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Harnessing the capabilities of spray granulation in the food industry for the production of functional foods

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Abstract

The article is the literature review of a current state of production technologies of powdery foodstuff, concentrates and multicomponent mixes. The need of the food industry for qualitative methods of processing of raw materials of different physical and chemical structure is noted. The authors give the reasons about need and possibility of a choice of granulation as a method of data processing of products. Physical and chemical features of granulation methods of disperse environments of various aggregate states based on the studied regularities and works of other authors are considered. The authors made the assumption of the application prospects of the method of liquid dispersion on the surface of particles in a suspended state for a granulation of foodstuff and they offered the alternative option. The possibility to use whey as binding element is considered. At the end of article authors draw the conclusion about the prospects of use of a method of dispersion of liquid on the surface of particles in a suspended state for a granulation of foodstuff.

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1. Introduction

The priority areas in the field of food production are the development of advanced methods of production,

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storage, processing and transportation of products, the formation mechanisms for the rational use of raw materials, development of new high-quality foods. A characteristic feature of modern food products is the complexity in their formulation composition, that is, the presence in the product a large number of food ingredients of different chemical nature, which properties are included in the manufacturing process required to produce the food of the desired biological and nutritional value.

Over the past 30 years the amount and range of food concentrates have been significantly increased. A significant share of these products is presented in the form of powders and multicomponent mixtures (vegetable powders, dry concentrates of juices and drinks, baby food, flour mixes and other food compositions, etc.). For such products the processes of transportation, dispensing and packaging due to dusting, caking of powders, poor flow etc. become more complicated. There are some difficulties in ensuring uniformity of multicomponent mixtures because of component segregation[1,2]. This is especially important in the production of baby foods, and dietary products containing functional additives (vitamins, minerals, prebiotics, probiotics, etc.).

The level of requirements for the quality of these products to date, according to "SanPiN 2.3.2.1078-01" (Sanitary Regulations and Norms in Russia) is approached to Pharmaceutical norms. Traditional processing technology of food and raw materials in many ways cannot meet the requirements to the quality of products and need either serious improvements or creating new ones. For example, the mixing processes of powders and granular materials can provide the required homogeneity of mixture, but in the process of transportation, packing and storage the mixture can segregated.

Besides, it should be noted that the qualitative mixing is a rather complicated technical problem. In this regard, it is necessary to apply and develop technologies to ensure the stability of the quality of the mixture, to improve the functional properties of powders and granular materials. Typically, in many industries such tasks are resolved by using various methods of agglomeration.

Granulation process, as one type of agglomeration is a comprehensive process, which found application in various industries (chemical, construction, pharmaceutical, etc.)[10], and limited use in the food industry[15]. Thanks to its use, it is possible to obtain a large class of products with the improved physical and mechanical properties. Using of granular products in manufacturing processes can improve the efficiency and intensity of production, reduce the loss of raw materials and improve the working conditions.

A significant number of scientific articles have been published in foreign articles on the theme of granulation. In the papers of research on the mechanism of granule formation, properties of the obtained granules and the attempts to develop mathematical models of the granulation process are presented. However, unfortunately, it should be noted that the articles mainly consider a limited number of methods and devices, and scientific papers related to the study of regularities of granulation foods are limited.

The increased consumer demand for food products with certain quality characteristics stimulates the development of technologies. For example, the need for instant food products (coffee, milk, chocolate drinks, vegetable and fruit juices, etc.) gave rise to different ways of agglomerating of dispersion media. Characterization of methods, their advantages and disadvantages, are quite well described in the scientific literature[2,19]. As a result of agglomeration the products acquire marketable conditions, the required functional properties: the ability to rehydration, rapid dissolution or dispersion in a liquid medium, etc.

With the development of production and assortment of food products a producer has to solve a variety of tasks: obtaining of products with high nutritional and biological value, ensuring homogeneity of granular mixtures, providing the functional properties to the product, etc. Solving these problems is impossible without systematization of data obtained in various fields of science and industry. The granulation technology is not an exception to this rule. The obtained scientific and practical details for granulation of individual classes of substances in a variety of industries can be used for the food industry.

The task of ensuring the homogeneity of the mixture is typical for products containing food additives (flavorings, colorings, etc.), various functional products. Annually world market of functional products are intensively increased by 15-20%. Currently, in all developed countries of the world the questions about healthy nutrition are raised to the rank of state policy. In Russia the main principles of this issue have been formulated in the "Principles of State Policy of the Russian Federation in the field of healthy nutrition for the period up to 2020" (Decree of the Russian Federation dated October 25, 2010 N 1873- p). In this regard, urgency of using and development of the granulation processes of functional foods as multicomponent mixes with additives of biologically active components is

increased. The homogeneity of the components in the mixture is strictly regulated. Granulation allows fixing the homogeneity of the mixture reached in a volume of granules and complying with the requirements.

Modern granulation methods are usually modifications of the previously developed methods, but have a high level of technical performance and process equipment. This applies mainly to foreign equipment manufacturers ("ICF & Welco", "Neuhaus Neotec", "Alfa Laval", "GPC" and others).

Selecting of the granulation process depends on many factors including the behavior of the system under dynamic conditions, which is determined by the physicochemical and mechanical properties of disperse systems and starting materials[15-19] and also depends on the problem to solve.

2. Materials and methods

According to physical and colloid chemistry, the main part of foods and raw materials refers to disperse systems, which are in the different state of aggregation[16,18]. Limited use of granulation processes for food-dispersed systems is associated with a number of distinctive features, in particular - the multicomponent variability and complexity of physicochemical composition, the content of easily oxidizing and degrading components, etc. Furthermore, depending on the composition, disperse structure and particulate composition they have different rheological and textural properties[13,14], which may change during processing due to by various factors (mechanical, physical, and chemical, biological, microbiological). All this adds further difficulties in the selection and development of an effective method and apparatus for granulation. According to the accepted classification[23] the following methods of granulation are widely used in food industry:

- dispersion of liquid in free volume;
- dispersing of liquid on the surface of particles in the suspended state;
- compacting of the dry powders in the form of briquettes, tiles and etc., followed by crushing to granules of the desired size;
- molding or extrusion followed by crushing to granules of the desired size (or without).

A Granulation method is rarely used, it is mainly used for jellybeans in the confectionery industry (multilayer pellets). While the pressing and molding techniques allow segregating the finished product, the method of dispersing liquid on the surface of particles in suspension does not. This is an important aspect in the case of the production of functional foods.

For the functional products the most promising is a method of obtaining granules via devices of vibro-fluidized layer with the spraying of binder solution or suspension (Fluid Bed Technology)[24]. This method is used in the pharmaceutical industry, where similar problems are solved. Depending on the proportion of solid and liquid phases - using a different type of a liquid binder, the process conditions it possible to receive loose or dense structure of granules. Layer-by-layer deposition of the components or creating a coating on the granules also may be received[22].

Parameters of granules obtained by different methods shown in the table 1. Besides, this method reduces the price of the process and reduces the time to obtain the finished product through the implementation of the three processes - mixing, granulation and drying in a single unit.

Table 1. Comparison of granules dispersibility prepared by different methods

Granulation method	Product	Mean bead size, mm	The average rate of dissolution in water at a temperature of 95-98°C, s
Fluid Bed Technology	Whey	0.3-1.5	15
Dish-shaped mixer-granulator	Whey	0.5-2.0	40
	A composition comprising the flour of blueberry pulp and 40% whey	0.7-2.5	25
	The kissel with 10% whey	0.5-3.0	18
Screw extruder	Whey	2.0	95

Great attention should be paid to the choice of a binder for granulation because the binder gives the desired

physicochemical characteristics to granules, ensures the stability of the mixture. Using of whey as a functional binder additive in a granulation method can be very promising. Whey is a valuable protein-carbohydrate feedstock. In foreign practice the whey processing is conducted on several ways: getting powder by spray drying, separation of valuable components from the serum, bioprocessing, beverages production containing whey. In Russia the dairy plants virtually ceased to solve this issue for economic and technical reasons. However, in the Russian scientific literature the works associated with the use of raw materials, which were previously as waste products - whey, meal fruit crops - for the production of the instant functional beverages appeared[17-19, 21]. Pulp of fruit crops is a valuable source of trace elements, biologically active compounds and dietary fibers.

There is an alternative perspective variant for obtaining food granules. In[17], the author developed two methods and apparatus[20] which are suitable for granulation of whey concentrate. The most interesting , in our opinion , is the second way in which dry fruit raw material is granulated by using a whey concentrate of coupling fluid 40% (by weight). The obtained granulate after convection drying in various types of dryers (shelf, drum, fluidized-bed) is used for the production of fast-preparation drinks. Thus, the expensive and complicated spray drying is excluded from the process. Owing to the method and apparatus there is the opportunity to get instant functional beverages that contain valuable whey concentrates and natural fruit juices[5,7,18,19], containing useful nutrients, which are usually thrown away after production of juices and jams.

3. Discussion

Conversion of food materials in granular forms considerably intensifies the drying, extraction and blending processes which are carried out for the production of final products. Intensification of the processes is reached due to the fact that the granules unlike powders, due to the directed structurization gain such favorable properties as: non-caking, good flowability, good wettability and solubility, - favorable forms.

Using of the so-called “food production wastes” can be economically beneficial. The recycling scheme with granulation technology can be organized in different ways. For example, in the fruit-and-vegetable sectors in enterprises or in the production of juices a waste processing can be organized in the following ways:

1) briquetting, or extrusion of meals - followed by drying is used as a fertilizer in agriculture ;
2) the use of fruit meals with whey in the production of instant drinks , etc.

4. Conclusions

Because of the complexity, diversity and the understudied processes of granulation the unified theory of granulation of food products hasn’t been developed, in particular for powders and pastes. The Accumulated scientific and practical data on material granulation in various industries can be adapted to the process of food granulation after additional research.

Owing to the use of granulation technology it is possible to obtain high-quality food with the desired functional properties, as well as, involvement the “food production wastes” in a prescription composition and the process. To meet the market requirements for instant drinks and food, in our opinion, the method of dispersing liquid on the surface of the particles in a suspended state and an alternative variant of the preparation of the granules is worthy.

Introduction of the granulation stage in the technological stage of production of an individual class of foods will improve resource efficiency, waste-free production and competitiveness. Depending on the purpose, the feedstock characteristics and economic considerations various granulation methods may be used.

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