Application note

Twin-screw granulation for food applications

From powder handling to functional ingredient design

Author

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Abstract

Twin-screw granulation (TSG) is a versatile manufacturing process that is well suited for the processing of novel protein ingredients. TSG enables improved powder handling, improves process stability, and allows targeted modification of material functionality. Using soy protein isolate as a model system, the application overview described here demonstrates how TSG can enhance downstream structuring behavior, thus supporting the development of plant-based products with defined texture. Beyond particle size control, TSG offers a scalable approach to process intensification, mild processing, and functional ingredient design for next-generation protein applications.

From continuous pharmaceutical wet granulation to food innovation

Twin-screw granulation is an established continuous granulation technology widely used in the pharmaceutical industry to improve powder flowability and downstream process stability.[1] In wet TSG, a co-rotating twin-screw extruder equipped with an open discharge is typically operated near room temperature while a fine powder, together with a plasticizer, is fed into the extruder barrel. Depending on mixing, shear, and residence time, the wetted powder forms granules that are discharged directly as free flowing particles. Process parameters such as screw speed, liquid-to-solid ratio, and screw configuration directly control particle size distribution and granule quality.[2]

These established process principles can be transferred to food powders, enabling not only improved handling but also new opportunities in ingredient design. As demonstrated in previous work on upcycling of apple pomace,[3] twin-screw granulation can functionalize food side streams while simultaneously improving handling properties. By combining agglomeration and particle size control within one continuous step, the TSG contributes to process intensification and simplifies downstream processing.

This overview introduces twin-screw granulation as a versatile process platform for food powders, highlighting the method's ability to enable process intensification, allow mild processing, and impart targeted functionalization across different food matrices.

Why granulation matters for food powders

Granulation is a well-established process in the food industry. It is commonly used to improve flowability, reduce dust, and enhance handling of fine powders. Conventional approaches include fluid bed granulation, high shear mixing, or post-extrusion agglomeration. However, many food powders, such as plant protein powders, remain challenging to process due to attributes like very fine particle size, low bulk density, and tendencies toward electrostatic charging or uncontrolled agglomeration. These properties can lead to feeder blockage and inconsistent powder flow.

These challenges are particularly relevant in plant-based product development, where protein powders are widely used to manufacture meat and dairy alternatives. Twin-screw granulation integrates wetting, mixing, and agglomeration into a single continuous step, enabling targeted adjustment of particle properties and improved process reliability. Through controlled variation of process parameters, granule characteristics can be tailored to meet specific processing requirements. Lab-scale twin-screw extruders from Thermo Fisher Scientific can be equipped with a dedicated granulation kit, enabling early-stage process development for plant-based products under controlled conditions.[3]

Stable and continuous granulation of soy protein isolate was achieved, confirming the suitability of twin-screw granulation for plant protein systems. The process enabled the production of free-flowing granules with improved handling characteristics and stable process performance. As shown in Figure 1, a systematic reduction in oversized agglomerates and a shift towards a more uniform particle size distribution was observed across the investigated conditions. This was accompanied by fewer coarse particles and improved granule homogeneity.

Overall, the results confirm that twin-screw granulation provides a robust and flexible approach to engineer the preferred particle size and bulk behavior of plant protein powders. By adjusting key process parameters, granule characteristics can be tailored to meet specific application requirements. The use of a Process 11 hygienic twin-screw extruder for TSG enabled efficient process and formulation screening with limited material input, supporting rapid development and transfer to larger-scale systems.

Case study: Twin-screw granulation of soy protein isolate

To demonstrate the applicability of twin-screw granulation to plant protein systems, commercially available soy protein isolate powder was processed using a Thermo Scientific™ Process™ 11 Parallel Twin-Screw Extruder, with a granulation kit enabling operation on open discharge. A video of the extrusion process in action is available via this **link**.

The process was operated at a mild barrel temperature of 30 °C with a defined feed rate of 1.5 kg/h, representative of lab-scale development, while key parameters such as screw configuration and liquid composition were systematically varied. Screw configurations ranged from a standard design with a single mixing zone to configurations incorporating multiple mixing zones. As plasticizer, both aqueous and oil-in-water emulsion systems were investigated.

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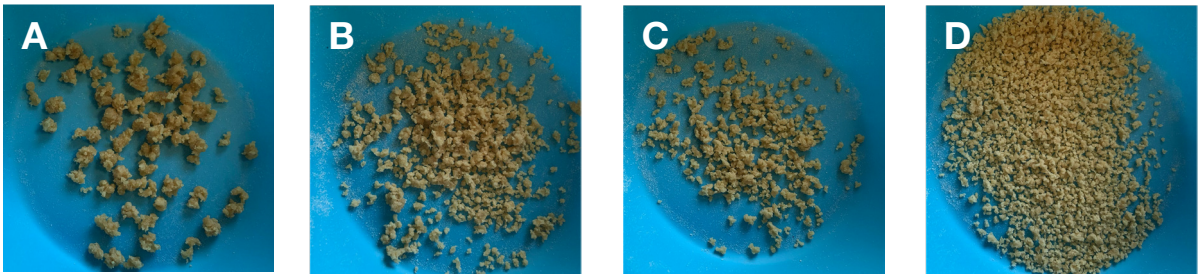

Sample	Screw speed	Screw config.	Plasticizer	Granule size d_{10} µm	Fines %	Lumps %
A	800	1	Water	645	0.4	66.7
B	800	2	Water	639	0.7	5.9
C	500	2	Water	689	0.4	37.1
D	800	2	Emulsion	601	0.9	3.4

Figure 1. Influence of process conditions on granule morphology and size distribution. Representative granules obtained under different process conditions. Corresponding values indicate d_{10} (µm), fines fraction (<250 µm), and lumps (>4500 µm, oversized agglomerates).

In addition to screw speed and screw configuration, which are well-established parameters influencing granule size,[1,2] the availability and distribution of the liquid phase were confirmed as critical factors for successful granulation. Sufficient wetting ensured continuous processing while minimizing the formation of fines. Beyond these known effects, the composition of the liquid phase was found to have a pronounced influence on granule formation. Variations in liquid composition, particularly when using oil-in-water emulsions, affected both granule size and visual appearance, indicating the importance of the liquid formulation in controlling granulation behavior.

Beyond granulation: Impact on downstream functionality

Granulated soy protein isolate was further processed in extrusion trials to produce plant-based products with anisotropic fibrous structures, which are an essential product characteristic for meat analogue applications.[4] As shown in Figure 2, scanning electron microscopy (SEM) images show a clear increase in particle size and associated changes in surface properties after granulation. Compared to the non-granulated powder, products processed from granulated material showed a clear shift from largely homogeneous structures towards the development of anisotropic fibrous structures. This transition highlights that granulation not only improves powder handling but also enhances the ability of plant protein systems to form structured products with meat-like textures. These results indicate that twin-screw granulation can act as a deliberate pre-conditioning step, influencing downstream structuring behavior and expanding the application potential of plant protein ingredients.

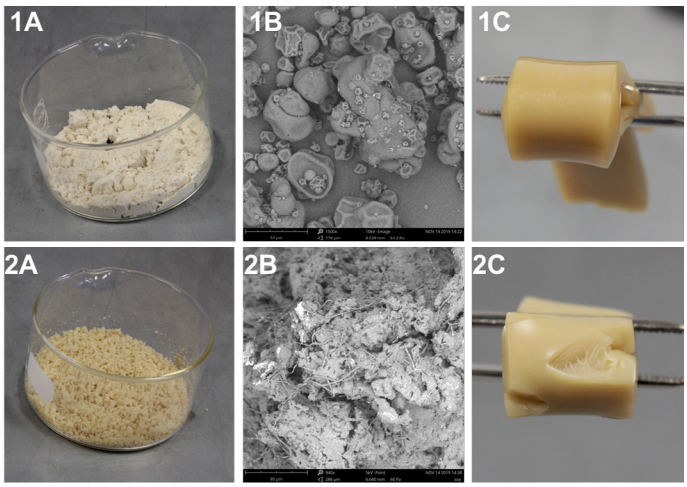

Figure 2. Influence of twin-screw granulation on particle morphology and downstream product structure. Granulation and extrusion trials were performed using a Process 11 twin-screw extruder. Particle morphology was analyzed using a Thermo Scientific™ Phenom™ XL Desktop SEM.

Similar observations have been reported for the functionalization of food side streams, where twin-screw granulation acted as a mild thermo-mechanical pre-treatment, modifying properties such as water binding and gelation behavior.[3] These findings further highlight the broader potential of the process to tailor functionality beyond particle size control.

Outlook: Mild processing and process intensification

Continuous TSG operates at comparatively low barrel temperatures and does not require organic solvents, enabling a mild processing approach. At the same time, wetting, mixing, and agglomeration are combined in a single continuous step, reducing processing complexity. As a result, TSG enables the design of granules with tailored structures and hydration behaviors, directly improving processability and enhancing potential for structuring in downstream applications. In addition, the process offers the possibility to incorporate functional ingredients via the liquid phase (for example, through the use of emulsions), enabling the development of value-added food products.

Twin-screw granulation therefore provides a scalable and flexible solution for a wide range of food applications, including pre-conditioning of plant protein powders, upcycling of food side streams, and the design of functional food powders. Rather than being limited to particle size enlargement, it can be understood as a platform technology that links particle design with final product performance while enabling efficient process development and scale-up.

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