SPX

Shortening
- General Information

White Paper

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EXECUTIVE SUMMARY

Food companies today are like other manufacturing businesses not only focusing on the reliability and quality of the food processing equipment but also on various services which the supplier of the processing equipment can deliver. Apart from the efficient processing lines we deliver, we can be a partner from the initial idea or project stage to the final commissioning phase, not to forget the important after-market service. SPX Flow Technology has Gerstenberg Schröder installations in more than 110 countries around the world.

INTRODUCTION TO SPX FLOW TECHNOLOGY

VISION AND COMMITMENT

SPX's Flow Technology segment designs, manufactures and markets process engineering and automation solutions to the dairy, food, beverage, marine, pharmaceutical and personal care industries through its global operations.

We are committed to helping our customers all over the world to improve the performance and profitability of their manufacturing plant and processes. We achieve this by offering a wide range of products and solutions from engineered components to design of complete process plants supported by world-leading applications and development expertise.

We continue to help our customers optimize the performance and profitability of their plant throughout its service life with support services tailored to their individual needs through a coordinated customer service and spare parts network.

CUSTOMER FOCUS

SPX Flow Technology develops, manufactures and installs modern, high efficient and reliable processing lines for the food industry. For the production of crystallized fat products like margarine, butter, spreads and shortenings SPX offers Gerstenberg Schröder solutions which also comprise process lines for emulsified food products such as mayonnaise, sauces and dressings.

FATS AND OILS IN GENERAL

The main components of fats and oils are triesters of glycerol and fatty acids. The triesters are named triglycerides.

The triglycerides are responsible for the physical properties of fats and oils as the physical properties are depending on:

- Chain length of the fatty acids.
- The degree of unsaturation in the fatty acids (i.e. number of double bonds).
- The distribution or position of the fatty acids in the triglycerides.

Generally, fats with a high content of saturated fatty acid will be hard, while fats with mainly unsaturated fatty acids will be liquid. Distribution of the fatty acids on the triglycerides decides whether the consistency is hard, soft or liquid. Thus, some types of fats can only be used for limited purposes. Normally, several fats or oils are used in a shortening oil blend in order to obtain the desired properties with regard to plasticity and consistency of the shortening.

DEFINITION OF SHORTENING

Shortening may be defined as an edible fat used to shorten or tenderise baked products. Being insoluble in water, fat prevents the cohesion of gluten strands during mixing, thus literally shortening them and making the product tender. „Shortening" is often used interchangeably with the term „fat". Thus, it is not uncommon to find reference to „icing shortening", „frying shortening", etc. For the purpose of this discussion, the term „shortening" will be applied in the broader sense to fats used in bakery products where, in addition to shortening or tenderising, such fats impart other important functional characteristics such as aeration to the finished product.

The physical properties of shortening are depending on the following factors:

- plasticity
- consistency
- structure

The three conditions essential for plasticity are:

- the fat blend must consist of two phases. One of the phases must be solid, whereas the other must be a liquid;
- the solid phase must be in a state of sufficiently fine dispersion for the entire mass to be effectively held together by internal cohesive forces. The openings between the solid particles must be so small that there is negligible tendency for the liquid phase to flow or seep from the material;
- a proper proportion must exist between the two phases. The solid particles must not form a rigidly interlocked structure.

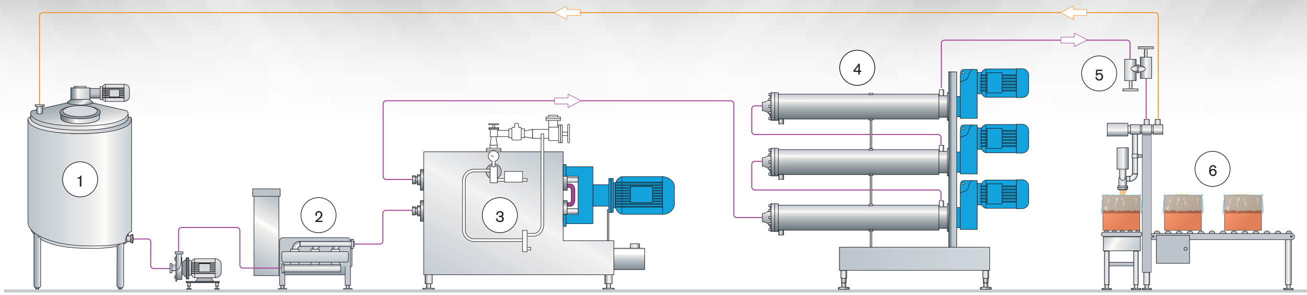
SHORTENING - PHYSICAL PROPERTIES

The hardness or firmness of any plastic shortening/fat is a function of the stress required to cause it to yield and flow. The predominant factor affecting this value is the volume ratio of the solid to the liquid phase. The greater the proportion of solids, the greater the possibility of the particles to touch and interlock and the firmer the material will be. The upper limit of the solid phase is approx. 52% by vol. The lower limit varies considerably with the size of the particles and the character of the material, but generally the range is within 5-25%.

Another factor influencing the firmness of a plastic shortening is the solids. It is important that the plastic shortening blend consists of solid fats exhibiting the proper crystal habit or polymorphic form. The triglyceride composition of the specific fat and the method of solidification determine the crystalline habit and polymorphic form. When the higher melting portion of the shortening consists of glycerides which are stable in the β' form, the entire fat will crystallize in a stable β' form. Fats exhibiting a stable β' polymorphic form tend to crystallize in small needles. Such shortenings appear smooth, provide good aeration, have excellent creaming properties, and make good cake and icing shortenings. Conversely, a shortening that crystallizes in a stable β polymorphic form tends to be grainy, produces large granular crystals, and exhibits poor aeration properties - but functions well in pie crust application. The addition of a β' tending hard stock to a β tending partially hydrogenated base oil may in some instances induce crystallization of the shortening blend into a stable β' form. This grouping of fats according to the tendency of crystallization can be seen in the below table:

B' TENDING FATS	B TENDING FATS
BUTTER OIL/MILK FAT	CANOLA
COCONUT	COCOA BUTTER
COTTON SEED	CORN
MODIFIED LARD	LARD
PALM	SOYABEAN
TALLOW	SUNFLOWER

Polymorphic forms of selected fats



Flow diagram 1: 1. Oil blend tank 2. GS high-pressure pump 3. GS Perfector 4. GS pin rotor machine 5. Homogenizing arrangement 6. Filling machine

The general rule is that fats with a low content of palmitic acid (approx. 10%) will crystallize in the β form if they are not exposed to shock chilling. Fats that have the tendency to crystallize in β‘ usually have the double amount of palmitic acid, however the position of the palmitic acid on the glycerol molecule does additionally affect the crystallization habit.

In general, it is possible to crystallize all types of fats in the β‘ form if the fats are shock chilled with subsequent intensive kneading without cooling. In this way a plastic shortening with smooth appearance, good aeration properties and excellent creaming properties can be produced. This method of crystallization and cooling of shortening mixture is accomplished in the SSHE GS Perfector line for production of shortening as shown in our flow diagram 1.

With reference to flow diagram 1, the crystallization process in the GS Perfector plant can be described as follows: The shortening may contain 1-2% of emulsifier. The high-pressure pump unit - mounted with nitrogen dosing equipment for aeration of the product - pumps the shortening product through the GS Perfector plant with a max. pressure of 40 bar. The GS Perfector is mounted with 4 chilling tubes. A simplified explanation of the crystallization in the GS Perfector is that the product is exposed to shock chilling in the beginning of the cooling process. In this way the unstable a crystals are created. By further cooling and kneading periods without cooling these a crystals start to undergo a transition from a to β‘. The β‘ crystal type is, as mentioned previously, the very small crystal type desired in shortening. When the product leaves the GS Perfector the chilling process is completed, but it is necessary that the product passes a big kneading unit called a pin rotor machine.

GS Perfector for crystallization of shortening

This is necessary to ensure that all crystals of the α type undergo the transition to the β‘ type. When such a transition takes place, a temperature increase in the product will be observed. For this reason the temperature of the product will increase in the pin rotor machine and also in the intermediate crystallizes that are mounted on the GS Perfector.

When leaving the GS Perfector the product will have a temperature of approx. 18°C or higher depending on the cooling temperature used in the GS Perfector, and the temperature increase observed in the pin rotor machine will be of approx. 2-3°C depending on the oil types used in the shortening. After the pin rotor machine the product has to pass a homogenizing arrangement before going to the filling station. The homogenizing arrangement is necessary to ensure an even distribution of the added nitrogen in the product before filling.

The SSHE GS Nexus or GS Kombinator can also be used for the above crystallization process.

CRYSTAL STRUCTURE

As mentioned above, fat mixtures that are not exposed to shock chilling will have a tendency to form large β crystals. This can be compared to the production of grainy ghee.

Products with a crystal structure based on large crystals will not possess the plastic properties that are desired in shortening. This is due to the fact that a crystal network formed by large β crystals is very strong due to forces acting between large particles. If a crystal network of this type is exposed to a deforming force, some of the bindings in the network will be destroyed and not re-established. For this reason products with a network of the β type often show a product failure called „oiling out“.

Products (i.e. shortening) with a β‘ crystal structure and thus a plastic appearance have the property of re-establishing the bindings in the crystal network when bindings are broken because of a deforming force. This property is preventing the above-mentioned „oiling out“ in the product due to the fact that there will be the same very high number of bindings in the product at any time. In this way the internal liquid phase in the product is maintained.

GS Nexus for crystallization of shortening

STORAGE OF SHORTENING

In some cases where the shortening oil blend includes very slowly crystallizing oils (f. ex. palm oil) it can be necessary to store the produced product in a storage room with a temperature of approx. 25°C for a period of max. 48 hours. The tempering is necessary to ensure the stability of the β‘ crystal structure. The stability is achieved by holding the processed shortening in the quiescent state at a temperature just below the melting point of the lowest melting crystals i.e. triglycerides.

ABOUT SPX

Based in Charlotte, North Carolina, SPX Corporation (NYSE: SPW) is a global Fortune 500 multi-industry manufacturing leader

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