Coating Systems: Opportunities in Batters and Breadings

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Coating systems, or Batters and Breaders, are used to enrobe a wide range of substrates in order to enhance their visual, textural, and flavor characteristics. With over 1.1 billion pounds used annually in the United States alone, they constitute an important category of ingredients. They can be used as a single or multiple layers, they can be a liquid, particulate based, or more often, a combination of the two. Within this discussion, we will describe what they are, give brief formulation descriptions, and discuss how they are produced, how they are used, and conclude with some opportunities for improvements.

Often times the question is asked as to why a coating system is used. What is the reason for taking a product and applying 30 to 50 percent batter and breading? One reason is to improve your product's yield. For vegetables, coating systems can contribute 50 to 60 percent or more of the finished product's weight. On shrimp, where the coating pickup is regulated, 50 percent coating is the standard. This means that one-half of the coated weight of a pound of breaded shrimp is the coating; the other half is shrimp.

For red meat and poultry, the allowable coating pick up is 30 percent. Going over that amount is acceptable but will require an adjustment in the name of the final coated item. A breaded meat patty with 30 percent coating can be labeled as a breaded meat patty. If the coating weight is over the 30 percent, then it must be labeled as a fritter. This may or may not be a negative connotation and change the perception or acceptability of the product. Fritters can have much higher pickups of coating, ranging up to 50 percent or more. This means less meat as the base.

Other benefits for coatings are that they can alter the visual appearance, texture, and taste of the total product. With the wide range of batters and breaders available, as we will discuss later, there is almost no end to the variations that can be made. By using one substrate as your base and changing the outer coating, you can create products that taste and/or look different. It is an easy way to extend your product line.

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Extension of reconstitution methods and protection during freezer storage are a few other side benefits.

In discussing coating systems, it is important to have an understanding of how the product will be coated and processed. This includes not only the processing methods but also how the end user, or final customer, is going to cook it back. In-store coating systems are normally formulated differently than those that are processed industrially. This is because in-store systems that are typically fried or cooked immediately then served. There is no freezing or frozen storage involved. Being from a "fresh" state, this may reduce the cook or reconstitution time. The coating system would then be formulated with more browning agents to achieve the proper finished cooked color with less cooking time.

The type of substrate being coated is important. A formed red meat or poultry patty will require a different coating system than a whole muscle substrate. When discussing Batters and Breaders, like with most technologies, understanding the terminology is a key factor. I believe it is safe to say that a boneless chicken breast is different than a formed patty. Knowing that and having your coating supplier aware of the type of product that you are using can be the difference between success or failure.

Processing methods are another key issue. Different coating systems require different equipment. An industrially prepared batter fry system, where the outer coating is a liquid application, will normally have a specialized batter applicator and be finished with a fryer stage prior to freezing. If the liquid batter is not "set" prior to the freezer, the batter will continue to flow around the freezer belt. The end result will be sticking to the belt and many voids in the coating where it has been pulled off the substrate.

If the system has a dry outer coating, be it flour or a baked particle, the coating process can become more intricate. Although a frying step may not be required, the layering of the coatings and the types used need to be compatible with the coating equipment. For example, a flour-based coating system will require equipment capable of handling the flour. Flour breaders tend to compact more and be less free flowing than other types of breaders. A flour applicator is designed to move the flour through out the coating process by means of flat-flex style belts. These are the same types used to convey the substrate through the applicator itself. Mechanically moving the flour through the applicator ensures that the coating will be applied when and where it is required.

A free-flowing type coating such as a Cracker Meal or Breader requires less of this mechanization. Gravity will assist the movement and placement.

Japanese Style Bread Crumbs and American Bread Crumbs, although free-flowing in nature, will call for another specialized applicator to reduce crumb degradation. Being of a larger particle size, more porous and fragile in texture than Breaders or Cracker Meals, JSBC needs to be handled and conveyed in a gentler manner. Trying to apply this style of coating with a flour applicator, for example, will result in a finer, ground up Crumb. The additional mechanization of a flour applicator would be detrimental.

During the development of a coating system or entire coating process, it is imperative that the processor, coating manufacturer, and equipment supplier have knowledge of the target product.

Communication prior to equipment or coating purchases can reduce overall developmental time and product nonconformaties.

The next part of this discussion will focus on the ingredients that go into the manufacture of coatings. There is a wide range of materials that are used as the building blocks in batter and breader formulation work. Each ingredient in itself could warrant an entire seminar. The fact is, there are seminars sponsored by the American Institute of Baking and the American Association of Cereal Chemists covering the functionality and types of starches, chemical leavenings, hydrocolloids, and flour, just to name a few.

Although not all-inclusive, the majority of the ingredient categories are Wheat and Corn flours, Starches, Browning agents, Coloring agents, Leavening agents, Gums, and Seasonings/Flavors.

Wheat flour is by far the largest single ingredient used. The flour type, soft or hard, in addition to how it is processed or treated, is matched to the Batter, Breader, or Crumb being developed. Flour-based coatings, such as those seen in bone-in poultry or chicken fried steaks, often differ in the flour type used. A hard wheat flour is common for bone-in poultry products to enhance the crispiness, fried appearance and reduce coating blow-off in the processing fryer. Chicken fried steaks, normally coated and frozen in an industrial process, use soft wheat flour. Fry color and texture differ from that of the poultry product. The objective is to match functionality with economy. Soft wheat flour is generally less expensive than hard wheat flour.

Further processed coatings are developed using the same thought process: What flour can be used to obtain the best results at the best cost? Certain bread crumbs use a typical bread flour, hard wheat, high protein. Others, such as Cracker meals, can be manufactured with a soft wheat flour.

Similar reasoning goes into the decisions for Batter formulations. The end user is hydrating the dry Batter mix at their location. How it is to be used, the mixing and application equipment, all play a role in the flour selection.

Corn flour, both white and yellow, are base ingredients for certain types of Breaders and Predusts. The main use is in Batter formulations. Yellow corn flour is the more predominant of the two. It contributes not only to texture but also adds a golden background color to the finished product. White corn flour will give the item a lighter background color.

Corn meal and corn cones are additional variations of the corn theme. Being harder in texture and larger in size than corn flour results in alterations to the visual and eating texture of the finished product. Catfish coatings typically carry high percentages of these two ingredients.

Starch is another significant ingredient used in Batters and Breaders. Corn starch and its variants are the largest by volume. Other types include wheat, corn, potato and rice.

Modified corn starch is a major contributor to adhesion in coating systems. It is used as a dry component in Predusts or in a hydrated state when formulated into Batter mixes. Adhesion, or the ability of the coating to stick to the substrate, contributes a lot to the finished product in appearance and eating quality. Having the coating come off while the consumer is eating or cutting into your product is not generally considered a positive attribute! As with wheat flours, function and economy should be important considerations in choosing the starch component.

Starches can have other important effects on coated products. They can aid in the crispiness of the finished product and effect the process ability. Too much modified corn starch can cause the Batter to set up, or dry, on the substrate prior to having the final Breader applied. The result would be poor or insufficient coating coverage. Too much starch in the Batter can also cause a shell-like effect to the coating. This can occur with red meat patties. The substrate and the coating are separated by an air layer giving the patty a balloon shape. The starch forms such a tight coating that the steam emerging from the cooking substrate cannot escape. The coating expands and sets into a hard shell. This not only changes the appearance of the finished product but also allows the coating to break off. Voids and an unsightly product are the result.

Wheat flour corn flour and starch are three of the major building blocks in the coating world. In Batters, they can and are used in various combinations to maximize product and processing performance.

Browning agents are ingredients that contribute color to the product during the pre-cook or full cook stages. Some basic Browning agents are sugar, dextrose, whey powder, and nonfat dry milk. Each, when blended or baked into a coating, give a certain color hue to the fried product. The objective is to use the correct ingredient that imparts the target color within cost and label restrictions.

There are other ingredients that can affect fry color. These are soy and potato flour, monosodium glutamate, and cheese powders, to name a few.

Coloring agents impart color to the dry Batter, Breader or Bread Crumb prior to the cooking stage. They not only add or increase eye appeal, but also can be used to modify the cook time. A product that may have a long fry time may have a low percentage of Browning agents. Too much would cause the product to darken or burn. The Coloring agent will add vibrancy to the finished product but not contribute a lot to the browning effect. This way the finished product is cooked and retains an appealing finished color.

Some examples are oleoresins of paprika, paprika-annatto, turmeric, caramel powders and artificial colors. Whether or not the colors are blended or baked into the systems are dependent upon the type and process involved in making the Breaders or Bread Crumbs.

Leavening agents, yeast and chemically derived forms, are used in Coating development. Baked Bread Crumbs, such as an American Bread Crumb or Japanese Style Bread Crumb, are yeast leavened. The dough goes through a proofing stage as is typical for any bread baking process. This, in part, gives the baked crumbs different textures and densities. The manufacturing process of the baked crumbs also contributes to the final product characteristics.

Chemical leavening is more often used in Batters and Blended Breaders. A mixture of sodium bicarbonate and a leavening acid or acids give off carbon dioxide gas bubbles when hydrated. Often, heat will have to be applied as well. Choosing the type of chemical leavening is based upon processing and the product characteristics. Chemical leavening can help alter the texture and crispiness of the coated product. A liquid batter will trap gas bubbles and set them into the coating upon cooking. (Think of pancakes being cooked on a griddle. Without a balanced chemical leavening system, they would either be flat and chewy or extremely light and crispy.) By manipulating the acid type or levels, fry color and oil absorption can be altered as well.

Using starches and flours to develop a batter mix may result in low viscosity upon hydration. Low viscosity Batters can cause low coating pick up weight and incomplete coverage of the substrate. Adding some guar gum can increase the viscosity and make the Batter more processor friendly. Too much may result in a highly viscous Batter that does lend itself to high speed production lines. Other gums that alter other characteristics are xanthan, sodium alginate, methylcellulose and hydroxypropyl methylcellulose.

One last major category is in Seasonings and Flavors. One appealing aspect of Batters and Breaders is their ability to alter the characteristics of the cooked product. Adding some Flavors and Seasonings contributes even more to the value added concept. What is now visually appealing to eat also tastes great. Subjecting coated products to high heat cooking conditions does tend to reduce overall flavor impact. New technologies in flavor development have had a positive effect in controlling the flavor loss.

When and where to add Seasonings and Flavor components is dependent upon the amount of flavor impact required, the processing equipment that is available, and the reconstitution methods of the end user. If the coating process has multiple steps, the Flavor and Seasoning can be added in each step. This will increase the overall taste of the finished product. Layering in these ingredients gives them some protection during fryer reconstitution.

Taking all the ingredients as discussed above, the next step in the Coating process is to make them into a finished Batter or Breader. The types of Coatings are generally listed as Cracker Meals, White and Pink Breaders, Extruded Crumbs, American Bread Crumbs, Japanese Style Bread Crumbs, Blended Breaders, and Batter mixes. Each will impart a different visual and eating quality to the finished product. Flexibility in processing these products is also important. Not all are produced on the same equipment.

Cracker Meals, White and Pink Breaders are manufactured on the same type of equipment. A sheet of dough is baked, ground and dried. The end result is a hard, granular particle that is extremely durable in Breading applicators. Choosing the correct formulation will be based upon the color and cooking process required by the processor and the end user.

Adding ingredients to the basic Cracker Meal will alter raw and fry colors. The White and Pink Breaders fall into these categories.

Extruded Crumbs can be similar to the above. The significant difference is in the way they are produced. A single or twin barrel extruder will produce a hard, dense particle similar to the Cracker Meal or Breaders. These Extruded Crumbs are baked under heat and pressure. Upon exiting the barrel of the extruder, the dough expands and sets. The rate and amount of expansion is controllable and allows variations in density and particle texture.

Modifying the process further will result in a much more porous product similar to a Japanese Style Bread Crumb. This product will be described a little later.

American Bread Crumbs add another Crumb variant. This is a yeast leavened dough system. The bread, prior to grinding and drying, looks like a retail loaf. There is the white inner portion and the surrounding crust. When finished, the result is a two tone product with a lower bulk density and visually more open structure then a Cracker Meal or Breader. The difference in texture is apparent in the finished fried stage as well. The American Bread Crumb will give a homestyle appearance before and after cooking.

The next product is unique in how it is produced and the properties that it imparts to the finished coated substrate. The Japanese Style Bread Crumb begins as a yeast leavened dough much like the American Bread Crumb. After a proofing stage, the bread is baked with an electric current. This dielectric baking process results in a very light, crust-free, slivered crumb. The fried product has a light crispy bite with an audible crunch. A Japanese Style Bread Crumb requires specialized application equipment to give optimum visual and eating qualities.

Blended Breaders, along with Batter mixes, are the two largest categories of coatings. They are produced in the same type of horizontal ribbon blender. The differences are in how the two products are used in the coating process.

Blended Breaders can be made from combinations of any of the previously discussed ingredients, Breaders, or Bread Crumbs. Imagination plays a role here in deciding what properties are desired and what combination of coatings and ingredients are needed to achieve it. A harder textured Breader can be combined with a lighter, crispier Japanese Style Bread Crumb, for example, to give duality in the bite of the product. Mixing light and dark frying products will enhance highlights and add additional depth. Seasonings and Flavors add to the taste and visual appeal. This opens up a very wide product category.

Batters are typically thought of as the "glue" that holds the coating and substrate together. This is an important but not

the sole function of Batter mixes. As outlined in the ingredient section, the make up of the Batter does contribute to the texture, color, and flavor of the finished product. As an example, a highly colored Batter can alter the background color thereby increasing the overall visual intensity of the final product.

For purposes of this discussion, Batter mixes can be considered as adhesion type, coating, as in the case of a batter fry product, and functional.

Certain ingredients do aid in the adhesion properties. The substrate that is being coated also contributes in a positive or negative way. Vegetables tend to be more difficult when it comes to achieving good adhesion whereas red meat and poultry products can have better results. There are interactions between the Batter components and substrate protein that helps with this binding property.

Functional Batters are those that act as carriers for flavors, colors, or textures. They contain similar ingredients as adhesion systems. They often are more versatile in use.

Coating Batters are those designed as the outer layer, no Breader or Bread Crumbs on top. Called Batter fry, Tempura, Fish n' Chip style, their purpose is to give a different appearance and eating quality to the finished product. They can have rough, textured surfaces or be smoother, almost puffy. The flour bases along with the chemical leavening used can alter this. As noted before, these Coating Batters must be set in a fryer prior to freezing to prevent run off of the liquid. Special application equipment is required as well as modifications to the fryer itself.

Batter fry products can also be made in-store. In this case, the substrate is coated, fried and served hot without being frozen and recooked.

With as much Batter and Breader sold annually, there still exist many opportunities for continued improvements. Adhesion is always a critical area. Without it, the coating can have a tendency to break off during the storage, transportation, or reconstitution. Some products, such as whole muscle fillets or meat portions, tend to be more difficult in giving consistent results. These products have a tendency to shrink and change shape during frying. The Coating systems cannot respond to these changes and instead fry into a rigid shell. Flour systems offer more flexibility but there can still be some coating loss. The science behind adhesion is not fully understand and could be worth further investigation.

Crispiness is another challenging area. This is considered a positive attribute for most products. Crispiness with fryer reconstituted products is easier to obtain than those being cooked back in an oven. Many improvements in starch technology have helped this over the years. A difference in crispiness still exists between these two reconstitution methods. In addition, what can help improve the crispiness can be detrimental to adhesion. A crisp coating that falls off the substrate is not as appealing as one that adheres well.

This area relates to not only Batter technology but also would include research into Breaders and Bread Crumbs that maintain their integrity.

Another opportunity relates to both coated formed red meat and poultry products. A typical process for these items is to batter and bread, prefry, than fully cook them through an in-line oven. The oven process usually entails heat and steam. A negative attribute to this type of product is a spotting or blotching to the surface upon fryer reconstitution. This condition is not apparent during oven reconstitution, only frying. The thought is that protein from the formed product migrates to the coating during the oven cooking stage. When the product is fried, the protein darkens. The products get dark red to red brown spots that are blood-like in appearance. This is not visually appealing. Variations in coating formulation and processing have not entirely eliminated this occurrence. Additional basic research is required.

In looking at any improvements in Coating technology, it is imperative that the test parameters reflect the real world. Trying to solve a bleed through problem with 40 percent coating pick up is not a realistic solution when the maximum coating pick up is 30 percent.

Glossary of Common Terminology

Adhesion: The action of binding between the coating system and the substrate surface.

Ballooning effect: Also referred to as a "football effect." The result of the substrate shrinking from the coating system upon reconstitution.

Highlighting: Outstanding details that contrast with the background.

Percent pick up: Defined as the weight of the finished product minus the initial weight of the substrate divided by the weight of the finished product multiplied by 100.

Predust: A dry coating material applied directly to the surface of the substrate.

Prefry: A frying stage after coating that has a short dwell time. Temperature range dependent upon the substrate.

Reconstitution: Heating a product to its edible state.

Void: An uncoated area of a substrate's surface. Generally considered to be a negative attribute.