SECTION 8

PRODUCTION IN LOCAL INDUSTRY

RELATIONSHIPS WITH THE ENVIRONMENT

INTRODUCTION

This section introduces you to the scientific procedures involved in the stages of production of local soap as well as some local foods like gari, kenkey, and tubani. The content will also focus on scientific concepts that underline the stages of production. Examples of these science concepts are emulsification, fragrance incorporation, saponification, fermentation, and heat-induced chemical reactions. You will carry out activities that will let you see how biology, chemistry, physics, mathematics and social studies are interrelated or integrated such that in learning one thing other subject areas may be covered.

At the end of this section, you will be able to:

- Describe the process of local soap production.
- Explain the processes of producing different types of soap.
- Investigate the production of Indigenous food to identify the science underlying the stages of production
- Investigate the production of indigenous food to identify the science processes in the production stages.

Key Ideas

- **Local Industry** refers to a production unit consisting of a few people in a community for producing a commodity for household or commercial consumption. Usually, it is a family affair and indigenous.
- **Emulsification** is the mixing/stirring of two liquids that cannot mix easily, for example, oil droplets with water molecules to form a light paste-like substance.
- **Saponification** is simply the process of soap making. “Sapo” is a Latin word for soap. In the process fats, oils and lipids are converted into soap by combining them with a base like sodium hydroxide (NaOH).

- **Reaction** is the rearrangement of atoms or molecules of two or more substances that come in contact with each other that results in the formation of one or more new substances.

PRODUCTION OF LOCAL SOAP

Activity: In a small group, each of you should mention the types of soap you use in the home. What are some of the home activities you engage in using soaps?

It is important to understand that soap is a cleansing agent. This means it supports cleaning. From your group discussion, you might have mentioned activities like cleaning your clothes, cooking utensils and your body during bathing. It is the oldest detergent known to man. The Romans are said to have produced it from animal fats, oil, and wood ash.

The process of soap-making is called saponification. Potash, an alkali derived from wood ash that comprises potassium hydroxide, potassium carbonate, and salt, is leached from wood ash. Soap is the sodium or potassium salt of fatty acids (e.g. palm oil) that is created by boiling oil and fat with caustic soda or caustic potash respectively. It comes in different varieties such as bars, liquids, and powders (e.g., detergents). Other ingredients can be added to soap to give it different qualities, such as scent or texture.

Saponification therefore is an alkaline hydrolysis reaction involving fats, oils and alkali. It is a process used to make soap. Triglycerides (from palm oil) are broken down into glycerol and fatty acids using lye.

Saponification Reactions: Fat + Lye → Soap + Glycerol

The production of local soap typically involves several steps, which may vary depending on the specific type of soap being made and the available resources.

Activity 9.1: Process of soap-making

Materials: Fats or oils (such as palm oil, coconut oil, or shea butter), water, and caustic soda (sodium hydroxide) or potash (potassium hydroxide) as a base.

Procedure:

1. **Ingredient Selection**
   a. Collect the materials required for soap making.

b. Melt the fats or oils to become liquid.

2. **Ingredients and Formulation**

a. Mix the melted oil with the caustic soda (NaOH).

b. Stir or blend thoroughly until it reaches a specific consistency (this is the point where the mixture thickens this is called “trace”).

3. **Additives**

a. Add ingredients such as fragrances, colourants, exfoliants (such as oatmeal or herbs), or moisturisers (such as glycerine) at this stage to enhance the soap’s properties.

b. After adding the additives, continue stirring for approximately two minutes until the paste is homogenous.

4. **Moulding**

a. Pour the resulting paste into plastic or wooden moulds (covered with a plastic film) in the desired forms.

b. Leave the moulds to sit undisturbed until the soap solidifies and hardens.

5. **Curing:** Leave the soap for about 4 to 6 weeks to get dried. This process is called “curing”.

6. **Cutting and Packaging:**

a. Remove the soap from the moulds and cut them into individual bars or other desired shapes.

b. Pack the cuts by wrapping them with paper or cloth for sale or personal use.

c. If it is for sale, you may arrange them from simple to more elaborate labelling and branding.

Observations: Write up your observations and share them with the class.

NOTE the following safety rules:

Production of soaps and detergents requires the use of chemical products that are potentially dangerous for humans and organisms. You must therefore undertake this task under the supervision of your teacher and observe several safety measures:

Safety gear

a. Wear a jacket, an apron or a long-sleeved shirt made of thick material (denim, velvet, etc.)

b. Wear a pair of well-fitting plastic or rubber gloves especially when preparing caustic soda solutions.

c. Wear a protective mask or scarf to avoid the inhalation of toxic vapours from the dissolving soda, preferably wear a protective mask or material soaked in water to cover the entire nose and mouth area.

d. Wear a pair of protective goggles during the soap or detergent production.

e. Wear a pair of rubber boots or closed-toe shoes during the preparation of the caustic soda solution.

Safety instructions

a. It is essential to work near a water source.

b. If the caustic soda solution encounters the skin, rinse off thoroughly with water to alleviate the effects of the soda.

c. If the soda solution is swallowed, drink copious amounts of water.

d. Always pour the soda into the water, and not the other way round, to avoid experiencing a violent reaction that could damage your skin or your eyes.

e. Drinking, eating, and smoking are prohibited during soap production operations.

f. Avoid any distractions during soap production operations.

g. Chemical products used for the maturing or drying stages of soap production must be kept out of the reach of children and domestic animals.

h. Soap-making equipment must not be used for cooking

Next there is another activity for you to perform to consolidate your understanding of how local soap is produced in your community.

Activity 9.2: Industrial visit to a Local Soap Production site.

Aim: To observe the production process of a locally produced soap.

Materials: Writing material (Notebook, pencil, eraser, goggles, Clothing that covers the whole body).

Procedure:

1. Your teacher will identify a facility where soap is produced near where you live.

2. Your teacher will arrange a visit to the facility for your classmates.
3. During the visit you will be able to observe how the soap is prepared.
4. Take notes of all that you see. Ask questions on processes you do not understand for clarification. Also, ask for an explanation of why certain processes or activities are done.
5. You need to ask permission to take videos and/ or pictures.
6. Compare the stages you observed with the stages you went through to produce your soap.
7. Write a report on the visit and make a video, poster or textual presentation to your class for discussion.

Conclusion: Draw conclusions on the methods you observed on your visit and what you did.

Your report on the visit should be written using the following structure:

Date:

Title: *Report on visit to a Local soap production facility in (Name of the community)*

Aim: *To acquaint oneself with how local soap is produced.*

Procedure:

1. ***Pre-visit preparation**: (Write about all the things you did before setting out on the visit)*
2. ***The Visit**: (Write about the introduction you did and whatever went on from the beginning as soon as you arrived at the facility up to when you ended your interaction with whoever you interacted with.)*
3. ***Post-visit Activities:** (Write about any things you did; the interactions you had with the main person and the people you met. Do not forget if you need to go back for any further enquiries, include it in the post-visit activities write-up).*

Conclusion:

Write a conclusion about your visit. For example, my visit allowed me to see how local soap is produced and I can imitate in the classroom what I saw produced at the local soap production facility.

EXPERIMENT TO PRODUCE DIFFERENT TYPES OF SOAP

A

B

Fig. 9.1: Black and white soap

The different types of soap could be African black or African white soap. These are both traditional soap varieties that have distinct differences in terms of ingredients, production methods, and properties. They are natural, handmade products that have gained popularity worldwide for their effectiveness in cleansing and nourishing the skin as well as for their cultural significance.

Using the descriptions discussed below, compare them to your discussion in the group activity below.

Group activity: From **Fig. 9.1**, discuss with your friends what might have caused the differences in the colour of the soap.

African Black Soap: African black soap is known for its dark colour, which comes from the ash content. It has a rough, textured appearance and a natural earthy scent. It is prized for its gentle cleansing properties, and it is believed to have various skincare benefits, such as moisturisation, exfoliation, and treating acne, eczema, and other skin conditions.

African White Soap: African white soap, also known as “Alata Samina” or “Ose Dudu,” typically contains similar base ingredients such as black soap, palm oil, coconut oil, and shea butter. However, it lacks the ash content that gives African black soap its dark colour. African white soap has a creamier appearance, and a milder scent compared to black soap. It is also valued for its gentle cleansing properties and is often used for sensitive skin types. Like black soap, it may have moisturising and skin-nourishing benefits, but without the exfoliating properties associated with ash.

Activity 9.3: Making African Black Soap

Aim: To determine the differences among local soaps

Materials: Plantain peels or cocoa pods, shea butter, palm oil, coconut oil, water, pot or cooking vessel, mixing bowl, spoon or spatula, safety equipment (gloves, goggles, apron), soap moulds or containers (stainless steel, heat-resistant plastic).

Optional: *herbs or oils for fragrance and medicinal properties*

Under the supervision of your teacher, you will follow the below steps:

Procedures:

1. **Preparation of Ash:**
   - **a.** Collect plantain peels or cocoa pods. Remove any dirt or debris.
   - **a.** Sun-dry the peels or pods until they are completely dried out.
   - **b.** Once dried, burn the plantain peels or cocoa pods until they turn to ash. Ensure they are completely burnt.
   - **c.** Allow the ash to cool down.

2. **Making the Soap Base:**
   - **a.** In a mixing bowl, combine the shea butter, palm oil, and coconut oil in the desired proportions. Use a ratio that suits your preference, but a common ratio is approximately 50 % shea butter, 25 % palm oil, and 25% coconut oil.
   - **b.** Heat the mixture gently until it melts and mixes thoroughly.
   - **c.** Remove from the heat and let it cool slightly.

NB: Oil or flammable things should be handled carefully

3. **Mixing Ash and Soap Base:**
   - **a.** Gradually add the cooled ash to the melted oil mixture while stirring continuously. Ensure thorough mixing to incorporate the ash evenly.
   - **b.** If desired, add any optional herbs or oils for fragrance or medicinal properties at this stage.

4. **Moulding the Soap:**
   - **a.** Once the ash is fully mixed into the oil mixture and the consistency is uniform, pour the soap mixture into soap moulds or containers.

b. Allow the soap to cool and solidify. This may take several hours to overnight, depending on the ambient temperature.

5. **Curing the Soap:**

   a. After the soap has become hard, remove it from the moulds or containers.

   b. Place the soap bars in a cool, dry place to cure for several weeks. During this time, the soap will harden further, and any excess water will evaporate, resulting in a longer-lasting bar of soap.

6. **Testing and Storage:**

   a. Once cured, test the soap to ensure it is suitable. Check its cleansing properties, lather and fragrance.

   b. Store the soap bars in a cool, dry place away from direct sunlight until ready for use.

NB: The production method for African white soap is similar to that of black soap, involving mixing oils and shea butter with water and lye (potassium hydroxide). However, the absence of ash results in a lighter-coloured soap. Soap making is essentially a neutralisation reaction - if there is not enough fatty acid to react with the sodium hydroxide ($NaOH$), the resultant soap will contain unreacted $NaOH$ and the soap will be very caustic or corrosive.

Activity 9.4: Experiment to show the effect of potash from different plant materials on the type of soap produced

Aim: To determine the effect of potash from different sources on the local soap produced.

Materials:

Potash from the ash of dried maize stalks, guinea corn stalks, plantain peels, cocoa pods, oil palm spike leaflets which house the palm fruits, metallic receptacle for burning the materials into ash, 5 receptacles for holding the solution of the different potash, a scale for weighing the ash from the different sources, a big receptacle of water, 2 one-litre measuring cylinders, 2 gallons of palm oil, stirrer, 5 mould frames

Under the supervision of your teacher, you will follow the steps below:

Procedure:

1. Make ashes from different plant materials.
2. Weigh 50g of ash from each plant material, pour it into a receptacle of 3 litres of water and stir thoroughly.
3. Measure 1 litre of the ash solution.
4. Melt the palm oil and pour it into a boiling pot.
5. Heat the palm oil until fumes develop and allow the fumes to stop (indicating that the red colour of the oil is burnt).

(CAUTION: Avoid inhaling the fumes. Cover your nose with a nose mask).

6. Allow the heated discoloured palm oil to cool.
7. Mix 800ml of the ash solution with 1 litre of palm oil.
8. Stir or blend thoroughly until it reaches a specific consistency (this is the point where the mixture thickens this is called "trace")
9. Pour the resulting paste into plastic or wooden moulds (covered with a plastic film) in the desired forms.
10. Leave the moulds to sit undisturbed until the soap solidifies and hardens.
11. Leave the soap for about 4 to 6 weeks to dry.
12. Remove the moulds and cut them into individual bars or other desired shapes.
13. Repeat the process using the solutions of the different ashes one after the other.

Observation:

- Observe each soap: its appearance, texture (hard or soft), and how it lathers with water.

Data Analysis:

- Using the table below, put a tick '✓' in the appropriate column.

Type of Ash Solution	Texture		Lathers with Water		Corrosive
	Hard	Soft	Much	Less	
Maize stalk					
Guinea Corn Stalk					
Plantain Peel					
oil palm spike leaflets					
Cocoa Pod					

Conclusion

Draw appropriate conclusions from your observations. For example, soap made from the cocoa pod ash solution produces soap with medium hardness.

IDENTIFYING THE SCIENCE UNDERLYING THE STAGES OF INDIGENOUS FOOD PRODUCTION

Following on from our exploration of the scientific principles in soap making, it is important to identify such principles in the production of any material either domestic or industrial. This is the behaviour a science student should exhibit. Understanding the scientific principles underlying the stages of production is essential for optimising processes, ensuring quality, and fostering innovation.

From traditional practices such as soap-making and kenkey production to modern industrial processes, science plays a fundamental role in every production stage. By identifying the underlying science, you can discover the reasons behind these processes, so that you can improve and innovate to add value to locally produced food.

You will go into the science behind each production stage, of different types of local foods, such as gari, akyɛkɛ, yakeyake, Ga or Fante kenkey, aboloo, tubaani, dawadawa, etc.) from its raw material acquisition to final product obtained. We will start with a focus on gari production.

Activities Involved in Preparing Gari

In gari production, one of the processes that stands out is **fermentation** to remove the hydrogen cyanide from cassava. The science behind cyanide production in cassava (the basis of many of these foods) is of general interest as is the fermentation of maize meal and locust bean to produce other foods.

Gari is a popular food made from cassava, a starchy root vegetable. Its preparation involves several steps. Gari can be enjoyed in various ways, such as soaking it in water to soften it before consumption or using it as an ingredient in dishes such as gari fotor or gari soakings.

You will now undertake an activity where you will learn how the favourite food of most students, gari, is produced.

Activity 9.5: Gari Production

Aim: To learn about how gari is prepared locally.

Under supervision from your teacher, you will follow the steps steps:

Procedure

1. **Sorting the cassava tuber**: You need to critically observe the tubers and select good and healthy ones. Certain cassava tuber roots may be damaged or decaying after harvesting and sorting is very relevant as shown in Fig. 2. Only healthy roots (free of rot or other damage) should be used in the processing phase.

Fig 9.2: Image of sorted cassava tubers

2. **Cleaning and peeling cassava roots:** Cassava roots will be covered with soil and dirt when you harvest them freshly. Therefore, you must peel

it to remove the outer brown skin. Then you wash the inner thick cream layer to eliminate stains and debris during the gari production process. You must regularly inspect the water supplied for washing to ensure that it is not filthy or polluted.

3. **Grating of the cassava**: Cassava grating is a phase where you reduce the cassava tuber into smaller particles to increase the surface area in eliminating a poisonous chemical called cyanide in order to make the root fit for human consumption. You will use locally made graters or automatic ones to mash the cassava to meet market and industry demands.
4. **Cyanide Detoxification in Cassava:** Cassava (*Manihot esculenta*) contains chemicals called cyanogenic glycosides, which can release hydrogen cyanide (HCN) when the plant tissue is damaged. To make cassava safe for consumption, you must break down glycosides to remove the hydrogen cyanide. Follow the process that follows to detoxify the cyanide:

Process in Cyanide Detoxification

1. First remove the cassava peel, which contains higher concentrations of cyanogenic glycosides.
2. Cut or grate the cassava to increase the surface area for more efficient detoxification.
3. Soak the cassava pieces in water for several hours to days. This process allows water-soluble cyanogenic glycosides to leach out.
4. Allow natural fermentation during soaking, which helps break down cyanogenic glycosides through microbial activity.
5. Spread the soaked cassava pieces in the sun to dry. Drying further reduces the cyanogenic glycoside content through enzymatic activity and evaporation of HCN.
6. Boil the cassava pieces to hydrolyse any remaining cyanogenic glycosides and volatilise hydrogen cyanide.

The de-watering and fermentation stages

This process is where the cyanide in the cassava mash is removed. The amount of water in the mash is reduced using a hydraulic press as shown in **Fig 9.3**. After that, the bags are left to drain and ferment for a few days before being used again. Fermentation involves the action of microorganisms like yeast, bacteria, and fungi that convert sugars into alcohol, acids, and other compounds. It also involves enzymes also play a crucial role in fermentation, catalysing reactions that break down sugars, proteins, and fats.

Fig. 9.3: Image of de-watering and fermentation stages

De-watering process

a. *Granulating:* Cassava mash is mechanically reduced in size, resulting in fine granules with a higher surface area, also known as grits.

b. *Gari frying:* To get a dry and crispy texture, the grits are roasted or fried in a hot frying tray or pan. Gari is typically white or cream in appearance, but it can be yellow if made with yellow cassava roots or fried in palm oil both of which are abundant in vitamin A and a good source of energy. After being roasted, they are stretched out on a high platform in the open air to cool and dry.

c. *Sieving:* The Gari is sieved to remove coarse particles, and a standard-sized sieve is used to generate fine granules from the coarse particles once they have been separated. The big grains are broken down into smaller pieces with the help of a grinder.

Scientific principles underlining gari production

The production of gari involves several stages, each has underlying scientific principles. The main stages are:

1. **Harvesting cassava roots:** The scientific principles of plant biology and physiology come into play during this stage, as enzymes within the cassava roots initiate biochemical reactions that degrade complex carbohydrates into simpler sugars.

2. **Grating:** The cassava roots are washed and grated into a pulp. Physics principles of force and motion govern the grating process, as mechanical forces are applied to break down the cassava roots into smaller particles.

3. **Fermentation:** The grated cassava pulp undergoes fermentation, where microorganisms such as lactic acid bacteria and yeast metabolise sugars present in the pulp. This fermentation process involves biochemical reactions mediated by enzymes, resulting in the production of organic acids and gases. The science of microbiology and biochemistry underlies this stage of gari production.
4. **Dewatering:** The fermented cassava pulp is dewatered to remove excess moisture. Physics principles of gravity and filtration are employed in this stage, as gravitational forces aid in separating the solid gari granules from the liquid phase.
5. **Roasting:** Physics principles of heat transfer govern the roasting process, as thermal energy is transferred from the roasting equipment to the gari granules, leading to the evaporation of residual moisture and Maillard reactions that contribute to the characteristic flavour and colour of gari.

To help your understanding, you will go on an educational trip to observe how gari is produced in **Activity 9.5**. You may do this in your group. Your teacher will help facilitate this visit.

Activity 9.5: Industrial visit to a Local Gari Production site or observing a video/animation of how gari is produced.

Aim: To observe the production process of a locally produced gari.

Materials: Writing material (Notebook, pencil, eraser, goggles, Clothing that covers the whole body).

Procedure:

1. Identify a facility where gari is produced near where you live
2. You may go alone or go with a friend.
3. Introduce yourself to the leader of the facility and request to be allowed to observe how the gari is produced.
4. Take notes of all that you see. Ask questions on processes you do not understand for clarification. Also, ask for an explanation of why certain processes or activities are done.
5. You should ask permission to take videos or pictures or both of the activities.

6. Compare the stages you observed on your visit with the stages you read about in your book on the production of gari.
7. Identify processes you observed as outlined in the text read about in your book
8. Identify any science principles at the stages you observed on your visit
9. Write a report of the visit and make a video or poster or textual presentation for your class for discussion.

Conclusion: Draw conclusions on the methods you observed and outline the processes seen on your visit, what you observed or what you read about in your book.

Watch the video below:

https://www.youtube.com/watch?v=kDkxk64dRHA

Your report on your visit to the gari production site or the video watched should follow the structure set out below:

Date:

Title: *Report on visit or observation of the video on a local Gari production facility in (Name of the community).*

Aim: *To acquaint myself with how local gari is produced.*

Materials: *Writing materials (Notebook, pencil, pencil, eraser, ruler, protective clothing and goggles.*

Procedure:

a. ***Pre-visit preparation****: (Write about all the things you did before setting out on the visit).*

b. ***The Visit****: (Write about the introduction you did and whatever went on from the beginning as soon as you arrived at the facility up to when you ended your interaction with whoever you interacted with.)*

c. ***Post-visit Activities:*** *(Write about any things you did; the interactions you had with the main person and the people you met. Do not forget if you need to go back for any further enquiries, include it in the post-visit activities write-up).*

Conclusion: *Write a complete report on your visit.*

In the next activity you will carry out is the production of Tubani. This is a group activity which your teacher will supervise.

Activities involved in preparing tubani

Tubani (*steamed black-eyed peas*) is a popular street food in Ghana made from beans and spices. Our northern family introduced it to Ghanaians. It is a very healthy meal that is high in protein. It is commonly eaten in the northern regions. It is a type of bean cake cooked by steaming and is often served with spicy pepper sauce or other condiments.

The steps to be followed in preparing tubani are:

Step 1: Soaking the Beans

Soak 2 cups of black-eyed peas or cowpeas in water overnight. This will help to soften the beans and reduce the cooking time.

Step 2: Preparing the Batter

- **a.** Drain the soaked beans and transfer them to a blender or food processor. Add 1 medium-sized onion, 2-3 cloves of garlic, 1-2 fresh chilli peppers (optional), and a pinch of salt.
- **b.** Blend the mixture until it forms a smooth batter. You can add a little water if needed to achieve the desired consistency.

Step 3: Fermentation

- **a.** Transfer the batter to a large bowl and cover it loosely with a clean cloth or plastic wrap.
- **b.** Allow the batter to ferment for about 8-12 hours at room temperature. This fermentation process helps to enhance the flavour and texture of the tubani.

Step 4: Preparing the Steaming Setup

- **a.** While the batter is fermenting, set up the steaming apparatus. This can be a large pot with a steamer basket or a specialised steamer.
- **b.** Fill the pot with water, ensuring it does not touch the bottom of the steamer basket or the tubani mixture.

Step 5: Forming the Tubani

- **a.** After the fermentation period, stir the batter gently to incorporate any settled sediments.
- **b.** Take a clean banana leaf or aluminium foil and cut it into squares or rectangles (about 4-6 inches).
- **c.** Spoon a portion of the batter onto each leaf or foil, shaping it into a small ball or oblong shape.

Step 6: Steaming the Tubani

a. Carefully place the formed tubani onto the steamer basket, making sure they are not crowded to allow even cooking.

b. Cover the pot with a lid and steam the tubani for approximately 30-45 minutes, or until they are firm and cooked through.

Step 7: **Serving for Enjoyment**

a. Once cooked, remove the tubani from the steamer and let them cool slightly.

b. Unwrap the banana leaves or foil and serve the tubani warm or at room temperature.

c. Tubani is often enjoyed as a snack or a breakfast dish in Ghana, and it pairs well with a spicy pepper sauce as shown in **Fig.9.4** below.

Fig. 9.4: Image of Tubani

Science processes involved in Tubani making

1. Soaking fosters microbial growth, particularly lactic acid bacteria and yeast, pivotal for subsequent fermentation. Enzymatic activity breaks down complex carbohydrates and proteins, improving digestibility and flavour.
2. **Grinding:** The cooled peanuts are ground into a fine paste using a grinding machine or a traditional mortar and pestle.
3. **Fermentation:** Fermentation is a key step in tubani production, where microorganisms metabolise sugars and produce organic acids and gases. This process softens the beans, enhances flavour and improves digestibility.
4. **Wrapping and Steaming**: Fresh leaves like banana leaves or plantain leaves are used to wrap the Tubani before the steaming process. The leaves are cleaned and dried before wrapping.
5. **Cooling and Serving:** Physics principles of heat transfer and thermodynamics govern the cooling process, as heat dissipates from the hot tubani to the surrounding environment, reducing its temperature to a palatable level.

SCIENCE PROCESSES IN THE STAGES OF PRODUCTION OF KENKEY

Kenkey is a popular staple food in Ghana. It consists of fermented and cooked maize dough, wrapped in leaves. Kenkey is a staple swallow food similar to sourdough dumplings from the Ga and Fante inhabited regions. It is popularly known as kɔmi (pronounced kormi) by the Gas or dokono by the Akans in Ghana.

What is kenkey and how is it made?

Kenkey is one of the principal fermented foods made of ground white corn (maize). The steps involved in the production of kenkey are as follows:

The corn is soaked in water for about three days, making sure to change the water every day without sticking your fingers in the corn.

Fig. 9.5: Image of grains of maize

Once the water has been drained from the dry corn, they are taken to a mill to be ground into the powdered form.

Fig. 9.6: Image of Powdered form of the gains

The corn flour is mixed with water and kept for some days to allow for fermentation. In between the fermenting, the dough may look yellowish on the top. Rinse it off gently with water. Fermentation is a metabolic process through which microorganisms such as bacteria, yeast, or fungi convert carbohydrates (sugars and starches) into alcohol, gases, or organic acids under anaerobic conditions (absence of oxygen). It is a form of anaerobic respiration used by certain cells to generate energy in the absence of oxygen.

Process of Fermentation

1. **Initiation**: Microorganisms are introduced to the substrate (e.g., yeast added to grape juice for wine).
2. **Lag Phase**: Microorganisms acclimate to their environment; minimal activity.
3. **Exponential Phase**: Rapid microbial growth and metabolism, converting sugars to fermentation products.
4. **Stationary Phase**: Nutrient depletion slows microbial growth; maximum product concentration achieved.
5. **Decline Phase**: Microorganisms die off as nutrients are exhausted and toxic byproducts accumulate.

Importance of Fermentation

1. Fermentation extends the shelf life of perishable foods by producing alcohol, acids, and other compounds that inhibit the growth of spoilage organisms and pathogens.
2. Fermentation adds unique flavours and textures to foods and beverages, making them more enjoyable and diverse. For example, the tangy flavour of yoghurt or the complexity of wine and beer.
3. Fermentation can increase the bioavailability of nutrients and produce beneficial compounds like vitamins, antioxidants, and probiotics that support health.
4. Fermented foods often contain live beneficial bacteria (probiotics) that can improve gut health and boost the immune system.
5. Fermentation has been a traditional method of food preservation and preparation across cultures for thousands of years, contributing to culinary diversity and cultural heritage.

Kenkey making process

Fig. 9.7: Image of Corn flour mixed with water.

1. Divide the dough into two parts once it is fermented. One part will be cooked and the other will be mixed with the cooked one. Water is then added to the raw part and some salt and then cooked.

Fig. 9.8: Image of Corn flour

Fig. 9.9: Image of 'Aflata' mixed with water

2. Once the dough is cooked, it is added to the raw dough. This cooked dough is called Aflata. Mix the Aflata with a wooden spoon to mix them to form a homogenous dough mixture.

Fig. 9.10: Image of 'Aflata' mixed with dough

Fig. 9.11: Image of Mixing 'Aflata' with a wooden spoon

3. The next step is to make small balls from the dough and then wrap them in the dried corn husks.

Fig. 9.12: image of a small ball from the dough

Fig. 9.13: Image of Moulded Kenkey

Moulding of Kenkey into balls

Tuck the ends in and mould or squeeze the ball together to close any large holes and cover the twisted end. The wrapped dough packets are placed on a wire rack above water in a large pot and allowed to boil and steam for one to three hours, depending on their size and thickness.

Fig. 9.14: Image of Cooking of kenkey (steamed kenkey)

Fig. 9.15: Image of Kenkey served with fish and pepper

Science Processes Involved in Kenkey Making

In local food production, several scientific processes come into play to ensure the safety, quality, and efficiency of the production process.

1. **Drying**: The corn is dried to remove water from the corn to help in milling
2. **Fermentation:** The rise of the corn dough as a result of the action of bacteria. The key scientific process in preparing kenkey is fermentation. Fermentation is a metabolic process in which microorganisms, such as bacteria and yeast convert carbohydrates into alcohol or organic acids. In the case of kenkey, the fermentation process is crucial as it imparts a unique flavour, texture, and sourness to the final product. The fermentation is facilitated by naturally occurring microorganisms present in the maize kernels, such as lactobacillus bacteria and wild yeast. Additionally, the production of organic acids such as lactic acid and acetic acid acts as natural preservatives, slowing down the growth of spoilage microorganisms and extending the shelf life of the kenkey.
3. **Amylase Activity:** Maize contains starch, a complex carbohydrate made up of glucose molecules. During the fermentation process, natural enzymes present in the maize, such as amylase, break down the starch into simpler sugars, primarily glucose. These simpler sugars are then consumed by microorganisms during fermentation, resulting in the production of lactic acid and carbon dioxide.
4. **pH Regulation:** The fermentation process in kenkey involves the production of lactic acid by beneficial bacteria. The lactic acid lowers the pH of the dough, creating an acidic environment. This low pH inhibits the growth of harmful bacteria and preserves the kenkey. The acidic environment also helps improve the digestibility and nutrient availability of maize.

5. **Gas Production:** As microorganisms consume the sugars in the maize dough during fermentation, they produce carbon dioxide gas. This gas gets trapped within the dough, causing it to rise and become lighter and more porous. The gas production contributes to the characteristic texture and volume of kenkey.
6. **Heating/ Boiling:** Heat is used to change moulded corn dough into the final product for consumption.
7. **Heat Denaturation**: After the fermentation process, kenkey is traditionally cooked by steaming or boiling. During the cooking process, heat denatures the proteins present in the maize dough, resulting in structural changes that contribute to the firmness and texture of the final product.

REVIEW QUESTIONS

Review Questions 9.1

1. A group of science students is conducting an experiment to optimise the fermentation process of kenkey, (a traditional Ghanaian dish made from fermented corn). They are investigating how different temperatures and fermentation times affect the flavour and texture of the final product.
   a. What scientific principles should the students consider when analysing the effects of temperature and fermentation time on the microbial activity during the fermentation of kenkey?
   b. How might these factors influence the biochemical processes involved in flavour development and the final texture of the kenkey?
2. How do the principles of science, specifically saponification and emulsification, influence the properties of soap, and what role do different oils and lye concentrations play in determining the effectiveness and characteristics of the final product?

ANSWERS TO REVIEW QUESTIONS

Answers To Review Questions 9.1

1.

a. The scientific principles underlining the fermentation process of kenkey which should be considered include:

- **Microbial Activity**

  Temperature Effects: Microbial growth rates are influenced by temperature. Each microorganism has an optimal temperature range for growth (typically between 25°C and 37°C for lactic acid bacteria). Higher temperatures may speed up fermentation but could also kill sensitive microbes, while lower temperatures might slow down the process.

  Fermentation Time: The duration of fermentation affects the accumulation of microbial metabolites. Longer fermentation times generally allow for more complete fermentation, leading to a stronger flavour and different texture.

- **pH Levels:** The fermentation process typically lowers the pH due to the production of organic acids (like lactic acid). The students should monitor pH changes during fermentation, as pH can influence both microbial activity and the flavour profile of kenkey.

- **Anaerobic vs. Aerobic Conditions:** Kenkey fermentation primarily occurs in anaerobic conditions (absence of oxygen). The students should consider how temperature and time may affect the oxygen levels and, consequently, the types of microorganisms that thrive (e.g., lactic acid bacteria vs. molds).

- **Substrate Availability:** The amount and type of carbohydrates available for fermentation (e.g., starches from corn) can influence microbial activity. The students should consider how temperature and fermentation time affect the breakdown of these substrates.

- **Metabolite Production:** Different temperatures and fermentation times will affect the types and amounts of metabolites produced by the microbes, which can include organic acids, alcohol, and gases. These metabolites contribute to flavour and texture.

b. Influence of factors on biochemical processes are;

- **Flavor Development**

  Temperature Influence: Higher temperatures can accelerate enzymatic reactions, leading to the rapid production of flavour compounds. However, excessively high temperatures may produce off-flavours or inhibit desirable microbial activity.

  Fermentation Time Influence: Longer fermentation times generally enhance flavour complexity as more metabolites are produced. The breakdown of carbohydrates into simpler sugars and then into acids and alcohols contributes to the overall flavour profile.

- **Texture Changes**

  Protein Denaturation: The fermentation process can lead to the denaturation of proteins, which may affect the texture of kenkey. Temperature plays a critical role in this process, as higher temperatures can cause proteins to coagulate differently.

  Starch Gelatinisation: The fermentation process may also lead to the gelatinisation of starches, affecting the texture. The balance of fermentation time and temperature can optimise this process, leading to a desired consistency (e.g., soft or firm).

- **Microbial Interactions:** The interplay between different microbial species during fermentation can also influence both flavour and texture. For instance, some lactic acid bacteria can produce compounds that enhance flavour, while others may contribute to the texture through the production of exopolysaccharides.

- **Acid Production:** The production of lactic acid during fermentation not only lowers the pH but also contributes to the tangy flavour characteristic of kenkey. The balance of acid production relative to fermentation time and temperature can greatly affect both flavour intensity and texture.

2. The principles of science, particularly saponification and emulsification, are fundamental to soap making and significantly influence the properties and effectiveness of the final product. Here's an overview of each principle and their roles:

Influence of saponification on the properties of soap:

- **Type of Fat/Oil Used:** Different oils have varying fatty acid compositions, affecting the hardness, lathering ability, and moisturising properties of the soap. For example, coconut oil produces a hard bar of soap with excellent lather, while olive oil results in a softer, more moisturising soap.
- **Balance of Oils:** A balanced combination of oils can lead to a soap that has a good hardness, lather quality, and moisturising effect. Too much of one type of oil can lead to undesired characteristics, such as a soap that is too soft or one that does not lather well.
- **Lye Concentration:** The concentration of lye affects the saponification process. The correct lye-to-oil ratio is crucial; too little lye will result in an uncured soap that is oily, while too much can lead to a harsh product. Calculating the saponification value for each oil ensures proper amounts are used.

Influence of emulsification soap properties:

- **Stability of the Soap:** The emulsification process contributes to the uniform texture of the soap and helps prevent separation, ensuring that all ingredients are well blended.
- **Skin Benefits:** Emulsifiers can enhance the moisturising properties of the soap, as they allow the soap to effectively combine with water and natural oils on the skin, providing hydration.
- **Texture and Lather:** Emulsification impacts the quality of the lather produced. A well-emulsified soap provides a richer and more stable lather, enhancing the washing experience.

EXTENDED READING

- Gari processing - https://www.youtube.com/watch?v=z2gtgUfx_QQ
- Alata Samina production - https://www.youtube.com/watch?v=hLvSOaNXluk
- Kenkey production in Ghana - Kenkey production, vending, and consumption practices in Ghana (practicalactionpublishing.com)

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GLOSSARY

Alkaline hydrolysis - is a way of breaking down substances to simple forms using alkaline reagents

Caustic - a substance that is capable of eating away another by chemical action.

Compounds - substances made from two or more different elements that have been chemically joined. Examples, H_2O, and NaCl.

Corrosive.- refers to a property of materials which can destroy other materials they come in contact with. Most corrosives are bases, oxidisers and acids.

Detoxification - the physiological or medicinal removal of poisonous substances or unwanted substances from an organism or a system.

Fermentation -This is a process in which a substance breaks down into a simpler substance with the help of microorganisms like yeast, and bacteria. For example, in the production of cassava dough, beer, yoghurt, bread and many others.

Flammable - Capable of being easily set on fire and of burning rapidly.

Glycerol – a 10% byproduct of transesterification of vegetable oils during soap preparation. It is colourless, odourless, viscuos liquid, and freely miscible with water.

Lye - a strong alkaline liquid obtained from wood ashes and used especially in making soap and washing.

Microorganisms - a microscopic organism. It may exist as a single cell or a colony of cells.

Neutralisation reaction - a reaction in which an acid and a base react in an equivalent quantity of each other such that there is no excess of either of them.

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