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# A REVIEW ON EFFECT OF FREEZING ON FOOD, FRUIT AND VEGETABLE TEXTURE

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## ABSTRACT

This review discusses factors responsible for the texture of fruits and vegetables and the changes brought about by freezing. It describes some of the early work on frozen food texture, as well as the more recent studies of cryogenic and other rapid freezing methods. The effects of storage and cooking on texture are also considered. Food shelf-life extension is important not only to food manufacturers, but also to home refrigeration/freezing appliance companies, whose products affect food quality and food waste. While freezing and refrigerating both extend the shelf life of foods, food quality deterioration continues regardless of the preservation method

## INTRODUCTION

Freezing has become increasingly popular as a means of food preservation. Nevertheless, since the establishment of the frozen foods industry it has been recognized that freezing brings about changes in the texture of food and also fruits and vegetables. Freezing rate is the most important factor in freezing process to prevent food tissue damage and drip loss in thawing. Faster freezing results in small ice crystals and a better frozen food quality (De Ancos et al., 2006; Hui et al. 2011; Alexandre et al., 2013). Freezing time is defined as the time required decreasing the temperature of the product from its initial value to a target value at its thermal center or the time elapsed between the onsets of the freezing until whole product is frozen. Therefore, freezing rate can be estimated as (i) the difference between initial and final value of product temperature divided by freezing time (°C h-1 ) or (ii) the distance between the surface and thermal center divided by the time elapsed to reach the thermal center temperature to -15°C when the surface temperature is 0°C (cm h-1 ). Freezing rate is a generic term used to compare the freezing operation on a relative basis. Freezing rates differ in the range of 0.2 and 100 cm h -1 in commercial applications. Slow freezing such as bulk freezing in cold chambers, ranges between 0.2 and 0.5 cm h -1 . Air blast and contact plate freezers operate in quick freezing ranges (0.5–3 cm h -1 ). Frozen storage temperature is also important and decrease

in storage temperature leads to increase in frozen food quality (Sun, 2011). Comprehensive information can be found in the literature about the effects of freezing and storage temperature on the nutrient content of fruits and vegetables (Kyureghian et al., 2010). The amount of data that directly compares fresh and frozen fruits and vegetables is very limited with most of the data dating back at least 20-30 years when some of the methodology for determination of vitamins and other nutritional compounds was also limited. (bulut et al., 2017). The reports on nutrient retention during frozen storage may also be contradictory. The most common physical changes during food freezing are modification in cell volume, dislocation of water, mechanical damage and freeze cracking, freezer burn, and ice recrystallization. Chemical changes are enzymatic reactions, protein denaturation, lipid oxidation and vitamin loss. (Sun, 2011).

Cellular food materials generally refer to fresh foods from living tissues such as plant and animal tissues that consist of fine organized cellular structures.(Sun, 2011b) Fruit and vegetables, meats, seafood, etc. are typical cellular food materials. In order to preserve the quality and safety of fresh cellular foods, many techniques such as packaging, drying, cooling, freezing etc. are employed by the food industry. Among them, freezing is a most popular preservation technique. (Dongme et al., 2017).

## TEXTURE

Once people become acquainted with the characteristics of a food, they expect to encounter similar characteristics when they eat it again. A preserved food is ‘good’ if it has the expected sensory properties, and ‘bad’ if these properties have been altered by the preservation process beyond acceptable limits. The range of acceptability, of course, depends upon the individual making the judgement. Nevertheless, for preserved, cooked vegetables it seems reasonable to assume that the ‘proper’ texture is that of a fresh vegetable cooked for the preferred time.(brown, 1977).

Texture may be considered as the combined effect of mechanical properties and behaviour perceived in the mouth as the food is eaten, (brown, 1977). This is influenced by both the cell wall and the cell contents.

## TEXTURE OF FROZEN FRUITS AND VEGETABLES

Because of the loss of turgor, the texture of a frozen fruit is never the same as that of a fresh fruit. Thus, when ‘proper’ texture of a frozen fruit is to be considered, one must not think of a fresh fruit, but rather of some form of preserved fruit, or fresh fruit that has been cooked.(Brown, 1977). Some examples would be frozen peach slices instead of canned ones, or a pie made with frozen berries instead of fresh ones. Most vegetables, on the other hand, are cooked before they are eaten and, therefore, cell turgor is not a factor in their texture. Thus, the ‘proper’ texture of a frozen/cooked vegetable, at least theoretically, could be the same as that of a cooked vegetable that had not been frozen. (Reeve and Brown, 1966).

## TEXTURAL CHANGES DURING FREEZING

Water makes up over 90 percent of the weight of most fruits and vegetables. This water and other chemical substances are held within the fairly rigid cell walls which give support structure and texture to the fruit or vegetable. (Ersus et al., 2010). Freezing fruits and vegetables actually consists of freezing the water contained in the plant cells. Fruits and vegetables that is much softer when frozen and thawed when the water freezes, it expands and the ice crystals cause the cell walls to rupture. Consequently, the texture of the produce, when thawed, will be much softer than it was when raw. This textural difference is especially noticeable in products which are usually consumed raw. For example, when a frozen tomato is thawed, it becomes mushy and watery. (Ersus et al., 2010). This explains why celery and lettuce are not usually frozen and is the reason for the suggestion that frozen fruits, usually consumed raw, be served before they have completely thawed. In the partially thawed state, the effect of freezing on the fruit tissue is less noticeable. Textural changes due to freezing are not as apparent in

products which are cooked before eating because cooking also softens cell walls. .(Brown, 1977).These changes are also less noticeable in high starch vegetables, such as peas, corn and lima beans.

## TEXTURE IMPROVEMENT BY FREEZING

According to brown 1977 in none of the cases described so far has the texture of a food been improved by freezing. An exception to thesis the freeze-leach texturizing of French fried potatoes (Nonaka et al., 1972). In this process, a crisp surface was formed by freezing the surface of potato pieces to permit the loss of soluble material in subsequent leaching with hot water. After this, the potatoes were par-fried and frozen for storage and distribution. The crisp surface formed in fish-frying did not soften as it cooled, and it contained less oil than a conventional French fry prepared without the first freezing treatment. In contrast to this, Spiruta and Mackey (1960) reported that a single freeze of French fries reduced the inner cohesiveness and allowed greater oil uptake.

## FREEZING METHODS TO MINIMIZE FOOD CELL DAMAGE

In order to minimize the cell damage during freezing and obtain frozen cellular foods with better quality, novel freezing methods have been widely investigated in the past decades (Sun, 2011a). These methods include high pressure freezing, ultrasound assisted immersion freezing, electric or magnetic field assisted freezing, vacuum impregnation with cryoprotectant solutions, etc.

**High pressure freezing: -** In HPF, there are three processes available, i.e., high pressure assisted freezing (HPAF), high 260 pressure shift freezing (HPSF), and high pressure induced freezing (HPIF) (Cheng et al., 2017). High pressure freezing (HPF) has drawn more attention for its advantages in improving the characteristics of ice crystals formed and the quality of frozen foods. In HPF, the degree of super cooling is enhanced as the freezing point of water decreases with pressure up to 210 MPa, various polymorphs of ice crystals including ices II - VI under different pressures and temperatures can be formed and these ice crystals are denser than water, thus reducing the crystallization damage in food tissue caused by volume expansion, and thermal gradient is absent during freezing and the ice crystals formed in the food tissues is even and uniform regardless of size, form and location.

## FUTURE PROSPECTS

Cell, as the basic unit of most fresh foods, its size, structure and morphology have an important influence on the freezing characteristics of foods as well as the sensory and texture properties of frozen-thawed foods. For fresh fruit and vegetables, the cells remain alive after postharvest, and thus cell viability of frozen-thawed tissues is a key factor that needs to be considered during freezing, while muscle cells lose their viability after slaughter, and therefore there is no need to consider the cell viability. Therefore, the difference between plant and animal cells should be taken into account when studying frozen food processing.

It is a challenge to fully understand changes in cell structure as affected by different freezing methods. The quantitative analysis of ice crystals formation and the morphological changes in cell structures should provide deep insight on this and thus further investigations are needed. Quantitative relationships between changes in cell structure and quality attributes such as texture during freezing is also useful and therefore further studies can focus on this aspect. In addition, The compatibility of the novel freezing methods is also worth studying as it would be difficult for one method to cater for all cellular food materials.

## CONCLUSIONS

This article reviews the effects of freezing on the cell structure of fresh plant and animal cellular foods. The relationship of cell structure and water distribution with texture and sensory properties of the foods are presented, and factors affecting the integrity and viability of cells during freezing, as well as novel freezing methods for minimizing freezing damage to cell structures are also discussed. Home freezing of fruit and vegetable provided slow freezing rates according to this experimental study.

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