Device and Principles of Its Practical Operation

The proposed apparatus for churning and homogenizing food compositions and composite butter is intended for the efficient production of composite dairy products based on fermented dairy raw materials, primarily sour cream or cream, preferably with a reduced fat content. The initial raw materials

or individual components may be subjected to fermentation prior to processing.

Preliminary experimental evaluation demonstrated that the apparatus efficiently produces butter not only from conventional sour cream but also from sour cream supplemented with a wide variety of ingredients, primarily of plant origin.

Representative additives include:

- carrot juice;
- carrot purée or carrot paste;
- tomato juice;
- tomato paste;
- cucumber brine;
- cucumber purée;
- avocado purée;
- kiwi purée;
- sweet pepper purée;
- various squash and zucchini purées;
- fruit purées, including apple, plum, peach, pear, apricot, pineapple, and purées prepared from tropical fruits and vegetables;
- combinations of the above ingredients together with dill, garlic, onion, and lemon;
- prune pulp;
- preserves prepared from chokeberry, sea buckthorn, and other medicinal fruits and berries;
- berry purées prepared from strawberry, wild strawberry, blueberry, blackcurrant, raspberry, mulberry, viburnum, gooseberry, and numerous other berries.

This list is not exhaustive and may be expanded to include fruits, vegetables, and other plant-derived ingredients characteristic of different geographical regions, either individually or in various combinations.

The composition of the resulting composite butter may additionally be modified by introducing vegetable fats during the churning process in order to regulate the ratio between animal-derived and plant-derived lipid fractions.

To maximize application flexibility, the apparatus has been designed to accommodate production of composite butter formulations containing a wide variety of additives and manufactured in different batch volumes.

The capability for rapid reconfiguration to produce composite butter formulations with different ingredients represents one of the principal operational advantages of both the apparatus and the proposed churning technology.

Mixer Vessel Design

The mixer vessel consists of three principal structural components, the most innovative of which have the greatest influence on churning efficiency and on the characteristics of the resulting commercial products.

Cylindrical vessel body

The cylindrical shell incorporates conical recesses at both flange ends. These simultaneously provide hermetic sealing of the working chamber while ensuring precise centering and three-dimensional geometric alignment of the vessel throughout the churning process, thereby maintaining constant spatial relationships between all structural elements and preserving the alignment of the apparatus axes.

Upper hemispherical end cap

The upper hemispherical cover incorporates two coaxially arranged conical surfaces designed for centering, positioning, and sealing the vessel. The upper conical opening, which receives the axial locking force from the fixing mechanism equipped with a closable axial passage, permits all required components of the butter formulation to be introduced into the sealed vessel without disassembling the apparatus.

Lower hemispherical end cap

The lower hemispherical cover incorporates three coaxial conical surfaces intended for centering, positioning, sealing, and removal of process by-products from the internal chamber. The lower conical opening receives axial locking force from a fixing mechanism equipped with a ball valve, allowing liquid by-products generated during butter churning to be discharged while the vessel remains fully assembled and hermetically sealed.

Churning Procedure

The production of high-quality, highly purified, homogeneous butter without additives consists of the following sequence of operations.

Following cleaning after the previous processing cycle, the cylindrical vessel body together with the upper and lower hemispherical end caps are aligned through their mating conical surfaces. The assembly is then positioned within the supporting frame, and the locking mechanisms are tightened along the longitudinal axis until complete engagement of the conical interfaces between both end caps and the cylindrical shell is achieved.

The sealing plug incorporated into the upper locking mechanism is then opened, and the required quantity of sour cream or fermented cream is introduced into the internal chamber of the vessel.

After filling, the sealing plug is closed and the drive frame is set into rotational motion. During operation, the product moves longitudinally inside the vessel, completing one full reciprocating displacement and impacting the hemispherical end surface once during every half revolution of the rotating frame.

Upon completion of the churning cycle, the apparatus is stopped and the frame is rotated until the lower hemispherical end cap occupies the downward position. The ball valve is then opened, allowing the liquid by-product generated during butter churning to be discharged from the vessel.

The locking mechanisms are subsequently released, and the vessel assembly is removed from the frame. Both hemispherical end caps are detached, after which the finished butter is removed from the cylindrical chamber of the mixer vessel. The three structural components are then washed, and, if required, replaced with a clean interchangeable vessel assembly.

When additives or combinations of additives are required, all components are introduced according to the procedure described above.

If ingredients must be incorporated sequentially or at predetermined time intervals, the rotating frame is temporarily stopped before each addition, the sealing plug is opened, the required component is introduced, and processing is resumed.

The ability to introduce ingredients flexibly according to processing time, degree of butter formation, temperature, or other physicochemical process indicators substantially broadens the technological capabilities and operational versatility of the proposed butter-churning apparatus.

Process And Apparatus for Churning Animal-Based Composite Butter From Multicomponent Raw Materials Comprising Plant- and Animal-Derived Ingredients Incorporated Into A Lactic Acid Matrix In Various Proportions What is Claimed as the Invention Process

A process for producing animal-based butter, preferably from multicomponent raw materials based on a lactic acid matrix having any desired fat content, including reduced-fat formulations, comprising:

- forming the initial processing composition within the internal chamber of a mixer vessel by sequentially introducing a lactic acid matrix together with additives of plant and animal origin;
- installing the mixer vessel within the mixer drive frame and hermetically sealing its internal chamber by axially fixing hemispherical end caps;
- mounting the mixer drive frame within the powered support of the mixer while maintaining a predetermined angle between the longitudinal axis of the mixer vessel and the axis of rotation of the drive spindles, said angular relationship remaining constant throughout the entire churning process;
- reciprocating the initial composition along the longitudinal axis of the mixer vessel, with the moving mass impacting the internal surfaces of the hemispherical end caps once during every half revolution of the drive spindles;
- reversing the direction of movement of the processing composition during every half revolution of the drive spindles;
- accumulating the kinetic energy of the moving mass each time its direction of movement is reversed;
- discharging the technological by-product generated during the churning process;
- depressurizing and removing the mixer vessel from the drive frame;
- separating the hemispherical end caps from the cylindrical vessel body and removing the churned product from

the cylindrical chamber of the mixer vessel.

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submitted 08.07.2026;
accepted for publication 22.07.2026;
published 31.07.2026

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