Investigation of the production of wet agglomerates of couscous grains using a fluidized bed granulator

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8th granulation workshop

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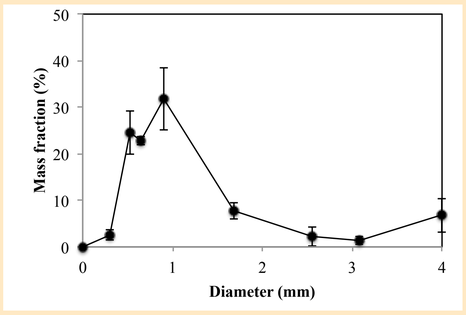
Introduction & Objectives

Agglomeration is a key operation in the elaboration of couscous grains of durum wheat semolina (made by successive operations: wet agglomeration, cooking and drying). It is usually conducted in mechanical mixers and determines the production yield, the final size, shape and functionalities of couscous. The main objective of this work is to **explore the capability of the fluidised bed technology to produce agglomerates of durum wheat semolina**.

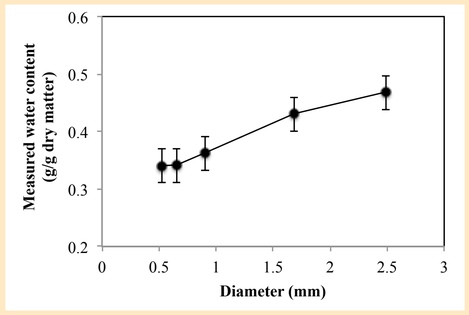
Results

Mechanisms of durum wheat semolina agglomeration in a fluidized bed

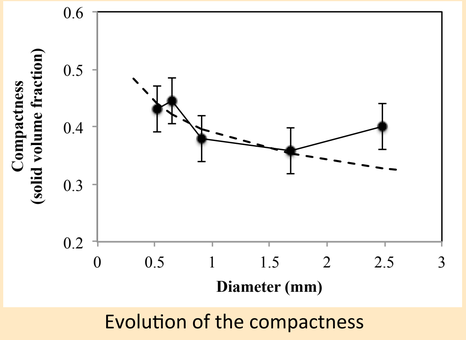
A large range in the diameter values is observed on the size distribution curve (d_{50} = 650 µm). The water content of the wet agglomerates is positively correlated with their diameter. The increase of the d_{50} of the wet agglomerates is also associated to a decrease of their compactness. Large agglomerates are more spherical. **Mechanism for the wet agglomeration** can be considered as **fractal morphogenesis** for the smaller structures (d_{50} ≤ 1600 µm), followed by some **phenomena of densification** for the larger structures (d_{50} ≥ 1600 µm) .



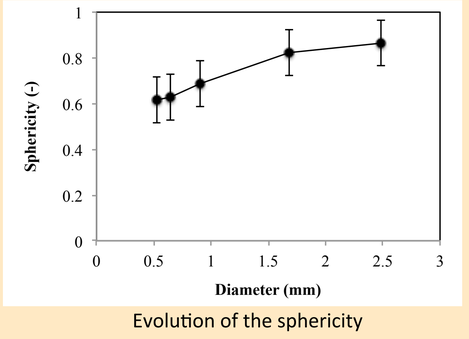
Size distribution



Evolution of the water content

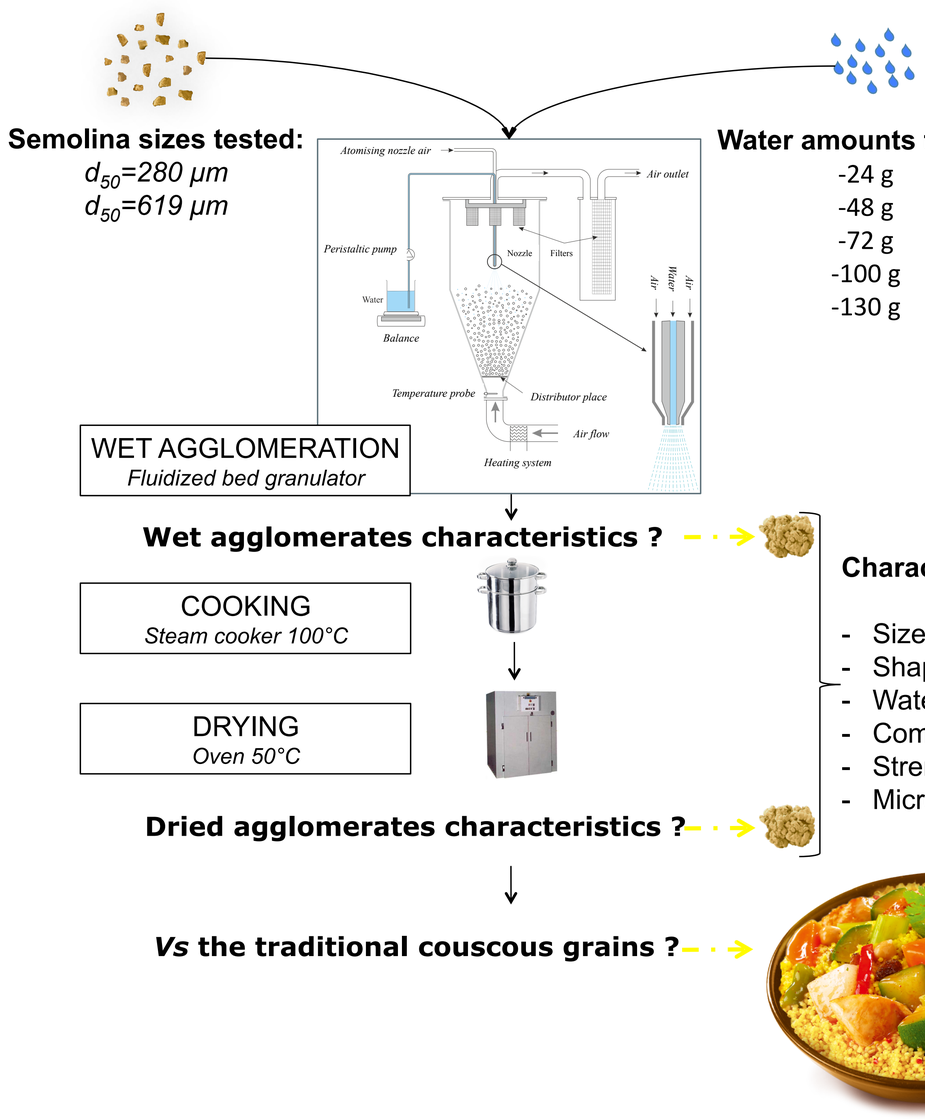


Evolution of the compactness



Evolution of the sphericity

Fluid Bed experiments



Water content impact:

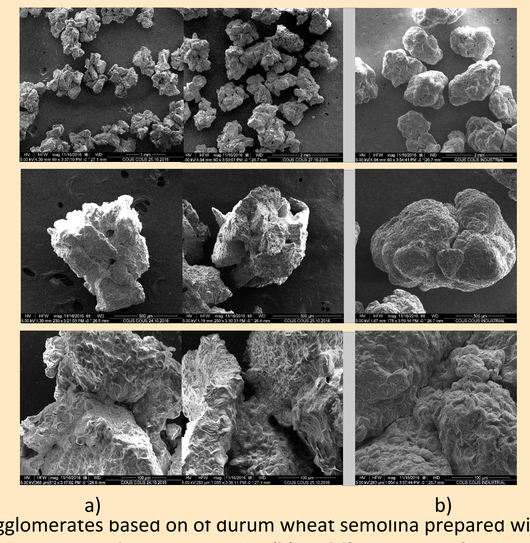
- Larger diameters
- Higher values of water contents
- Lower values of compactness
- No impact on the sphericity

Semolina size impact:

- Larger diameters
- Lower values of water contents
- Lower values of compactness
- Slight decrease of the sphericity

Characteristics of the dried agglomerates in fluidized bed

Dried agglomerates of durum wheat semolina are characterized by **irregular shape, with very rough surfaces**. They appeared as semi discrete particles glued to each other. **The strength to compress the granules was significantly lower** than those measured for the classical couscous grains.


a) b)
Microstructure of the agglomerates based on of durum wheat semolina prepared with the fluidized bed (a) and commercial couscous grains (b) at different magnifications.

Characteristics of the traditional couscous grains in low shear mixer

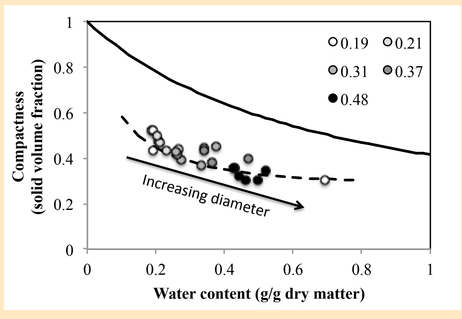
The classical couscous grains were characterized by **spherical shape with regular surfaces**. The native semolina particles were poorly visible in the grains. The **classical couscous grains were more compact** and consolidated by complete starch gelatinisation during the cooking stage.

Hydrotextural analysis

On the hydrotextural diagram, **the structures become closer to the saturation curve with an increase in their size.** Mechanisms of agglomeration in a fluidized bed show a **first stage of expansion**, which is induced by an addition of water. The saturation degree slightly increases. During **the second stage**, the structures continue to grow up but with **densification mechanisms** due to the capillarity influence.

$$\phi(w) = \frac{1}{1 + d_s^* w\left(1 - e^{-\frac{w - w_m}{d}}\right)}$$

A relationship describes the variation of the compactness (link to the size of the structure) by using only the water content. Where d^*_s is the real density of the semolina particle, w is the water content, w_m is the water content at S=50% and d is the reverse slope of the central quasi-linear section of the sigmoidal curve



Hydrotextural diagram

Conclusion

Agglomeration in fluidized bed of durum wheat semolina is characterized by a **higher amount of agglomerates** with diameter between 1 and 2 mm (considering as a better yield for the production of couscous). Agglomerates of durum wheat are **less compact** than the classical couscous grains. Agglomeration is driven by a **fractal formation process** followed and by **densification mechanisms** for the large agglomerates. **Specific model is used to describe the interparticle arrangements**.

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