

2001 MAFMA Final Report

Project Title: **Optimization of Seasoning Properties for Electrostatic Powder coating of Snack Foods**

PI **Sheryl Barringer**

Academic
Institution **The Ohio State University**

Award Date **Fall 2001**

1. Objective Summary

The objective of this project is to improve the coating of snack foods using electrostatics. The effect of powder properties on coating efficiency was determined.

2. Objective Accomplishments

Objectives:

The physical properties size, cohesiveness, chargeability and density were measured on a dozen different powders and correlated to their transfer efficiency and dustiness when coated electrostatically and nonelectrostatically onto various snacks. This was done for two coating systems, a conveyor belt and a tumble drum and the methods compared. Powders were ground to different sizes to isolate the size effect from other effects.

Results:

Electrostatic coating almost always produced significantly more efficient coating with less dust production than nonelectrostatic coating. Four physical properties: size, cohesiveness, chargeability and density were found to correlate to the efficiency and dustiness of the process. Knowing the physical properties of the powder enables how efficiently it will coat the food item to be predicted.

Size is a very important factor to coating efficiency and is dependent on the type of coating system used. Both electrostatically and nonelectrostatically, smaller particles have higher coating efficiency in a gravity fed tumble drum system. Smaller particles are more easily carried by air currents and dispersed evenly across the product in the tumble drum. Also, the repetitive mixing of the product and powder in the tumble drum may allow smaller particles to get into product crevices thereby increasing coating transfer efficiency. Opposite results were obtained using a pneumatically fed conveyor system. Powder is gravity fed in the tumble drum, while in the conveyor system powder is air propelled. Therefore more of the powder is trapped inside the drum than in the conveyor system. Air propulsion of the powder in a conveyor system may result in smaller particles with light masses being blown off or past the product on the conveyor belt. The gravitational forces acting on larger particles may overcome the aerodynamic forces in the conveyor system, causing large powders to land and

adhere to the target. Thus, the type of powder dispensing system determines the effect of particle size. Smaller particles are also dustier in all systems and under all conditions.

Cohesiveness is an important factor in both electrostatic and nonelectrostatic coating, but less important in dustiness. Free flowing powders are more efficient nonelectrostatically and electrostatically in both systems. It is critical that powder be able to maintain a uniform mass flow rate in order to be well dispersed. Cohesive powders have a propensity to form aggregates that hinder their ability to flow through the system, and as a result, cause variations in mass flow rate and transfer efficiency. In a conveyor system, clumps of cohesive powders can be observed rolling off the product and conveyor belt. Clumps are also more likely to fall off the product than if the product is evenly coated. Additionally, cohesive powders tend to choke, or form bridges, at the container outlets they are flowing from. Choking causes the powder flow to stop and hence, powder is not delivered to the substrate. This can be especially important in a tumble drum system where the powder is gravity fed.

The ability to pick up a charge is important to produce good electrostatic coating in both systems, as would be expected. The larger the charge a powder particle can attain, the greater the attraction it has for the substrate, resulting in greater transfer efficiencies. Powders that are efficiently charged achieve a uniform deposition efficiency and good adhesion. In addition, the greater the charge to mass of a powder, the greater the radial trajectory. This indicates that the larger charge causes powder particles to repel and spread out further resulting in a more uniform deposition.

Density was the least important of the four physical properties. Denser powders gave higher transfer efficiencies in the tumble drum, but was not important in the conveyor system.

The improvement in coating efficiency due solely to the use of electrostatics was greatest for less dense, highly charging powders. Small powders were more efficient in the conveyor system, but size had no effect in the tumble drum system. In the conveyor system, the small particles are pneumatically dispersed and so are more likely to be lost unless they are electrostatically charged. Additionally, small particles are generally considered to be the most efficient in an electrostatic system. The smaller the particle size, the greater the surface area, and the larger the surface area of a particle the more charge it can theoretically pick up. The larger the charge a powder particle can attain, the greater the attraction it has for the substrate, resulting in greater transfer efficiencies, so this was expected. In the tumble drum, regardless of size, all powders improved approximately 15% when electrostatics was used. Since smaller particles were already very efficient, they had less room to improve than large particles and size was not a significant factor. Thus, the importance of particle size to electrostatics depends on the coating system used.

For dustiness, small, free flowing, highly charging powders tended to show the greatest improvement due to the use of electrostatics in the conveyor system. There was no significant improvement in dust in the tumble drum system, possibly because there was less dust produced by the tumble drum process.

3. Unexpected findings, if any

The improvement in coating efficiency was dependent on the type of coating equipment used. It is generally accepted that smaller particles are better for when electrostatic coating is performed, but this was found to be dependent on the coating system used.

4. Practical impacts of research efforts.

Short term impacts:

This information has been given to equipment manufacturers who make electrostatic coating equipment, Spray Dynamics and Terronics. They are using this information to educate their customers and potential customers on the best powders to use for electrostatic coating. The industrial partner, Spray Dynamics, has used this information in their demonstrations for customers to show the advantages of electrostatic coating.

The effect of powder properties on coating efficiency is better understood. This information is being distributed to food companies who use powdered seasonings and seasoning companies that make the powders, to enable them to manipulate the physical properties to produce the best coating. The industrial partner, Kraft, is using this information in a proprietary manner to produce better food items.

Long Term Impacts:

The results of this study are another step toward a better understanding of powder physical properties. The information is being used by the industrial partners to improve their equipment and processes to produce more desirable products.

Ongoing research:

This research area continues to be an active one in my lab. The results of this work showed that the ability to pick up a charge is important to predicting how well a powder will work with electrostatic coating. Therefore, future studies will test several different methods for measuring charge pick up, as well as other physical properties, to determine which is the best predictor of coating success.

This project focused on the processing variables efficiency and dustiness, but did not look at the effects on quality. Future studies will measure the evenness of the coating on each different piece, to determine if electrostatics produces more even coating. Future studies will also do sensory evaluation to determine if consumers can detect a difference between electrostatically and nonelectrostatically coated samples.

The electrostatically coated samples appear to remain coated longer than those coated nonelectrostatically. This adhesion effect has been reported in the literature for paint, but has not been studied in food systems. Electrostatic adhesion will be studied further.

Publications

Ricks NP, Barringer SA, Fitzpatrick JJ. 2002. Food powder characteristics important to non-electrostatic and electrostatic coating and dustiness. *J Food Sci* 67(6): 2256-5563.

Biehl HL, Barringer SA. 2003. Physical properties important to electrostatic and non-electrostatic powder transfer efficiency in a tumble drum. *J Food Sci* accepted 8-24-03