



DAIRY INGREDIENTS FAX

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Bulk Density

Bulk density is a very complex product property for milk powder and is of great importance for economical and functional reasons. High bulk density is desirable for reducing shipping and packaging costs. On the other hand, low bulk density, as seen in agglomerated products, influences other powder properties such as flowability and instant characteristics.

Bulk density is the weight of a volume unit of powder and is usually expressed in g/cm^3 , kg/m^3 , or $\text{g}/100 \text{ ml}$. Bulk density is usually determined by measuring the volume of 100 grams of powder in a 250ml graduated cylinder after exposure to compaction by standardized tapping. The bulk density of nonfat dry milk has a wide range, from 0.18 to 1.25 gms per ml. Regular spray dried is approximately 0.50 to 0.60 gms per ml, while roller dried nonfat dry milk is 0.30 to 0.50gm/ml. Generally, foam spray dried milk has the lowest bulk density, followed by roller and then by spray dried. Figure 1 shows 100 grams of high heat nonfat dry milk powder and 100 grams of agglomerated nonfat dry milk powder in a 250ml graduated cylinder.

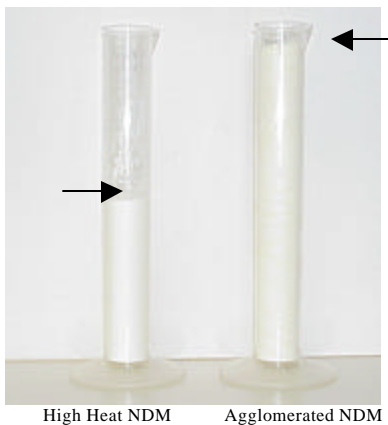


Figure 1 - 100 gms of high heat NDM ($P=0.68 \text{ gm/ml}$) compared to 100 gms agglomerated NDM ($P=0.33\text{gm/ml}$)

Bulk density of the final powder is a result of particle density (occluded air and density of the solids) and the interstitial air. Bulk density can be influenced by many different factors which include:

- density of the solids
- amount of air entrapped in the particles (occluded air) or the particle density
- amount of interstitial air (air between the particles)

Occluded air is one of the most important factors for controlling bulk density. If a high bulk density product is warranted, occluded air content should be kept as low as

possible. Low bulk density can be achieved by increasing occluded air or by agglomeration. As occluded air content increases, particle volume increase, thus decreasing particle density and bulk density.

Occluded air content rises if air is incorporated into the feed prior to spray drying. Air is also drawn into the feed during atomization with rotating wheels. Air may be incorporated into the concentrate during transfer from the evaporator to the spray dryer or during atomization. The degree of denaturation of the whey proteins, concentration and temperature of the feed also as an affect on the amount of occluded air in the powder. Low heat products have a higher content of occluded air due to the higher content of non-denatured whey proteins which increases foaming properties. Therefore, the higher heat treatments have a higher bulk density due to a lower foaming ability and lower content of occluded air. During processing, the occluded air content can be minimized by heating the concentrate (50% total solids) up to 80°C .

Spherical shaped particles make for a low content of interstitial air which results in higher bulk density. Irregularly shaped particles with attached smaller particles result in a lower bulk density. It is the shape, as well as the size of the particle that will affect how close the particles are packed together, thus influencing bulk density.

There are many different methods for determining bulk density of powder. The IDF-Standard 134-1986 uses a 250 glass cylinder and 625 taps. The Engelsmann tapping machine is the most widely used apparatus for measuring bulk density. The Ledoux method requires 28.31 grams of powder to be placed on top of 28.34 grams of powder in a 100 ml measuring cylinder that is tapped 100 times.

In summary, a high bulk density powder can be achieved by limiting the air entrapped in a smooth particle with spherical shape and appropriate particle size distribution. Low bulk density can be achieved by increasing the occluded air or by agglomeration.

Reference:

Pisecky, J. 1997, "Handbook of Milk Powder Manufacture", Niro, A/S, Denmark.

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