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CORNFLAKES DON'T GROW ON TREES

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A b s t r a c t. The food processing industry has dramatically increased the kinds and types of food products which are now available for public consumption. The developments of new products by food scientist and the development of new equipment by engineers to mass produce these products are increasingly dependent on our knowledge of the physical process and computer simulation of these processes. Process design always requires a thorough knowledge of the physical properties of the ingredients. Scientist specializing in defining and using the physical properties of foods are becoming more involved with all kinds of biological materials. They are concerned not only with the physical properties of foods in their various states but also the physical properties of the media in which products are grown and the physical properties of the materials used to handle, store, package, and distribute these products. Physical properties are used in many different ways. There is need for an international workshop to standarize the techniques for measuring, reporting, storing, and disseminating information on physical properties. A good centralized information center or system is needed where engineers and scientists can access available physical property data.

K e y w o r d s: physical properties, biological materials, food products

A short visit to any retail food store quickly gives one visual evidence of the role that the food processing industry plays in the food we eat. This can even be observed in one's kitchen cupboard or refrigerator/freezer. This industry provides not only an almost endless variety of food products, but, overall, the safest and most nutritious food supply we have ever known.

The general public is becoming increasingly unaware of the source of their food. This, of course, is largely a result of the decreased need for on-farm labor resulting from mechanization and changes in agronomic and animal production practices. Fewer people live and work on our farms today. For example, in the United States only 1.8 % of the population is now employed in farming. There is now a several generation gap between the largely agrarian population of the past and our current urban population. In countries where food is plentiful and relatively inexpensive, many people are not particularly concerned about the source of their food supply, much less the fact that

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If the name did not identify the basic ingredient of this popular cereal, most consumers would likely be unable to identify the plant from which it came.

While the move of people from the farm to urban areas is occurring, the food processing industry has dramatically increased the kinds and types of food products which are now available for public consumption. Fifty years ago, a typical breakfast for a farm family in the Southeastern part of the United States might consist of fried eggs and bacon with grits and gravy served with biscuits and jelly with milk for the children and coffee for the adults. The only one of these food elements that would not have been grown and processed on their Southeastern farm would be the coffee. Today, a typical breakfast for most farm families and certainly their urban neighbors might be a processed cereal, such as 'cornflakes' or another cereal, or bakery-prepared rolls warmed in the microwave or toasted bread and jelly served with coffee or milk, all coming to the home in a prepared format.

The technologies involved in producing the raw ingredients for prepared food and, indeed, the processing of these ingredients into the food products we consume is impressive. While much of this technology has come about by the time-tested method of 'cut-and-try', the developments of new products by food scientist and the development of new equipment by engineers to mass produce these products are increasingly dependent on our knowledge of the physical process and computer simulation of these processes. Process design always requires a thorough knowledge of the physical properties of the ingredients.

A THOROUGH KNOWLEDGE OF THE PHYSICAL PROPERTIES OF THE MATERIALS WITH WHICH WE WORK IS THE VERY BACKBONE OF ENGINEERING DESIGN.

Imagine, trying to design a skyscraper or space capsule having no confidence in the values of the modulus of elasticity for the metals used.

Since "*Cornflakes Don't Grow on Trees*", this product like nearly all of the breakfast cereals we eat is ground, blended, mixed, pumped, formed, baked, weighed, and packaged to name a few of the unit operations to which they are subjected. To design the machines to accomplish these and many other operations of a modern food processing line requires a knowledge of the thermal, mechanical, electrical, optical and sonic properties of the ingredients and mixes. Even fresh fruits and vegetables are often washed, polished, graded, sized and packaged somewhere in the food distribution chain. Today, it is truly difficult to find any food product on the shelf of a grocery store which has not been processed in some way.

The importance of knowing the physical properties of biological products extends much further back in the food production and distribution chain than suggested above. Indeed, the properties of individual seeds will affect how well they can be stored and what conditions must exist for them to germinate. The size, shape, and density characteristics will determine how the planting mechanisms are designed whether it is the time-tested principle of rotating cells or perhaps one of the newer pneumatic seed metering units. Once the seed is in the soil, there are many things which affect plant growth. The physical properties of the soil will affect root development, moisture movement and nutrient transport.

During the past two decades, there has been an exponential increase in the number and complexity of computer simulation models designed to predict water movement in soils and sediment transport in streams. The problems involved in estimating sediment yields from a large disturbed watershed containing different types of soil on various slopes being used for many purposes are extremely complex. The modern computer is the tool which has provided us a means to make these simulations, but it is the knowledge of the physical properties of the components of the system along with the proper use of many principles that determine the usefulness of the answers. The old axiom 'garbage in, garbage out' certainly applies to this situation, where a lack of knowledge of the physical properties used with the prediction equations in the simulation will likely produce questionable results.

The Third European Symposium on Storage and Flow of Particulate Solids was held in Nurnberg, Germany in 1995. The 100th aniversary of the development of a paper by

H.A. Janssen was commemorated. The paper titled "On the Pressure of Grain in Silos" outlined the development of an equation which has been used by engineers through the years to predict the pressures which are exerted by granular materials on the walls and floors of bins. The "Janssen Equation" has two parameters representing the applicable physical properties of the model which Janssen used to derive his equation. These are the bulk density of the granular material and its coefficient of friction on the bin wall material. Over the years, extending from the time of Janssen, many researchers have conducted experiments with both model and commercial sized bins and compared their results with values predicted by the Janssen Equation. The comparisons have been varied leading to the manipulation of the Janssen Equation and the development of different prediction equations. There are at least five different basic approaches that have been used to solve the problem. Currently, the most popular manipulation of the Janssen Equation to make it better conform to observed experimental results has been the use of a multiplier or 'overpressure factor'. In recent years, experiments conducted to determine how various factors affect the coefficient of friction of grain on materials commonly used in grain bin construction have shown as much as a four to five fold difference in the value of the coefficient. 'Wear-in' alone by the polishing action of grain and deposition of waxy substances from the grain on the bin wall material has been shown to reduce the coefficient two to threefold. Other factors such as sliding velocity and pressure have been shown to have a lessor but significant effect on the value of the coefficient. This kind of knowledge involving this important physical property likely explains much of the variation found in the results reported in different experiments conducted in various laboratories over the years. The conditions under which the experiments were conducted may have influenced the results. Likewise, the use of the proper value of the coefficient of friction in the Janssen Equation consistent with the design conditions being imposed may more accurately predict the proper design pressures on the bin components. This could negate the need to manipulate the prediction equation by providing a better fundamental understanding of the physical aspects of the system. While Janssen's Equation has withstood the test of time, ultimately, its utility along with many other mathematical models is dependent on our knowledge of the basic physical properties used in its application.

Scientist specializing in defining and using the physical properties of foods are becoming more involved with all kinds of biological materials. They are concerned not only with the physical properties of foods in their various states but also the physical properties of the media in which products are grown and the physical properties of the materials used to handle, store, package, and distribute these products.

Scientist today are working with biological materials that are not considered to be foods but are related to foods or food-derived products. These materials include bones, tendons, hides, skin, shells, and other materials. It is true that many of these non-food materials result from the processing of foods but some are encountered in other settings. For example, many of the physical properties of manure from cattle, swine, chickens, horses, and other animals have been characterized. Other researchers have defined physical properties of bones, muscles, and tendons in almost all animals, including race horses and fish. Many of these physical properties are defined to provide the life scientists with the tools they need to monitor the growth and quality of an animal or plant. A device was designed more than 30 years ago to determine the physical properties of a growing corn stalk to predict its ultimate strength at maturity and, thereby, its resistance to lodging. This permitted the corn breeder to measure the strength of young corn stalks, predict which stalks would have the greatest lodging resistance and only make those crosses in their breeding program which would result in the strongest stalks. This resulted in a geometric saving of time in the corn breeding program related to this particular trait.

Recently there has been an attempt to measure the physical characteristics of fish and correlate these properties with fish weight so that a system can be designed to constantly monitor the weight of large number of fish in a recirculating fish production system. If successful, this will allow producers to optimize the amount of feed that will result in maximum feed efficiency and minimum water contamination. Other recent studies have concentrated on the measurement of the physical properties of bones of animals. One study was conducted to define a quick test to determine the characteristics of the skeletal structure of spent chicken hens so that one bone from a sample of subjects from a flock could be used to predict whether the bones of the flock would be susceptible to breakage and contamination of the meat during processing. In other studies, the physical properties of bones are being measured to provide an indication of the effects of diet, exercise, environment, anabolic agents, and other factors on bone strength.

Physical properties are used in many different ways. There is the need for an international workshop to standardize the techniques for measuring, reporting, storing, and disseminating information on physical properties. There is also a need for an international workshop on using these many physical properties to develop the important transducers needed by engineers in the production, processing, packaging, storage, and distribution systems. A good centralized information center or system is needed where engineers and scientist can access available physical property data.

Indeed *Cornflakes Don't Grow on Trees*. We can enjoy them because some farmer produced the major ingredients from which they are formulated, someone developed the proper formulation, and others designed the equipment with which they are made and packaged. This entire process requires a thorough knowledge of the physical properties of the materials with which we work. We must continue to study the properties of materials. It is fundamental to our application of agrophysics.