IMA's solutions for handling non-compressible powders

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Introduction

The nutraceutical market is increasingly driven by consumers who are highly aware of and attentive to the quality and natural origin of the products they choose. This trend reflects a broader shift in behaviour: the desire to improve one's lifestyle and prevent health issues, rather than intervening only once they arise.

The preference for pure natural products, the careful selection of high-quality raw materials, and the use of capsules to ensure practicality and accurate dosing all contribute to a stronger perception of safety and reliability for the end user.

To meet this market demand, many manufacturers are developing formulations composed exclusively of pure natural powders, entirely free from excipients. While this approach aligns with consumer expectations, it introduces several technological challenges. Eliminating excipients means giving up the functional components that typically improve powder processability, such as flowability, compressibility and the ability to maintain stable behaviour under variable environmental conditions. As a result, many natural powders display less predictable and more difficult behaviour during production.

This article focuses on a 100% pure natural powder characterised by a particularly challenging technological profile: its **inability to be compacted.**

The mechanical and process-related strategy provided by IMA to handle this type of material will be presented, demonstrating how these technologies enable efficient and reliable processing even when dealing with non-compressible natural powders. The aim is to offer a concrete example of problem-solving and process optimisation, serving as a reference for other natural formulations without excipients that show similar criticalities.

The challenge of non-compressible nutraceutical powders

Powder dosing technology on IMA capsule filling machines relies on the use of dosators and pistons (syringe-type dosing).

The piston moves within the dosator, creating a dosing chamber. The powder is collected inside this dosing volume at the moment the dosators penetrate the powder layer in the bowl. Slug formation occurs through powder compaction generated both by the penetration of the dosators into the powder layer and by the movement of the piston within the dosator.

However, some natural-origin powders do not respond effectively to the compression forces applied during the dosing process. This behaviour can lead to two possible scenarios:

a) The **incomplete** formation of the powder slug
b) The **total absence** of powder slug formation

Both situations can affect the quality and stability of the dosing process.

When the powder does not compact properly, the dosing unit cannot retain the product consistently inside the dosing chamber. For powders with these properties, adopting a different dosing strategy is essential. Which optimisations does IMA offer to reliably manage these types of products?

Suction dosators: IMA's response to non-compressible powders

To address these challenges, IMA provides vacuum dosing unit technology.

In this system, the dosators and pistons are designed to create a regulated vacuum that allows the powder to be **collected and retained** without the need for compaction.

Vacuum remains active during both the powder collection phase and turret rotation, ensuring that the powder stays inside the dosing chamber throughout the entire dosing cycle. Only in the final phase — when the powder must be released into the capsule body — the vacuum is deactivated, allowing a controlled discharge of the product.

The airflow moves from bottom to top, passing through the tight clearance between the internal diameter of the dosator and the piston head. A preliminary laboratory particle size distribution (PSD) analysis helps anticipate powder behaviour and select the most suitable vacuum settings.

For powders that only partially respond to compression forces and produce incomplete powder slugs, the combined use of light compaction together with vacuum can provide additional benefits. Compaction offers a minimum level of cohesion, while vacuum ensures stability of the partially formed slug during transport.

Both the vacuum level and the potential compaction force must be optimised based on the specific characteristics and granulometry of the powder being processed. This flexibility makes vacuum dosing an ideal solution for pure natural powders and other difficult-to-process materials, significantly enhancing overall process stability.

Pure powders – without excipients to improve processability – a further aspect of nutraceutical powders

Natural powders often present intrinsic characteristics that can complicate processing: poor compressibility, adhesion to metal surfaces, tendency to agglomerate or form lumps, high batch-to-batch variability, and unpredictable behaviour influenced by environmental factors such as temperature and humidity.

Adding specific excipients to a natural powder can compensate for these conditions, simplifying processability and improving the repeatability of the manufacturing process. However, the nutraceutical market increasingly demands pure powders, and in these cases, it is the technology that must compensate for the limitations of the raw material.

This is where IMA's core strength truly emerges: **providing mechanical and process solutions that make it possible to successfully handle even pure powders**.

Formulation and technological analysis

Grape seed extract (Vitis vinifera) is a natural product rich in polyphenols, particularly proanthocyanidins, known for their strong antioxidant, anti-inflammatory and vasoprotective properties. The material appears as a red-brown powder with the characteristic aroma of grapes.

Technological analysis of pure powder grape seed extract (Vitis vinifera) was carried out in the IMA Active Competence Center laboratory. The purpose of these evaluations is to predict and optimise the processability of the powder on automatic alternating-motion capsule fillers.

Table 1 summarises the main technological parameters evaluated during the trial: bulk and tapped density also used for calculating the Carr Index and providing an indication of flowability; particle size distribution – PSD, measured using a sieving method; residual moisture content (loss on drying – L.O.D.) determined using a moisture analyser.

Analysis	Grape seed extract (Vitis vinifera)
Bulk density (g/mL)	0.570
Tapped density (g/mL)	0.600
Carr Index (%)	5
Flowability (USP)	Excellent
L.O.D. (%)	3.5

Formulation	
Grape seed extract (Vitis vinifera)	100%

Table 1 – Technological analysis and formulation of grape seed extract (Vitis vinifera)

The grape seed extract (Vitis vinifera) powder is characterised by low density and excellent flowability (Carr Index 5%). The minimal difference between bulk and tapped density indicates that the powder does not tend to compact, even when subjected to mechanical stress. Therefore,

regardless of the compaction forces applied during dosing, powder slug formation is not expected to occur with this material.

The moisture content (L.O.D.) falls within the typical range for botanical extracts and is consistent with the natural origin and purity of the powder.

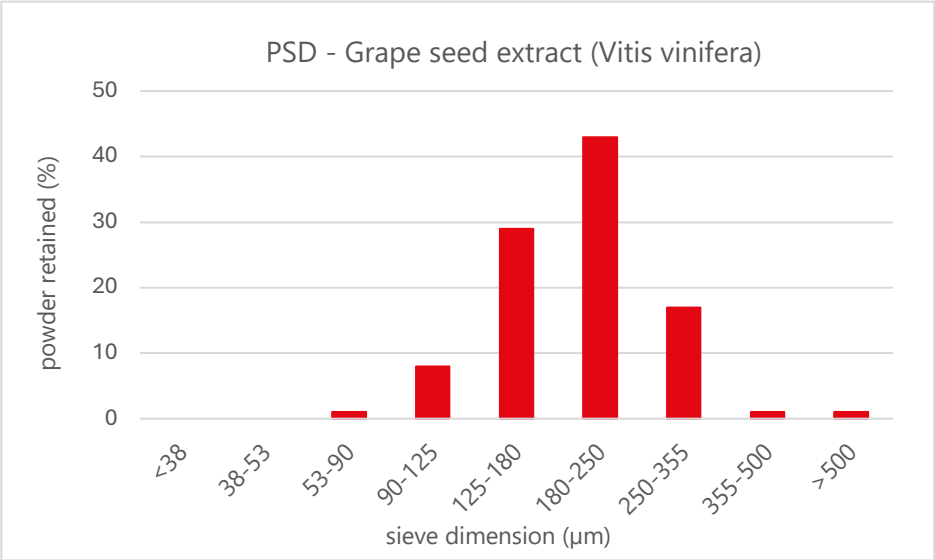


Figure 1 – Particle size distribution – PSD grape seed extract (Vitis vinifera)

Figure 1 shows the particle size distribution of the grape seed extract (Vitis vinifera) powder. The PSD exhibits a unimodal profile, with the main particle fraction between 125 and 355 µm.

Machine parameters and recommended optimisations

Table 2 provides an overview of the main machine parameters used to process pure natural grape seed extract (Vitis vinifera) powder. The test was performed on a medium-speed alternating-motion capsule filler machine belonging to the ZANASI series.

Machine Parameters	Grape seed extract (Vitis vinifera)
Net target weight (mg)	400
Capsule size	0
Machine used for tests	ZANASI 40
Dosator and pistons type	Suction with hard chrome coating
Dosator suction (on/off)	on
Suction bowl (on/off)	on

Table 2 – Machine parameters for testing of grape seed extract (Vitis vinifera)

Below is a description of the optional features used during the test and their respective functions:

- **Dosator and piston with suction:**

The powder tested in this study exhibits non-compressible behaviour. During the various trials, product loss was observed throughout the dosing phases, particularly as machine speed increased.

The use of vacuum dosing unit technology made it possible to address this limitation.

The vacuum generated inside the dosing chamber allows the powder to be collected and retained, ensuring stable powder retention inside the dosing chamber, reduced powder loss during the movement of the dosing unit. As a result, a stable, repeatable and compressibility-independent dosing performance was achieved.

- **Dosator and piston with hard chrome coating:**

The pure natural grape seed extract (Vitis vinifera) powder shows a tendency to adhere to metal surfaces. The absence of excipients — such as lubricants — does not compensate for this behaviour. Standard product-contact metal parts are made of stainless steel. However, when working with powders that tend to adhere to metal parts, dedicated dosators and pistons with a hard chrome surface coating are recommended. This treatment significantly reduces powder adhesiveness, resulting in a more stable process and lower weight variability.

- **Suction bowl:**

The suction bowl allows the extraction of inter-particle air present in the powder inside the bowl, leading to a significant increase in density. Airflow moves from top to bottom, passing through a circular opening located at the bottom of the bowl. A calibrated mesh positioned above this opening allows air to pass through while retaining the powder particles.

In this trial, the suction bowl was used to improve the homogeneity of the powder layer and consistent density inside the powder bowl.

The powder displayed an almost fluid-like behaviour, with very limited cohesion between particles. The application of a light vacuum from the bottom helped to make the powder bed uniform, leading to a more stable dosing process. This solution proved particularly effective with light, highly free-flowing and non-compressible powders.

Final Remarks

Grape seed extract (Vitis vinifera) is a 100% pure natural powder characterised by the lack of an effective response to the compression forces applied during the dosing process. As a result, it is unable to form the powder slug required for dosing with dosator-and-piston (syringe-type) technology.

What optimisations does IMA provide to process this type of product?

IMA’s response to non-compressible powders is the use of dosator and piston with suction, a solution that, allows the powder to be collected and retained effectively inside the dosing chamber. This ensures a regular and repeatable fill inside the capsule body, even in the absence of internal cohesion of the powder.

This case study shows the Competence Center’s scientific approach and the operational flexibility of its capsule fillers, from technological powder analyses used to predict behaviour to the selection of the most suitable mechanical and process optimisations aimed at reducing machine set-up time, even when handling products with highly diverse characteristics requiring different configurations.

IMA is a leader in capsule-filling technology. Its experience ensures consistent and repeatable processes even when working with challenging products such as non-compressible powders and pure natural materials, guaranteeing operational stability, dosing accuracy and continuous production performance.