

**Title** Flowability and handling characteristics of bulk solids and powders – a review with implications for DDGS

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### **Abstract**

Much research regarding handling and storage characteristics of bulk solids has been conducted over the years. Physical properties of granular solids play a significant role in their resulting storage and flow behaviour, and are therefore essential to design appropriate, efficient, and economic bulk solids handling and storage equipment and structures. Distillers Dried Grains with Solubles (DDGS) is a bulk material that has been widely used as a protein source for ruminants and non-ruminants for more than two decades. Distillers grains are energy and nutrient dense, and are often used as a replacement for corn in animal diets. With the exponential growth of the fuel ethanol industry in the last few years, large quantities of distiller's grains are now being produced. To effectively utilize these feeds in domestic and international markets, however, these co-product streams are increasingly being transported greater distances, and must be stored until final use. DDGS flow is problematic as it often becomes restricted by caking and bridging which occurs during transportation and storage. This issue probably results from a number of factors, including storage moisture, temperature, relative humidity, particle size, time, or temperature variations, to name a few. The objective of this study was to review the primary factors affecting flowability, handling, and storage of granular solids and powders, as well as appropriate testing methodologies for these materials. Considering these will be helpful when examining granular flowability and storage challenges for byproduct feeds, including those surrounding the use of DDGS.