dark brown colour. If heated further a black-brown colour results emitting an irritating burnt sugar aroma, the mass having a bitter taste.

In food preparation and processing, the undesirable features are minimized to obtain the desired colour and flavours of caramel in products. Caramelization is an important non-enzymatic reaction.

### *Inversion*

When sucrose is heated in the presence of acid or the enzyme *invertase,* equal amounts of *dextrose* and *levulose* are formed. This mixture is known as invert sugar. The process by which invert sugar is prepared either in the laboratory or in nature by enzyme or acid hydrolysis is called *inversion.* Invert sugar is usually considered superior to sucrose in food processing operations because of its sweetness and the special textural properties it imparts to baked products because of its moisture retention qualities.

### *Hydrolysis*

Enzymes bring about hydrolysis of sugars for example, invertase acts on sucrose and converts it to glucose and fructose, maltase converts maltose to glucose (dextrose) and lactase acts on lactose to convert it to glucose and galactose. Enzymes also bring about the hydrolysis of oligo saccharides and polysaccharides. They however get inactivated when food is cooked at high temperatures.

Weak acids like lemon juice, vinegar, fruit juices, cream of tartar and others also bring about inversion of sucrose. Like acids alkalis too decompose sugars. Weak alkali present in hard water makes sugars yellow or brown in colour.

### *Reducing potential*

Sugars have the property of removing oxygen from other substances thus acting as reducing agents. They easily give up H ions which bind with free oxygen and make it unavailable.

## Uses of Sugars

There are innumerable uses of sugars in nature, food preparation and in processing.

(*i*) They add sweetness, flavour, colour and texture to foods.
(*ii*) Being hygroscopic in nature, sugars possess water retention properties and thus prevent foods from drying out.
(*iii*) They also help in preservation by binding the moisture thus inhibiting the action of micro-organisms.
(*iv*) Sugars provide the medium for action of yeast in fermented products.
(*v*) Unrefined sugars are a source of minerals like calcium, potassium and iron in the diet.

Thus, with an understanding of the behaviour of sugars on heating and the effects that can be produced by the addition of other substances in a mixture containing sugar, the properties of sugars can be used very creatively in food preparation and processing.

Experiments 1-5 have been designed to provide some first hand knowledge and practical experience of the properties of sugars and create interest in developing ideas for their application in food preparation.

## EXPERIMENT 4

### Aim

To demonstrate the process of sugar recrystallization through the preparation of fondant, fudge *shakarpara* and *chenna murki.*

### Equipment

Weighing scale, measuring cups and spoons, cooking utensils, kadai (wok), strainer, wooden spoon, stainless steel knife, cooking range, perforated ladle, plates, dishcloths, butterpaper.

### Materials

Maida, fat, sugar, oil, milk, butter and water, cottage cheese, cream of tartar, kewra essence (optional).

### Principle

Sugars are soluble to different extents depending on the temperature of the water or liquid in which they are dissolved. However, when the solution is heated it becomes capable of dissolving a greater amount of sugar than at room temperature. This capacity increases with rise in temperature, but when the solution is cooled the sugar recrystallizes. This phenomenon is utilized to different extents in the preparation of sweets, candies and desserts to provide varying textures, colours and other sensory qualities. The acceptability of a product depends largely on the size of the crystals and the amount of interfering substances added in a particular preparation.

### Procedure

In this experiment 3 recipes have been chosen to demonstrate the type of crystallization that takes place in food preparation. The first one is made purely from sugar and water, while the other two show crystallization when interfering substances are added.

### A. Fondant

(*i*) Measure out 200 g sucrose and add to it 100 ml water in a pan or enamel bowl.

(*ii*) Cover and heat the pan for 4-5 minutes on medium heat without stirring the contents.

(*iii*) Keep boiling the sugar till it reaches a temperature of 114°C.

(*iv*) Remove from fire, cool to 60°C, and then beat the mixture continuously with a wooden spoon till it all comes together around the spoon and crystallization is complete.

(*v*) The mass can now be kneaded and pressed or rolled on a greased flat surface, cooled and cut into any shape.

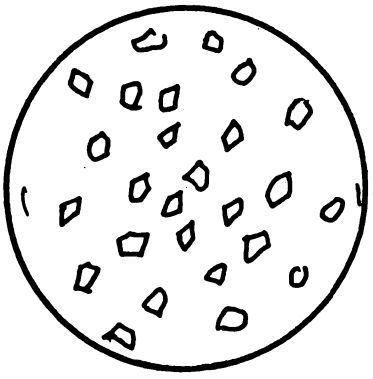
(*vi*) Make observations with respect to clarity, colour, mouthfeel, texture and size of crystal under the microscope.

(*vii*) Keep some pieces wrapped in grease proof paper for 12-24 hours, and repeat the observations, to find out if any differences occur in the quality of the product.

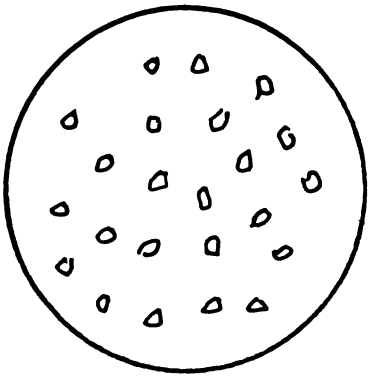
### B. Fudge

(*i*) Stir 200 g sugar, 15 g butter and 20 g chocolate into 120 ml milk in a pan.

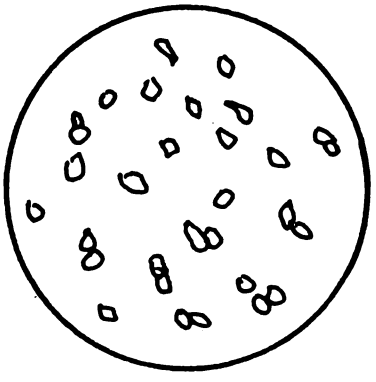
FUDGE



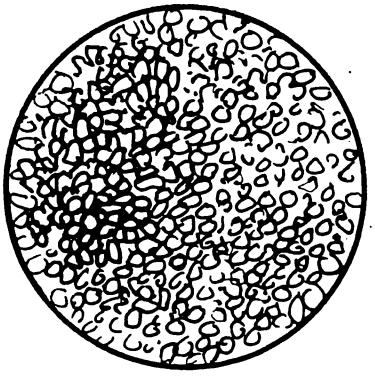
Sucrose crystals



Fudge cooled to 30°C



Fudge cooled to 40°C



Fudge cooled to 60°C

**Plate II:** Microscopic view of sugar recrystallization in preparation of fudge.

was first observed in 1861 by T. Graham, who described the process as an exudation of small amounts of liquid on standing because of a slight contraction of the gel. With certain gels however, syneresis is observable with increase in substrate concentration whereas with others a dilution is necessary as in the case of gelatin and agar-agar gels. Although no net volume change occurs in the gel, syneresis cannot be described as a reversible process.

### *Retrogradation*

When, some cooked gels showing syneresis exhibit further realignment of the amylopectin fractions to further alter the structure, the process is termed as retrogradation. This phenomenon is observed on cooling, but only in some cooked starches such as wheat and corn where recrystallization of the gelatinized starches occurs, as in the cooling of bread or corn preparations. Waxy starches do not exhibit retrogradation.

### *Malting*

The effect of applying of both dry and moist heat are seen in a process called malting. This is a process in which grains are dampened to allow them to germinate. They are then dried, dehusked and milled. Malting breaks down the starch to sugar, as well as increases the content of riboflavin, niacin and iron. A gruel made from malted flour is less thick because of the presence of amylase, and more flour can be used in preparing the food than ordinary flour. Malting increases the energy density of food, a factor important for feeding young children.

## Use of Starches in Food Preparation

Starches may be used for various reasons as ingredients in cooking, because they act as agents for thickening, binding, coating, gelling and so on.

### *Thickening*

Starches used for thickening gravies, soups, puddings etc. need to have clarity, viscosity and pasting properties depending on the quality of the finished product required. Commonly used are corn, refined wheat and rice flours and arrowroot. Corn has twice the thickening power than wheat flour, but if the flours are roasted or browned this power decreases due to dextrinization. Liquids thickened with potato or other waxy starches are more elastic.

### *Binding*

Any of the above mentioned starches or foods containing them may be mixed with other ingredients that need to be closely bound together. For example, in the preparation of vegetable cutlets, a wide variety of vegetables which do not mix together are made to do so by adding refined flour, breadcrumbs or potato to the mixture. The starch helps to bind the ingredients together and prevent the cutlets from splitting during frying.

### *Coating*

Starches are often used in the from of batters to coat foods before frying. This gives the product crispness, and seals-in the flavours by forming a barrier to evaporation of food contents, and provides a smooth golden appearance to the product by filling any crevices or irregularities on the surface.