

Why Microstructure?

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### Abstract

Humans judge the quality of food according to its appearance, taste, colour and flavour. These properties are observable by unaided basic human senses. They give the immediate impression regarding the quality of food. However, with advanced understanding of digestive processes and interactions of the human body and food substance scientist have understood core important properties of food. With advancement of science of materials, scientists and nutritionist have understood the microstructure of food materials and corresponding changes when they are subjected to various extreme conditions.

The underlying determinant of microstructure is the chemical properties of the basic compounds and elements that constitute food material. Although the chemical behaviour properties of constituent substances may not be observed in the macrostructure of food material, the chemical properties of the food substance are similar to those of the constituent chemicals. When the microstructure of food changes due to drying or cooking, it affects the texture of the food substance. Consequently, the sensory properties of the food are affected. The sensory function of the mouth determines the quality of food depending on its texture. Drying or cooking of food results in changes in texture, which is an important determinant of the sensory properties of food. Moreover, sensory properties are important considerations in the food processing industry. Changes in microstructure are either disadvantageous or beneficial to the food-processing industry or the consumer. In this paper, the behaviour of pasta with vegetable particles when subjected to either drying in the food processing industry or cooking by the consumer is analysed. The effect of micro-structural changes of the pasta is discussed, and the benefit of the resulting changes to the consumer or the industry is outlined. These processes may be disadvantageous or beneficial depending of the goals of individual parties. The study and knowledge of the microstructure is essential for the food processing

industry as well as for the customer. Importance of understanding of the microstructure of food substances is also discussed in this paper. The particular discussion gives reasons why microstructure of food material is more important than its macrostructure.

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### **Method**

For this analysis, the micro-structural properties of pasta containing vegetable particles when subjected to drying or cooking are discussed. Importance of the resulting changes to the consumer and food processing industry is explored. The contribution of microstructure in determining the macrostructure of the food materials is also gauged. Generally, reasons for study and knowledge of micro-structural properties of food material are investigated.

## 1. Introduction

Food, a basic component of everyday life for any living person, is one of the most important fields of scientific study. The physical properties of food material that can be observed are part of the macrostructure of the food substance. It is this structure that determines the consumer's attitudes towards the food. On the other hand, the processes that the food undergoes at the microscopic level determine the macroscopic observations made by the consumer. This makes microstructure of food material an important area of study. However, food microstructure has been ignored in the past due to lack of proper understanding of materials science and the tendency of the market to capitalise on macroscopic characteristics of food. With the knowledge of materials science in the modern times, it becomes necessary to use the study of the microstructure of food in order to facilitate food processing and preparation. This report investigates the microstructure and macrostructure of pasta with vegetable particle while it undergoes the process of drying in the industry and cooking by the consumer. The impact of micro-structural changes in the pasta containing vegetable particles is an important target of investigation. Furthermore, the role of the microstructure of food materials in determining quality and perception of the consumer is established. Food industries have conducted studies that have revealed the microscopic structure of food materials, especially food for human consumption (Aguilera 2005, p.3). While the technologists who study the microstructure of food materials perceive the nature of food at the microscopic level, consumers observe its macroscopic structure.

Due to the competition in the market, food industries have studied food materials in order to understand the structure of food at the fine microscopic level. This field of science is known as food technology (Aguilera2005, p.5). Industries create mechanisms and processing procedures that change the microstructure of food material to that which has the optimum benefit for the consumer and the seller. A balance is made between the utility of the food

material and its attractiveness to the consumer. The microstructure of the food material is important to the industry and the consumer since it determines the popularity of a certain food products in the market, and influences the health status of the consumers.

## **2. The role of microstructure**

### **2.1 Elementary composition of food materials**

The effects of most food substances on human body can be attributed to the chemical properties of elements and basic chemicals that constitute the food material. Most food products are complex substances made up of many different chemicals. Vegetables and fruits have some of the largest varieties of elements in them (Aguilera 2005, p.6). The chemical integration of these elements into the food material conceals their physical properties. Thus, an element like iron may not exhibit its metallic properties when present in vegetable material. However, most of the elements and chemicals that constitute vegetable material maintain their chemical properties even when they are chemically integrated into food material. The behaviour of atoms and molecules of specific chemicals at the microscopic level remains the same. It follows that the study of the microstructure of food materials enables people to understand the nutritional value and the effect of food substances on the consumer. Moreover, it helps food processing industries to design appropriate processes with the knowledge of chemical behaviours of basic components of food material (Aguilera 2005, p.6).

## **3 Understanding of food microstructure as a determinant chemical properties**

### **3.1 Shift from macroscopic level to microscopic level of study**

The shift from macroscopic study of food materials to the microscopic study has been catalysed by the increased knowledge of biological response of human beings to various foods with different structures. Furthermore, the fact that most properties of food that affect human response to the food materials are microscopic and within the range of a tenth of a

micrometer to 100 micrometers automatically advocates for adoption of extensive study of food microstructure (Bonekamp 2011, p.5). Thus, the microstructure is the primary determinant of all characteristics of food material.

Furthermore, by studying the effects of change of food microstructure on its interaction with human body is an essential aspect of health promotion. Knowledge of microstructure is fundamental for protection of consumers of processed food substances. It is essential to study the nature of raw food and processed or cooked food in order to understand its effect on the utility of food products and human health.

## **4 Case of Pasta Containing Vegetable Particles**

### **4.1 Drying of pasta containing vegetable particles**

Drying is a one process that affects the microstructure of food materials. This process is used to remove water from pasta in order to improve its stability. In addition, drying may improve the macrostructure of the food such that it can be handled easily. Dried pasta becomes caked and loses its ability to adhere to surfaces. Such properties are ideal for preservation of pasta. When pasta containing vegetable particles is dried, the cells that make up the food materials become detached such that the bond between the cells may not be very rigid. The cell walls in the vegetable particles become more rigid such the food material is less flexible. Since cells move to occupy the intercellular space, the total volume of the food material is significantly reduced. The ability of the food material to allow absorption of water increases with drying action due to increase in porosity. When food is processed in the industry, it does not necessarily lose its important properties. In fact, some food substances become more digestible and absorbable when processed. On the other hand, nutrients can become contained within the microscopic cells when they are cooked. A study of the effect of industrial drying and cooking on pasta containing vegetable particles by the consumer reveals

the benefits and disadvantages of the processes. Drying is an important process for vegetables, which easily disintegrate and decay easily if stored with high moisture content.

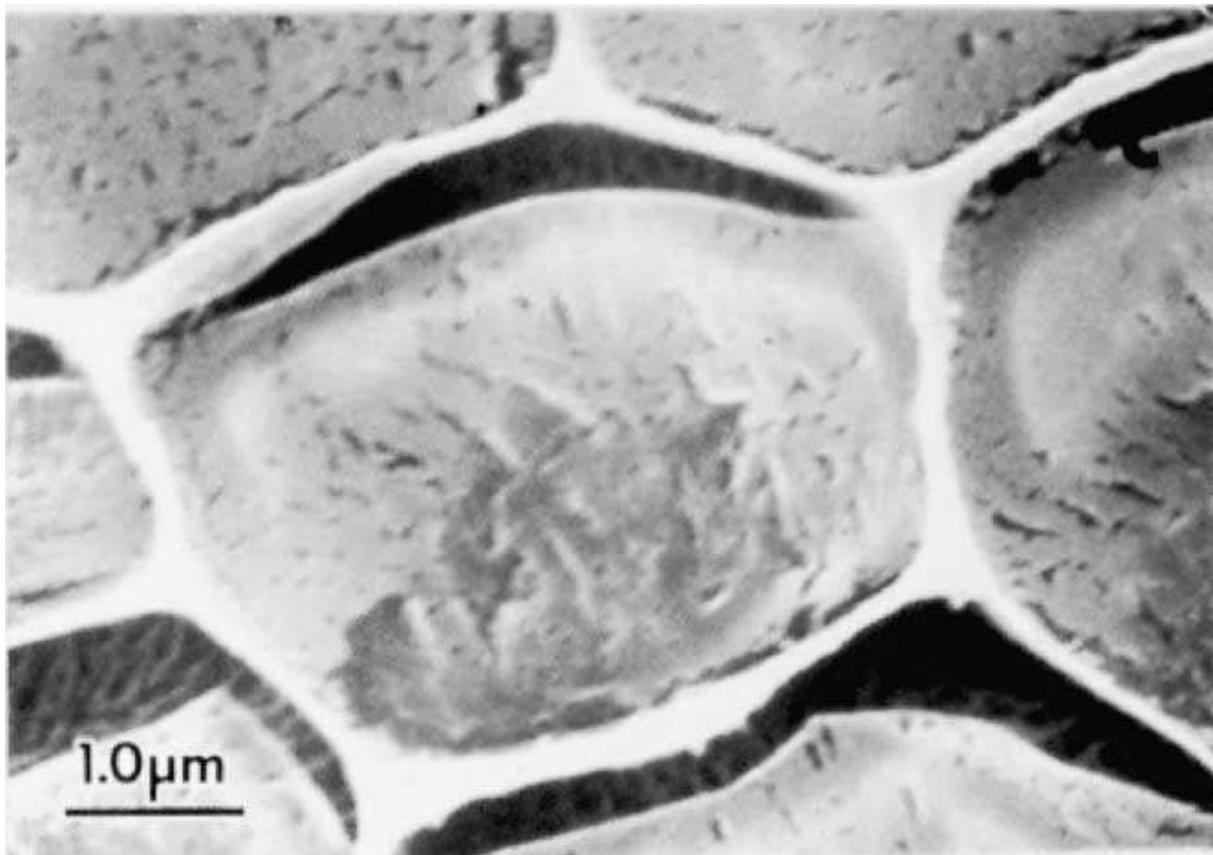
Drying of vegetable particles in pasta causes change in colour, shrinkage of the food material, and alteration of moisture diffusivity in the food substance. While stability is obtained, the appeal of the food material to the customer, the state of the cellular structure, and its ability to rehydrate when consumed is significantly affected. When water in vegetable pasta is reduced, water activity,  $a_w$ , is also reduced (Bonekamp 2011, p.4). This is an important aspect of drying since water activity correlates strongly to stability of food material the volume of water in the material in question. Change of structure is the most significant aspect of drying, which occurs when the intercellular spaces are emptied of the water they usually hold. Dried pasta is characteristically stiff and hard. Imaging techniques are used to estimate the effect of drying on the microstructure of pasta containing vegetable particles. Fourier descriptors can be applied to the image for comparison.

#### **4.2 Dehydration, and Cooked Pasta with Vegetable Particles**

The macrostructure of dried food is also important in food industry. Physical properties of food determine the perception of the consumer regarding the quality of the food material. Appearance alone may determine the willingness of a consumer to buy a particular food product. Changes induced on food material, especially through drying are important in enhancing the nature of observable effects for the consumer. Raising temperature is one method of drying pasta with vegetable particles. However, this method has many disadvantages. Raising temperature to dry food material often leads to degradation of some nutrients such as vitamin C, which is destroyed even by a small rise in temperature. In addition, most proteins are denatured at high temperature. On the other hand, some food materials acquire a different and better taste when subjected to high temperature. Thus, for some vegetable food materials, alternative methods of drying are preferred. When the pasta

with vegetable material is freeze dried, the solid caked food material may disintegrate if temperature is not kept below a certain maximum level. This is caused by breaking of bondage in the microstructure of the pasta due to removal of water from the intercellular spaces. This is a disadvantage of this drying method since the dried food material has to be stored in a carefully controlled environment. Any proteins present in freeze-dried pasta with vegetable particles become degraded with the disintegration of the microstructure.

**An example of microstructure of dried vegetable tissue.**



**Figure 1: A freeze-dried potato specimen showing empty intercellular spaces (Source: Aguilera 2005, p.7).**

The major benefit for the food industry when food material is dried is the stabilisation of the material. Creation of empty spaces in the microstructure by removal of water from intercellular spaces minimises water activity in the pasta promoting stability. Microorganisms cease growth at water activities of less than 0.7 (Aguilera 2005, p.8). This facilitates storage

and longer shelf life for the pasta. Where weight of the pasta is a disadvantage for the industry, drying is used reduce water content and hence weight. When some vegetables are dried, they change their texture and taste. Pasta will become hard and crispy when dried, but will remoisten and become easily edible by the consumer. This makes trade possible for the food industry. Moreover, fast foods can be easily obtained through drying (Devahastin & Niamnuy 201, p.1757). The food material becomes easier to handle due to its low moisture content.

For a consumer, dried pasta has more appeal in terms of appearance and aroma. The food is attractive and may evoke appetite. Furthermore, there is less likelihood of ingesting microorganisms in dried food. Pasta stored in dried condition does not allow pathogens to thrive on it (Devahastin & Niamnuy 2010, p.1765). Most dried foods do not agglomerate since the adhesive capacity of dried food is limited due to separation of cells in its structure. Finally, most pesticides disintegrate when the moisture content in food is low (Aguilera 2005, p.7). Thus, many consumers of dried pasta are likely to ingest fewer carcinogens on consumption of the food. However, it is likely that the vegetable particles in the pasta may not rehydrate after the drying process.

#### **4.3 Effect of cooking pasta with vegetable particles on its solid structure**

Although industrial processing may add utility to food products, it is necessary for the consumer to prepare some foods for consumption. Most food material requires cooking to make it digestible, and to add flavour, taste and colour. When pasta is subjected to heat during the cooking process, the microstructure of the food material changes. Consequently, the macroscopic properties of the food may also be affected. Texture, colour, taste, flavour and physical integrity of solid food material is affected by cooking (Aguilera 2005, p.9). All these characteristics of cooked food can be observed by natural human senses. Much of

microstructure changes that are observed in cooked pasta are due to the effect of heat on cells, which make up the food material (Ramos 2002, p.2).

On the other hand, when food is cooked, it is easier to break it down mechanically in the mouth. However, the plant cells that make up the vegetable particles in the pasta do not rupture but separate. This is caused by the change in the properties of the vegetable microstructure because of the heating effect of cooking (Ramos 2002, p.7). Through the study of the effect of heat on cells and microstructure of different vegetable materials, it is possible to know when they are most beneficial to the body.

#### **4.4 Effects of drying and cooking of pasta with vegetable particles on sensory properties (Sensory Analysis)**

Pasta containing vegetable particles presents a good specimen for investigation of the effects of drying and cooking processes. Most vegetables shrink when subjected to drying processes that take effect at different rates. A slow rate of drying results to less micro-structural changes in the vegetable particles. On the other hand, fast loss of water results in a more extensive and less uniform physical change. Drying rate of vegetable pasta influences the ability of the material to absorb water. Fast drying results in large spaces inside the material, increasing its ability to rehydrate. The cell structure remains intact during fast drying, while cell arrangement pattern is disrupted leading to cracks. However, the original overall shape of the material is maintained (Aguilera 2005, p.9). A food processing company can use different drying methods to maintain a particular drying rate for controlling density of the pasta.

When pasta is dried in the industry, it becomes hard and stiff. This makes it feel tough to anyone trying to eat it raw. Pasta requires some cooking to make it soft rehydrated to attain the desired texture, rehydration and taste. Rehydration of pasta makes it feel smooth and slippery to the mouth. It is more palatable in this condition. Furthermore, cooking affects the

vegetable particles in the pasta. As the pasta is rehydrated and during cooking, vegetable particles undergo changes due to presence of heat and water (Wen-Chieh & Stone 2003, p.64). However, the changes give the pasta with vegetable particles a better feel in the mouth.

The changes in the microstructure and macrostructure of the vegetable material lead to changes in the texture. Sensory properties of food are affected by texture. Vegetable particles can easily be identified by their texture in the human mouth. Judgment of sensory sensation by the mouth is biased due to the preconditioned state of the human reflex system. For this reason, some vegetables particles may feel comfortable when they are cooked to a certain extent. On the other hand, when some vegetable particles are overcooked, the microstructure and hence the macrostructure of the food system is disrupted leading to an unpleasant feeling when consuming the particular food material. To avoid complete disintegration of the structure, the pasta may only be cooked up to a certain level. However, cooking is often necessary to attain the right texture for pleasant sensory effects. Furthermore, cooking of pasta makes it soft and swelled. These are desirable properties for the consumer of the food material. Apart from the slight lustre attained after cooking, the colour of pasta containing vegetable particles remains uniform (Wen-Chieh & Stone 2003, p.67). On the other hand, the general shape of the pasta is preserved after a mild cooking. Overcooking of the pasta causes a significant distortion of the original shape.

## **5. Conclusion**

In conclusion, it is evident that the microstructure of food material is important. Observable physical properties of food material that can be perceived by unaided human senses constitute manifestation of macrostructure of the material. However, the interaction of food material with human body depends on the microstructure of the food. Furthermore, it is observed that when food substance is subjected to extreme conditions, the microstructure of the food changes. Due to the alteration of the food material structure at the microscopic level,

the macrostructure of the said material may also change. However, micro-structural changes determine the chemical properties of the food material. Drying of pasta makes it light due to loss of water, and this may be an advantage to the industry because less weight is easier to handle and transport. Moreover, it may make food more attractive and easier to package and thus attract more customers. Colour and flavour may also be changed by drying. On the other hand, drying leads to shrinking of food material. Shrinking may be a disadvantage to the food processing industry due to less volume. However, drying affects the microstructure of pastas and may result to difficulty in rehydration. This may make digestion and absorption of food slower or inefficient. Cooking of food has effects on the microstructure of the food material. Heat softens food and makes it palatable. However, some nutritious substances in food material are sensitive to heat and may be denatured on heating the cells that constitute food material such as vegetables may not be digestible after cooking of the food. Heat breaks down the microstructure of the food material such that nutrients enclosed by the cell wall cannot be accessed by mechanical breakdown by human digestive system. The study and knowledge of the microstructure of food under different conditions is important for proper understanding of nutrition and health. Knowledge of properties of microstructure of food is also important for the food processing industry as well as for the consumer. Understanding of the changes of food microstructure when food materials are subjected to different conditions is more important than observation of changes in the macrostructure of food material.

It is evident that drying of pasta containing vegetable particles makes it stable and suited for storage. In other words, the ability of dried pasta to resist growth of pathogenic microorganisms on the food system is limited. Furthermore, reduction of agglomeration by drying of pasta facilitates easier packaging and handling by food processing industry and retailers. The food system does not regain its stickiness after being cooked by the consumer, and thus it maintains its non-agglomeration property. Changes in sensory properties of the

food result in a better outcome since flavour is maintained after cooking. Moreover, taste and texture of the pasta containing vegetable particles improves significantly due to softening and rehydration. However, the pasta should only be subjected to mild cooking for desirable results.

The physical structure of the pasta containing vegetable particles changes drastically on drying. Rigidity, hardness and shrinking are some of the observations after drying. Rehydration occurs when the consumed cooks the pasta, and the food material is softened again. The volume of the pasta also increases with rehydration during cooking, but is always less than the initial volume prior to drying of the pasta since some structural changes in the pasta due to drying are permanent.

## **6 Recommendation**

The study and knowledge of microstructure is important for the consumer and the food processing industry. However, the present study is aimed at determining the types of food that are suitable for the consumer and the food processing industry. In future, it will be more appropriate if the study of the microstructure is aimed at determining the best processing methods and additives for food materials in order to make them attractive to the consumer as well as beneficial to the consumer's health. This approach would be effective since participation of the ignorant consumer in the scientific field of analysing food microstructure would be eliminated. The responsibility of food processing and preparation would be left to experts and food processing industries.

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