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Increasing the sustainability of the food industry by expanding the range of shortening fats with new types of fat sources

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Abstract. New types of fat shortening range using vegetable oils and hard fats are proposed. The new proposed products provided high physical and chemical properties of new types of fat shortenings. The existing methods for the production of shortening fats are characterized by certain technological advantages and disadvantages. Much attention is paid to expanding the range of shortening fats using traditional and non-traditional vegetable oils and fats, as well as products of their processing.

1 Introduction

Cottonseed oil and its tallow are traditionally widely used in Uzbekistan, the taste and smell of which has become familiar in food products for many decades. On the contrary, sunflower and soybean oils are difficult to master in Uzbek cuisine. The same situation is observed when using shortenings imported from abroad, because there is a specific smell and taste in these fats.

Shortening fats belong to the category of edible fats and are used for the production of margarine products, bakery and confectionery products. The existing methods for the production of shortening fats are characterized by certain technological advantages and disadvantages. Recently, much attention has been paid to expanding the range of shortening fats using traditional and non-traditional vegetable oils and fats, as well as their processed products [1-2].

The needs of the food industry are met by the production of shortenings in three forms: plastic, liquid (suitable for pumping) and granular (in the form of flakes, powder). Almost all types of shortening can be supplied both in packaging and in bulk (in bulk).

2 Plastic shortenings

Most of these shortenings are formulated to provide optimum performance in the finished product. General purpose shortening is a mixture of animal and vegetable fats, with or without emulsifiers, with a wide range of uses. But most other types of shortenings, as a rule, are classified according to their purpose (for example, shortenings for MKI, icing, Mellorin, milk fat replacers, baking, frying fats, etc.) [3].

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3 Liquid shortenings

Liquid or flowable shortenings are considered to be all liquid suspensions consisting of solid fat dispersed in liquid oil, usually in β-crystalline form, or a refractory emulsifier. This type of shortening was developed for bulk transport and dosing at room temperature, as well as for more convenient handling of the packaged product, which can be pumped and measured volumetrically.

Shortenings in the form of flakes, granular, powder. Shortenings of this type consist of refractory edible oils that have been cured into these shapes in order to facilitate transportation, melt faster, or to provide certain functions in the food product [4].

Currently there are shortenings for individual food products, often even designed for a particular production technology. To provide special functional properties required in some technological processes, shortenings and glaze stabilizers have been developed in the form of flakes. Both of these products differ both from traditional shortening, which is in a solid state and having a plastic consistency, and from later developed liquid shortenings - both of them resemble flakes or chips in shape. Thanks to shortening in the form of flakes, it became possible to introduce new technologies for the production of puff pastry, which provide a flaky structure of the finished product. Stabilizers improve the functional properties and appearance of packaged fat and oil products, which provides them with a higher market demand.

Advances in technology have increased the knowledge available about oils and fats, which has contributed to the introduction of improved products in all sectors of the food industry. With the help of specialized types of shortening, completely new food products have been created, and the range of products for retail and catering has been expanded. The word "shortening" is no longer associated with the function that a fat and oil product provides, and does not indicate the type or consistency of such a product. Currently, shortenings are produced both with a plastic consistency, and liquid, flaky and powdered. They can be designed for a wide variety of applications, such as the bakery, confectionery, dairy substitutes, snacks, dietary formulas and various prepared food products [5-6].

Prior to the use of emulsifiers, antioxidants, and defoamers, the functional properties of fat-and-oil products depended solely on their fatty acid composition, crystal shape, and plasticization and tempering methods. The ability of plastic shortenings to aerate correlates with the polymorphic form of triglycerides, while the degree of saturation or unsaturation depends on the shelf life and frying stability. Fats consisting of small crystals in the β` form provide aeration of whipped dough much more efficiently than fats with large ones (3-crystals, and the saturation of unsaturated fatty acids eliminates the reactive site with which oxygen could interact, thereby improving indicators such as oxidation stability, shelf life and frying stability [7].

At present, emulsifiers, antioxidants and defoamers are added to liquid shortenings. Although the shape of the crystals and the degree of saturation of the original oils still play an important role, the use of these additives made it possible to provide the necessary functional characteristics, previously determined only by the composition of the fatty raw material.

With the use of such additives, the functional characteristics of the product became much less dependent on the presence of solid fats, which led to the development and implementation of liquid, or flowable, shortenings intended for flour products (both yeast and chemical baking powder), for deep frying and on frying pan in catering establishments, as well as for the production of dairy substitutes, liquid, or flowable, shortening combines the excellent functional characteristics of plastic shortening and the convenience of transportation and bulk storage inherent in liquid oils. Liquid shortening is an old dispersed system, fluid and suitable for pumping in the temperature range from 15 to 32 ° C, the continuous phase of which is liquid oil, and the dispersed phase is solids in the required polymorphic form. Solids may be solid fats or emulsifiers, or sometimes both. When choosing a liquid oil, it is guided by the requirements for oxidative stability, the choice of solids depends on the purpose of the shortening [8].

When producing a stable flowable slurry, it is important to consider the type and content of solids. For liquid shortening, unlike plastic shortening, a composition is desirable that is stable in the β-form, large crystals of which usually form a stable dispersion. Aeration of whipped dough for cupcakes using plastic shortening is achieved with a homogeneous plastic consistency, which is ensured by the use of oils that crystallize in the form, as well as rapid cooling and tempering, while aeration of liquid shortenings is due to the presence of an appropriate emulsifying system. Antioxidants are added to improve the resistance to oxidation of lubricating fat mixtures with a mild taste. A very effective defoamer is polydimethylsiloxane (E900), which also prevents oxidation, thanks to which the liquid opaque shortening acquires the functional properties characteristic of a plastic, refractory frying fat [9-10].

4 Research methods

The crystallization process of liquid shortenings is as important as the composition of the liquid oil, as it provides a concentration of β-crystal matrix at which the viscosity is low enough to be pumped or poured, but high enough to keep the suspension stable in over a long period. In the production of liquid shortening, it is necessary to choose the right ingredients, dissolve additives and solid oils in liquid oil, and ensure controlled crystallization of the product [11].

The consistency of hard fats is one of the important indicators of their structure and it is closely related to the formation of crystals in the resulting products. Therefore, in the chemistry of fats, studies of the polymorphism of solid fats and fatty acids are carried out with the aim of directed regulation of their rheological properties.

Upon rapid cooling, α crystals are formed, they can turn into β-primary (β') forms, which in turn can turn into the most stable β-form crystals. α crystals have the lowest melting point (point). They are usually very small and very unstable [12].

β crystals have the highest melting point and are usually large. The formation of crystals in fats leads to the release of the heat of crystallization and during the transformation α → β' → β a certain amount of heat is also released [13].

Figure 1 shows the melting curves of the shortening solid fat components.

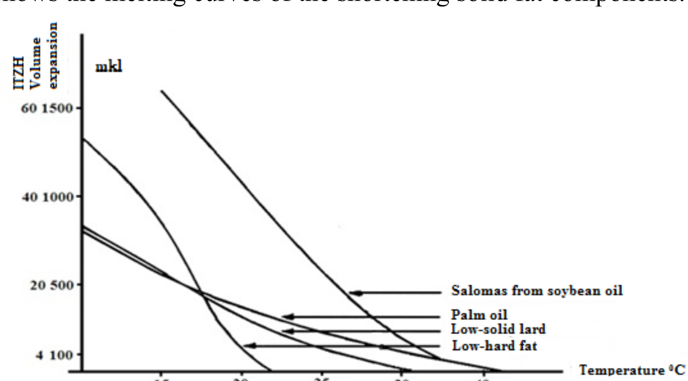

Fig. 1. Melting curves of shortening solid fat components.

From Figure 1 it can be seen that the components of shortening fats have a different melting temperature dependence, which should be taken into account when compiling its recipes.

If fats are cooled in a static state, a solid mass is formed, consisting of large crystals connected to each other. With subsequent mixing, these crystals are destroyed, and the mass becomes much more plastic. Since the physical condition of shortening fats for MKI is an important indicator, great attention should be paid to obtaining such crystals that allow obtaining the optimal structure of the product. This function in the production line is performed by an apparatus called a mold/plasticizer.

When cooling and plasticizing the fat, it may be desirable to introduce air, an aqueous phase, a surfactant, or a non-fatty solid phase into the fat. In this case, the equipment may be called a crystallizer/emulsifier.

Liquid shortening after crystallization does not require tempering; it can be sent to the consumer immediately after production, both in packaged form and in bulk. In both cases, the advantage over plasticized shortening is ease of use and dosing. Packaged liquid shortening can be poured from consumer containers, measuring the required volume. Bulk liquid shortening does not require heated equipment and can be pumped and dispensed at room temperature.

Shortenings in the form of flakes are a refractory product made from edible oils, hardened and in the form of thin flakes (chips), which makes it easier to work with, promotes rapid melting, and can also perform special functions in the composition of individual food products [14].

Traditionally flaked products are based on saturated oils known as stearin or low iodine hard fats. In addition to hard fat flakes, shortenings are now available for specific uses in which this form is desired. Such flaky shortenings and stabilizers find use in the manufacture of many types of food products. The third type of product based on refractory low-moisture fats is powdered shortening [15,16].

5 Research results

The expansion of the raw material base and the increase in the production of qualitative indicators of fat shortenings, the use of new types of raw materials for these purposes are of particular importance.

The aim of the study is to expand the range of shortening fats based on cottonseed, soybean and linseed oils.

The objects of the study were traditional and non-traditional vegetable oils, products of their processing.

The studies used modern physical, chemical and physico-chemical methods (IR, GLC, TLC, dilatometry).

Shortenings are made with cottonseed lard and other hard fats. In Table. 1 presents the compositions of new types of shortening fats.

Table 1. The composition of new types of shortening fats.

Name of fatty raw materials	Content of components, %						
	Vegetable raw materials			Mixture of raw materials of animal and vegetable origin			
Hydrogenated cottonseed oil, J.ch. = 80 g J2/100 g	90.0	–	–	–	–	–	91.0
Hydrogenated	–	88.0	–	–	–	89.0	–

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cottonseed oil, J.ch. = 88 g J2/100 g							
Hydrogenated cottonseed oil, J.ch. = 96 g J2/100 g	–	–	–	35.0	–	–	–
Hydrogenated cottonseed oil, J.ch. = 109 g J2/100 g	–	–	–	14.5	–	–	–
Bleached palm oil	–	–	91.0	55.0	–	–	–
Solid animal fat	–	–	–	–	82.5	–	–
Hydrogenated cottonseed oil, Tmelt = 60 °C	10.0	–	–	–	–	–	–
Palm oil, Tmelt = 56 °C	–	12.0	9.0	10.0	–	–	–
Solid animal fat, Tmelt=59°C	–	–	–	–	3.0	11.0	9.0
TAG content, % at: 10.0°C	26	31		25		32	
26.7°C	20	20		18		21	
40.0°C	9	11		10		9	

Note: J.ch. - iodine number; Tm - melting point; TAG - triacylglyceride.

6 Discussion

As can be seen from the data in Table. 1 new types of shortening fats with different content and ratio of hydrogenated cottonseed oil and other hard fats. This made it possible to change the content of TAG in the obtained shortening fats at 10.0°C from 25 to 32%, at 26.7°C from 18 to 21% and at 40.0°C from 9 to 11%.

Further, shortening fats were obtained using interesterified fat and its mixture with linseed oil (Table 2).

Table data. 2. indicate that the fat components used have a unique property for food ingredients - ample opportunities to replace one type of raw material with another in the production of shortening fats for various purposes.

Table 2. Physical and chemical parameters of shortenings obtained on the basis of interesterified fats.

Compositions and indicators of shortening fats	**Getting shortened fats**	
	From interesterified fat, %	**From a mixture of interesterified fat with linseed oil, %**
High oleic linseed oil	55.0	30.0
Solid fat from soybean oil, Tm = 63°C	45.0	–
Interesterified Fat	–	70.0
	Interesterification of fats	
Dropping point at:		
25°C	16.0	10.0
35°C	11.0	8.0
Iodine number. g J2/100 g	86.5	91.6
Total amount of saturated fatty acids. %, incl.	45.0	34.0

- stearic	40.2*	30.0*
- and others	4.8*	4.0*
Content of trans-isoacids, %	2.0	2.0

* Estimated value.

At the same time, shortening fats were obtained in three forms: plastic, liquid and granular (in the form of flakes, powder). Plastic shortenings for general use were a mixture of hard fats and vegetable oils with a wide range of uses.

7 Conclusions

The resulting liquid shortenings were suspensions consisting of solid fat dispersed in liquid oil in β-crystalline form. Flake, granular, powdered shortenings consisted of refractory edible oils that had been cured into these forms for ease of transport, faster melting, or to provide certain functions in the food product. Thus, a technology for obtaining shortening fats based on cottonseed, soybean and linseed oils has been developed, the composition and formulation of new types of fat shortenings have been created.

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