The Application of Flavors to Extruded Products

By Richard P. Lane, WJ Flavors, St. Louis, Missouri

"Food extrusion has been primarily an art and only within the last ten years has any serious effort been made to apply rigorous principles to this complicated process. This statement is not to condemn the art, for it has been the trial and error approach coupled with a keen sense of observation which has lead to the many successful applications of food extruders."[3]

This statement by Dr. Judson Harper in his two volume text *Extrusion of Foods* is, I believe, particularly appropriate today. For while we in the flavor industry have seen significant changes in our products and in the technology associated with their development over the last decade, like the artists that have pioneered food extrusion, we know that trial and error coupled with careful observation are two constants that have remained.

The first food extruders were used in the meat industry to stuff sausages. I suppose an old fashioned meat grinder could also be considered an early form of screw type food extruder. In the early 1900s extruded pasta came into existence and represented one of the first forms of extruded cereal grain products.

With time, things have changed and food extrusion today is a commonly used process seen in the manufacture of a variety of pastas, cookies, crackers, meat and dairy products, pet foods, textured vegetable proteins and a large number and variety of breakfast cereals and snack foods.

In this article, I will review some of the factors involved in the flavoring of food products produced by what is commonly referred to as "high temperature/short time" (HTST) extrusion.

A typical HTST extruder is shown in figure 1. An electrical power source turns the screw as a cereal grain is fed into the feed section of the extruder. The flight of the screw moves the moistened meal or dough along the barrel towards the die end of the extruder. Along this path the root diameter increases causing a compression or increased internal pressure and increased shear to develop as the dough is moved forward. This results in an increased internal temperature as the dough reaches the metering section of the extruder.

In this metering section of the extruder the meal is subjected to the extremes of pressure, temperature and shear and it is here that the viscosity of the meal decreases substantially due to the pseudo-plastic nature of a cereal grain-based dough. At this point in the process, temperatures may reach as high as 200°C and pressures as high as 60 atmospheres.

After a brief period of time in the metering section of the extruder, the molten grain-based dough emerges from the extruder through a carefully selected and precisely tooled opening called a die. The shape and size of the extruded final product is defined at this die opening. Upon exiting the die opening, the newly formed extrudate is cut into appropriate lengths, cooled and dried. The product is now ready to be packaged or further processed.

There are three major types of food products

This paper is a slightly editted version of a chapter from The Society of Flavor Chemists Publication "The Development and Application of Natural and Artificial Flavor Systems." To order, use the form on page 59.

 0272-2666/85/0004-5301$02.00/00—© 1985 Allured Publishing Corp.

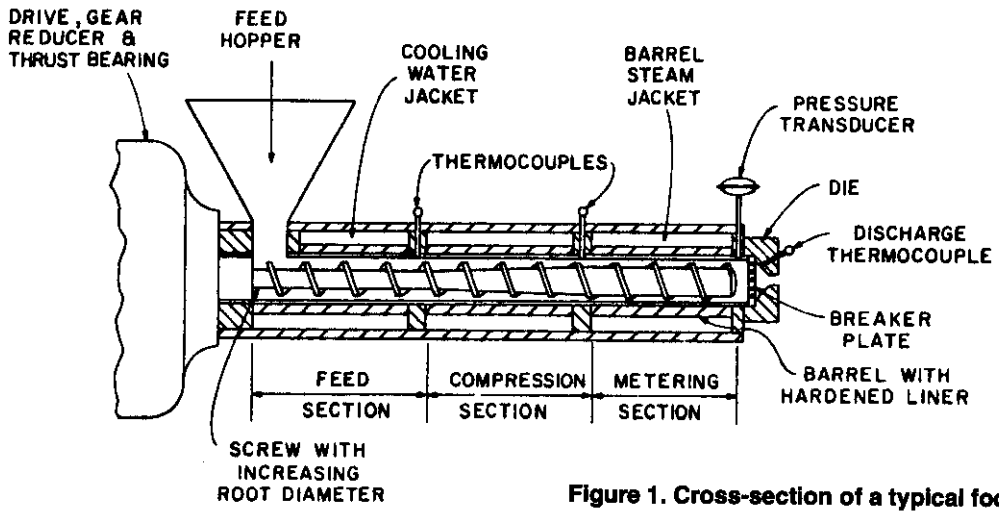


Figure 1. Cross-section of a typical food extruder[3]

produced by HTST extrusion today that utilize significant amounts of flavor: breakfast cereals, snack foods and pet foods.

From a manufacturing and flavoring point of view, pet foods are a separate technology and I will not discuss that product area in this paper.

The remainder of this article will focus on the different methods of processing and flavoring extruded breakfast cereals and snack foods. Let's first look at some of the different ways these products are manufactured. Figure 2 shows three methods of making extruded breakfast cereals as summarized by Harper.[3] It can be seen that not only can extruders be used to produce finished cooked and shaped products ready to be dried and packaged immediately, but they can also be used to cook and form intermediate or "half pellet" products that are later processed to produce an even wider variety of shapes, sizes and flavors.

A variety of snack foods can, likewise be produced as shown in figure 3 using the extrusion process. Potato chips are considered to be "first generation" snack foods. Second generation snack foods were born with the commercialization of cereal grain extrusion as evidenced by the extruded collet—the corn curl. Third generation snack foods are produced from a modified extrusion step followed by a frying step. The modified extrusion parameters allow for the use of a greater variety of cereal ingredients and produce finished products of unique shapes, textures and flavors.

While this is a simplified overview, it gives a general idea of the processing of extruded cereal-based products in the area of breakfast and snack foods.

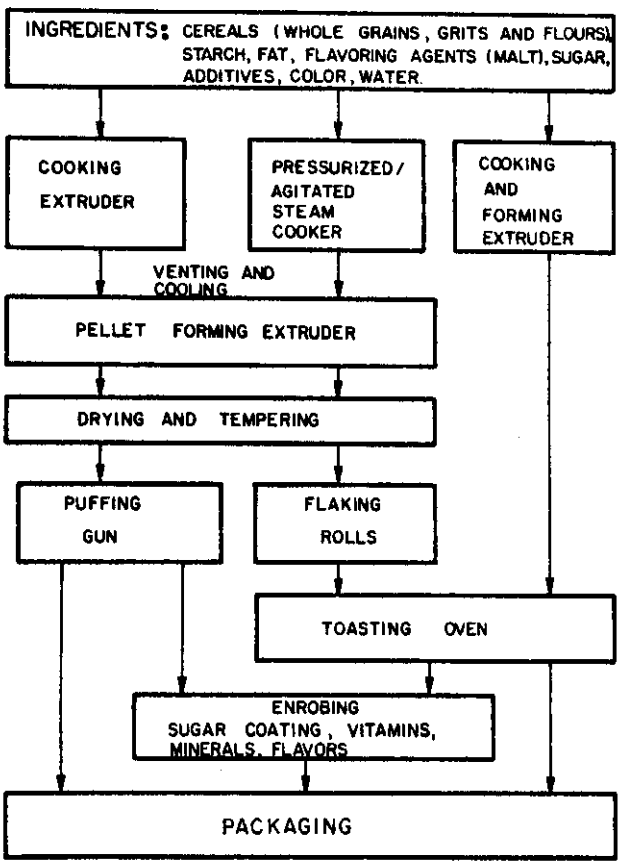


Figure 2. The role of extruders in the processing of ready-to-eat breakfast cereals[3]

Advantages and Limitations

Some of the several advantages of extruding food products are listed below:[1,3]

1. Nutritional improvement of soy based products

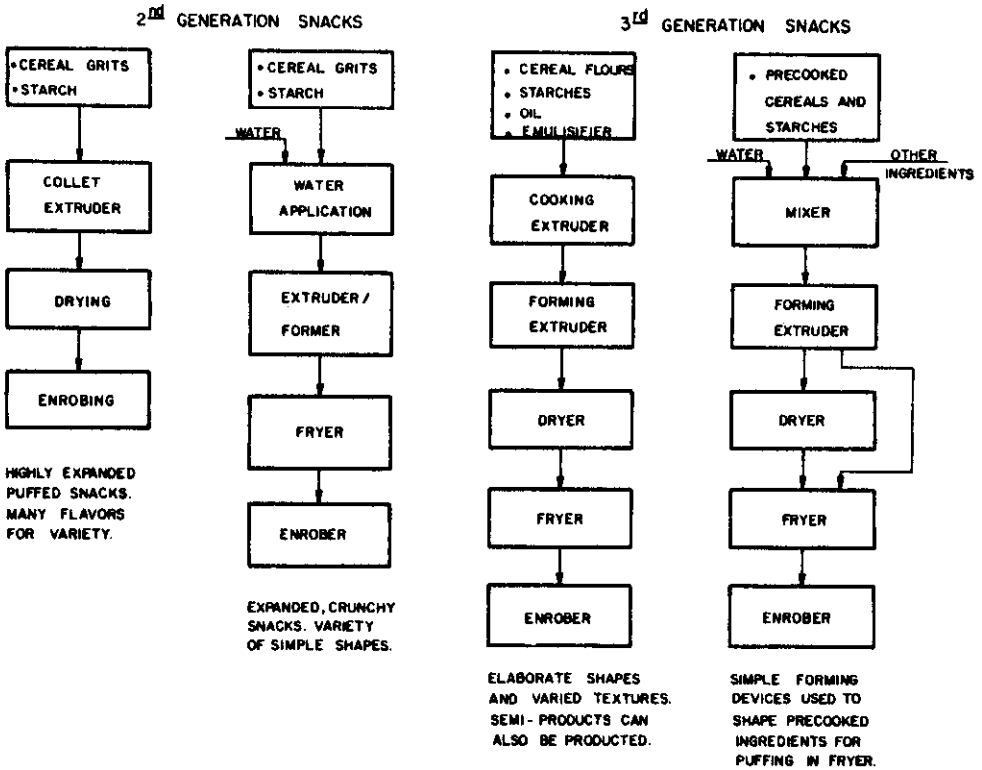


Figure 3. Extrusion process used in the production of snack food[3]

2. Continuous process
3. Efficient method of forming and cooking cereal products
4. Very uniform product shape, texture, and flavor
5. Capable of very high output of product per unit time per extruder
6. Relatively small operating area per unit output
7. Great versatility allows a wide array of product types to be produced from a single piece of equipment
8. More economical product compared to other conventional types of processing.

The advantages are not without some limitations, however, and these, I feel, can be summarized into four broad areas.

New Technology—New Unknowns

As in any new area of technology, the rapid growth in extrusion technology has meant that with it have come many unknowns that must be addressed, as Dr. Harper says, through "trial and error" as compared to a more empirical approach possible in more classic methods of bakery technology. If a change is required in composition, the net effect on the final product might not be immediately apparent without going through the rigor of actual plant trial. Much of the modeling being carried out by researchers in industry as well as in academic programs is to be better able to predict the extrusion process effect over a wide range of scale of operation as well as a wide range of ingredients.

Expertise in Operation

The wide range of processing conditions available, e.g., temperature, pressure and shear, coupled with the wide array of ingredients and limited predictability of final product lead to the realization that a high degree of expertise is required by the operator of HTST extruders in order to ensure that the desired product characteristics are attained. These so-called "artists" of extrusion technology are essential to good product manufacture.

Fabricated Connotation

Most of the extruded products in the snack and cereal product areas have a strong fabricated

connotation associated with them. Although the majority of food products we consume could be considered to be fabricated, few are of the extruded type of products as in the market place today.

Flavor Stress

Flavor stress during extrusion can be determined in two different areas as listed below.

Inside Extruder	*Outside Extruder*
High temperature	Temperature drop
High pressure	Pressure drop
Flavor degradation	Quick expansion
Base reactions	Quick moisture loss
Flavor/Base reactions	Volatile flavor loss
Flavor/Flavor reactions	

Inside the extruder barrel the high temperature environment can cause flavor degradation as a result of adverse flavor component interaction or from reactions with base ingredients or base degradation products. These reactions can translate into significant changes in flavor character. At this stage of extrusion, it is important to note that, generally speaking, no flavor has actually been lost, although the flavor profile may have been significantly altered.

When the flavored extrudate exits the die opening it is as a hot fluid mass. At this point there is a sudden drop in pressure that occurs simultaneously with a slightly less sudden, yet significant, drop in temperature. This combination causes a quick expansion of the extrudate and a quick loss of water vapor. This can result in a significant loss of flavor volatiles. We are, in fact, steam distilling away the flavor.

For those of us working on the development of extrusion-stable flavors, it is essential to formulate a flavor that can withstand this very difficult period of flavor stress and produce a product that has an acceptable flavor.

Flavoring Extruded Products

I would like to discuss more specifically the application of flavor in extruded products. In general, extruded cereals and snacks can be flavored in one of three ways: external application, internal application and a combination of external/internal application.

External application of flavors is the most common method of flavoring extruded cereals and snacks today. A large number and variety of materials available are for flavoring these products. Some of the more common items are listed below.

Snacks

Hydrolyzed Vegetable Protein (HVP)—many varieties
Monosodium glutamate (MSG)
Autolyzed yeast extract
Enzyme-modified cheeses
Spices/Oleoresins
Nucleotides
Flavors

Cereals

Dry fruit powders—freeze dried, cool dried
Chocolate/Cocoa
Peanut butter, honey, etc.
Malt extract
Essential oils
Vanilla, Vanillin, Maltol, etc.
Flavors

These externally applied flavor ingredients are applied to the extruded product in the enrobing step shown in the previous figures. In the case of cereal products, after the drying step the liquid flavors may be sprayed on with an enrobing oil blend or added with the grossing syrup in the case of pre-sweetened cereals. Dry flavoring ingredients are either dissolved or dispersed in an enrobing material or "dusted" on after the enrobing step. The surface application of dry flavor ingredients on flavor blends is more common in flavored extruded snacks.

Internal application of flavors is usually accomplished by adding the flavor to the grain meal prior to extrusion. Initial attempts at extruding liquid flavors proved to be unsuccessful.[5] Dry, encapsulated, or micro-encapsulated flavors performed much better. However, this technique has also generally been regarded as unsuccessful.[1]

Recently efforts to improve the temperature stability of flavors have resulted in the ability to successfully extrude flavors in an HTST extruder.[2,6] While flavor cost to the finished product is still a major concern, I believe that progress in this area will continue and will cause a significant change in the method by which extruded products are flavored in the future.

A third method of applying flavors to extruded products is by using a combination of internally and externally applied flavors. We have done a significant amount of work in our laboratory in order to evaluate the merits of this technique. Figure 4 shows a contour plot generated by surface response methodology analysis of data on a cheese flavored collet where various levels of

Table I. Flavor Characteristics of Common Extrusion Ingredients

Source	Strength	Character	Potential Flavors
Corn	Strong	Popped corn 2-Acetylpyrazine, etc.	Cheese, meat Chocolate
Rice	Mild	Sulfides Malty	Chicken Fruits, dairy
Oats	Mod. strong	Pyrazines Sulfides Aldehydes	Meat Chocolate
Wheat	Mod. strong	Bread Phenaldehydes	Bread, cheese Chocolate
Potato	Strong	Alkyl pyrazines Fatty Fried potato	Potato chip Chicken Onion

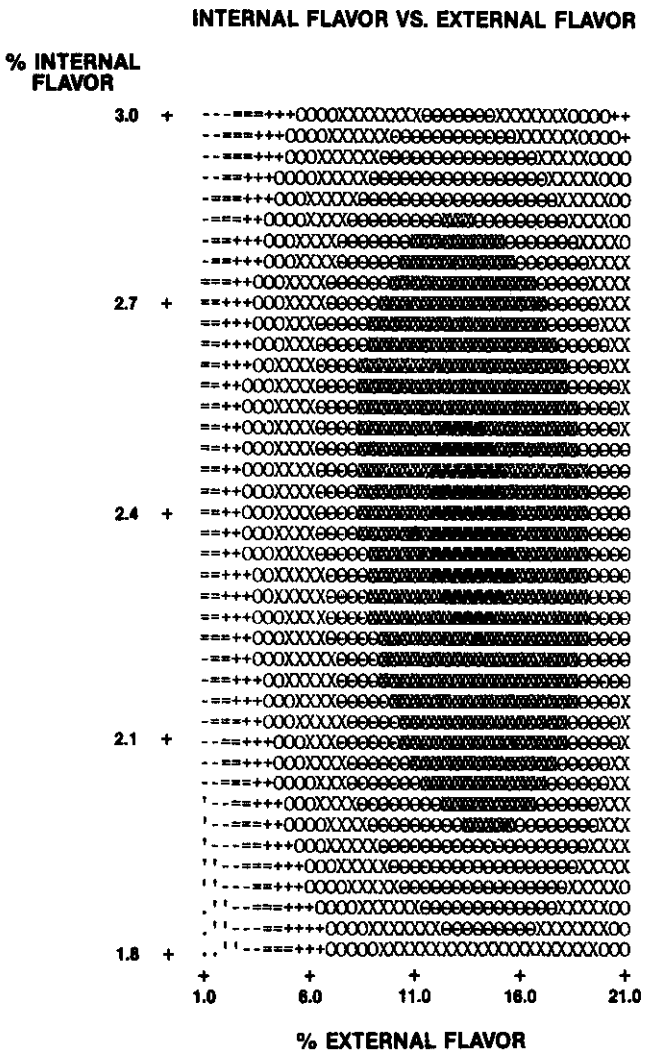


Figure 4. Contour plot of overall product acceptability

internally applied cheese flavor and externally applied cheese powders were evaluated. The results of this test indicate that the most acceptable cheese flavored extruded snack was derived from a combination of an internal and external application of the flavor system.

In addition to these various types and methods of applying flavor to an extruded product, a very important consideration is at least of equal importance to the flavor of the final product. That is the base grain or starch material being extruded. The major base materials all generate significant flavor character due to the interaction of fat, protein, and carbohydrate components as they are being cooked in the extruder.

Table I shows the flavor characteristics of some of the commonly used base materials in extruded products today. As you can see, there is wid variation in flavor strength, character and potentially compatible flavor systems that can be developed around the base grain or starch source if it is selected with flavor quality and character in mind. Many examples of extruded products today show that the flavor beneficial aspects of the base grain are greatly responsible for the flavor quality of the finished product. In some cases, the grain meal provides the only characterizing flavor of the product.

Recently I had the pleasure of tasting an extruded snack made from 100% corn meal that looked and tasted like freshly popped corn. This is an example of the utilization of the extruder's processing capabilities and the flavor properties of the base grain to maximize the flavor character of the finished product. Of the many extruded

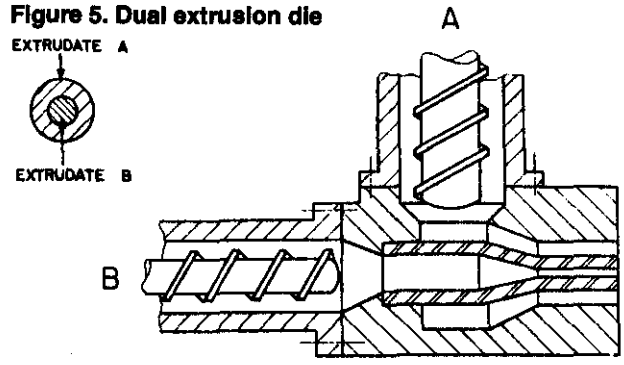
cereals and snacks available today, there are many flavor characteristics that would not be as easily attainable if the product had not been extruded. This is because the food extruder actually processes flavor as well as the food. Careful selection of grain base constituents and processing conditions can result in very beneficial flavor attributes in the finished product.

Most extruded breakfast cereals and snacks will require some type of additional flavoring to optimize the product; however, the most cost efficient flavored products will result when both grain base and added flavor are balanced around the extrusion process.

Flavoring Extruded Foods in the Future

Many of the extruded products found on the grocery shelf today are examples of the increased utilization of base ingredients to generate a desirable flavor character. The food technologists and extrusion experts will focus on this quality in development of extruded products in the future. They will utilize the extrusion process to not only generate unique shape and texture properties but also to generate unique flavor properties in extruded products.

Figure 5. Dual extrusion die



The diagram of a typical food extruder (figure 1) was in some aspects an over-simplification when compared to some of the variations equipment manufacturers have recently commercialized. I expect to see continued changes made in extrusion equipment that will result in new texture, new product identities and, in fact, new flavor effects in the final product.

Figure 5 shows a diagram of a patented extruder die.[6] This die is unique in that it allows the simultaneous extrusion of two different materials with one surrounding the other. While in this case the intent was to create a unique appear-

ance, it is not inconceivable that a product such as this could potentially solve the problem of flavor loss during extrusion with the outside layer serving to trap escaping flavor volatiles introduced into the inner matrix. I believe the advances in equipment technology shown in this type of modification, and others sure to follow, will have significant influence on the flavor systems used in extruded products in the future.

The flavor creators will have a parallel opportunity in the future. Flavorists will not only need to understand better the products and processes used in manufacture but also will have to understand better the flavor interactions that occur during processing. In the most successful new extruded products we will see the combined efforts of food technologists, extrusion technologists, and flavorists optimize ingredients, processes and flavor in the final product.

I strongly believe we will see continued improvements in the thermal stability of flavors developed for extruded products. Those of us in the flavor industry will continue to learn more about the changes that occur in flavor during extrusion. Those of you in the food industry will continue to learn more about the intricate processing changes occurring in the blends of protein, fat, carbohydrates and fiber that make up these extruded products. We will learn more about each other's areas of expertise in our working relationships and find explanations for existing phenomena currently without explanation.

Through the changes we will experience in the next few years in both the extrusion of foods and in the creations of flavors, the scientists, the technologists and the artists of each discipline will continue to rely upon a certain amount of "trial and error" in their approach and most certainly will be required to possess a "keen sense of observation."

References

Address correspondence to Richard P. Lane, WJ Flavors, 2526 Baldwin St., St. Louis, Missouri 63106, U.S.A.

1. S. J. Galluzzo, Flavoring Extruded Snack Foods. AACC "Flavor Application" Short Course: Chicago, Il. 1980
2. A. Graete and M. Mansfield, Extruded Flavor—Trend Setter for a New Generation of Foods. H & R Contact, No. 33, 1983
3. J. M. Harper, Extrusion of Foods. Vol. I, CRC Press, Inc., Boca Raton, Fl. 1981
4. J. M. Harper, Extrusion of Foods. Vol. II, CRC Press, Inc., Boca Raton, Fl. 1981
5. J. W. Kinnison and R. S. Chapman, Extrusion of Colors and Flavors. Snack Food, 61 (1), 40, 1972
6. R. P. Lane, Formulation Variables Affecting the Flavor of Extruded Snacks and Crackers. Cereal Foods World, Vol. 28, No. 3, 1983
7. L. Slaybaugh, Methods and Means of Making a Composite Food Product, U.S. Patent #3480445, 1969