Objective Methods of Food Analysis

Introduction

- Objective tests/tools include physical, chemical and microbiological analyses of foods, whereas subjective tools comprise of discriminative tests, descriptive tests and affective tests.
- They are essential part of both new product development and quality control, they also support marketing and marketing research activities.
- Objective methods involve the use of instruments in carrying out evaluation of various attributes in food instead of human sensory organs.
- They are important in identifying contaminants in foods and uncover faulty processing and adulteration.
- These tools include:
  - chemical tests which are used for the determination of chemical composition as well as chemical and metal contaminants in foods;
  - microbiological methods that are used for detecting microbial contamination, insect excreta and other fragments in foods; and
  - physical methods which are used for measuring characteristics like texture, viscosity, color intensity, turbidity and fill weight among others.

SUBJECTIVE VS OBJECTIVE EVALUATION

➢ Subjective Evaluation

- A scientific discipline in which characteristics of food are measure, analyze and interpret their chemical reaction through different senses is called subjective or sensory evaluation."

➢ **Methods:**

- Sense of sight.
- Sense of smell.
- Sense of hearing.
- Sense of taste.
- Sense of touch.

➢ Objective Evaluation

- A scientific discipline in which characteristics of food are measure, analyze and interpret their chemical reaction by using instruments or standard procedure and are not dependent on observation of individual is known as objective evaluation"

➢ **Methods:**

- Chemical method.
- Physicochemical method.
- Microscopic examination.
- Physical property evaluation.

Physical Methods

- The physical methods deal with attributes like appearance (size and shape), texture, color, viscosity, turbidity, firmness and imperfection, not only that but also process variables such as headspace, fill weight, drained weight and vacuum.

Weight

- Weight of a food indicates the quality like in case of apple or egg.

Volume

- Liquid volumes can be measured by using measuring cups.
- Solid food volume can be found by displacement method.
- In this method, the volume can be calculated by subtracting the volume of seeds held by a container with a baked product from that of volume of seeds without the baked product. Usually mustard seeds are used.

Specific Volume

- Measurement of bulk volume in a porous and spongy product like idli is difficult.
- The volume may be measured by displacement with solvents like kerosene.
- The idli is given a momentary dip in molten wax to seal off the pores. Increase in volume is taken as the measure of its bulk volume.

$$\text{Specific Volume} = \frac{\text{Bulk Volume}}{\text{Wt. of the substance}}$$

Index of volume

- It can be found by measuring the area of a slice of food with a planimeter.
- It is important to use a slice that is representative of the product such as a centre slice.

Specific gravity

- It is a measure of the relative density of a substance in relation to that of water.
- The measurement is obtained by weighing a given volume of the sample and then dividing that weight by the same volume of water.

Moisture

- Press Fluids: Initial weight of the sample is noted. After the appropriate pressure has been applied for a controlled length of time, the sample is again weighed. The difference between the two weights represents the amount of juice contained in the original sample e.g., juiciness of meats, poultry and fish.

Drying:

- The weight of the origina $\text{Moisture Content} = \frac{\text{Initial Weight-Dried Weight}}{\text{Initial Weight}} \times 100 = \%$ ed until the weight remains constant.

Wettability

- Baked products can be tested for moisture level by conducting a test for wettability.
- For this test, the sample is weighed before being placed for 5 seconds in a dish of water.
- Immediately at the end of the lapsed time, the sample is removed from the water and weighed again to determine the weight gain.

Cell Structure

- Cell structure of baked products is an important characteristic to measure the uniformity, size and thickness of cell walls.
- Photocopies of cross-sectional slices give this valuable information.
- Size of the grain:
- This can be found by using photography or ink prints with stamp pad or sand retention e.g., idli. Retention of sand is more if the grains are coarse. Cut the idli into 2 pieces and take one piece and press it on the stamp pad and take an impression on the paper. Ink prints may be less clear but satisfactory for some purposes. Photography: This may be colour or black and white. They may not represent the sample size so a marked ruler should be kept adjacent.

Measurement of Colour

- *Disc Colourimeter:* Here the discs have radial slits that are spun on a spindle at about 2700 rpm so that the colours merge into a single hue without flickering. The test sample is placed adjacent to the spinning disc under controlled illumination and both are viewed simultaneously.
- *Coloured Chips:* A simple method is to match the colour of the food with the colour chips or colour glass, chart or colour tiles.
- *Spectrophotometer:* Visual matching of colours is subject to shortcomings of human observers.
- To overcome this spectrophotometer can be used.
- In this, tube with the liquid is placed in a slot and light of selected wavelength is passes through the tube.
- This light will be differentially absorbed depending upon the colour of the liquid and the intensity of the colour.

INSTRUMENTS USED FOR TEXTURE EVALUATION

- Percent sag
- The depth of a sample such as jelly is measured in its container by using a probe.
- The product then is unmoulded onto a flat plate. The greater the percent sag, the more tender is the gel.

$$\text{Percent sag} = \frac{\text{Depth in container} - \text{Depth in plate}}{\text{Depth in container}} \times 100$$

- Percent sag = Depth in container – Depth in plate . x 100 Depth in container

2. Baker's Jelmeter

- Simple capillary pipette developed by Baker is used for viscosity determination.
- The relative viscosity of pectin extracts or solutions is the ratio of the time of flow of the pectin solution through a given orifice compared to the time of flow of an equal quantity of water t the same temperature.

Measurement Of Viscosity and Consistency in Liquids and Semisolids

1. Stormer Viscometer

Measures the consistency or viscosity and gives an index of the viscosity.

The number of seconds required for the rotor to make 100 revolutions has been used to measure the consistency.

3. Brookfield synchrolectic viscometer

- Based on the measurement of resistance to rotation of a spindle immersed in the test material
- Used for measuring the consistency of custards, pie fillings, tomato products, mayonnaise, salad dressings and dairy products.

4. Bostwick consistometer

- Measures the consistency of tomato ketchup and sauce.

- Channel -2X2”
- Grades/ calibrations of 0.5cm intervals.
- Triggered gate on one side.
- Shows the distance traveled in fixed length of time(say 30 secs)
- Principle: Length of flow is proportional to consistency.

5. Efflux viscometer

Measures the time necessary for a quantity of fluid to pass through an orifice or capillary under standard pressure

e.g.,Tomato puree

6. Adams consistometer

❖Tomato puree, apple sauce, fruit pulps.

✓Consists of large metal disc with concentric circles increasing by 0.25 inch in radius. A steel truncated cone fits tightly in it, can be lifted vertically.

✓Cone is filled with the sample to the level and raised quickly. After 30 seconds, record the extent of flow at 4 equidistant points calibrated on the disc. The average of these 4 values is taken as avg. consistency value of the product.

7. Penetrometer

- Tenderness of gels, bakery products.
- Plunger equipped with a needle or cone that is allowed to penetrate the sample for a selected period of time.

Larger Reading= Longer Distance= More Tender

8. Brabander Farinograph

- Plasticity of wheat dough.
- Records the force required to turn the mixer plates through the dough.
- The force required increases as the solution develops during mixing and later decrease as sloution is slowly broken down by overmixing.

Measurement Of Resistance To Force In Solids

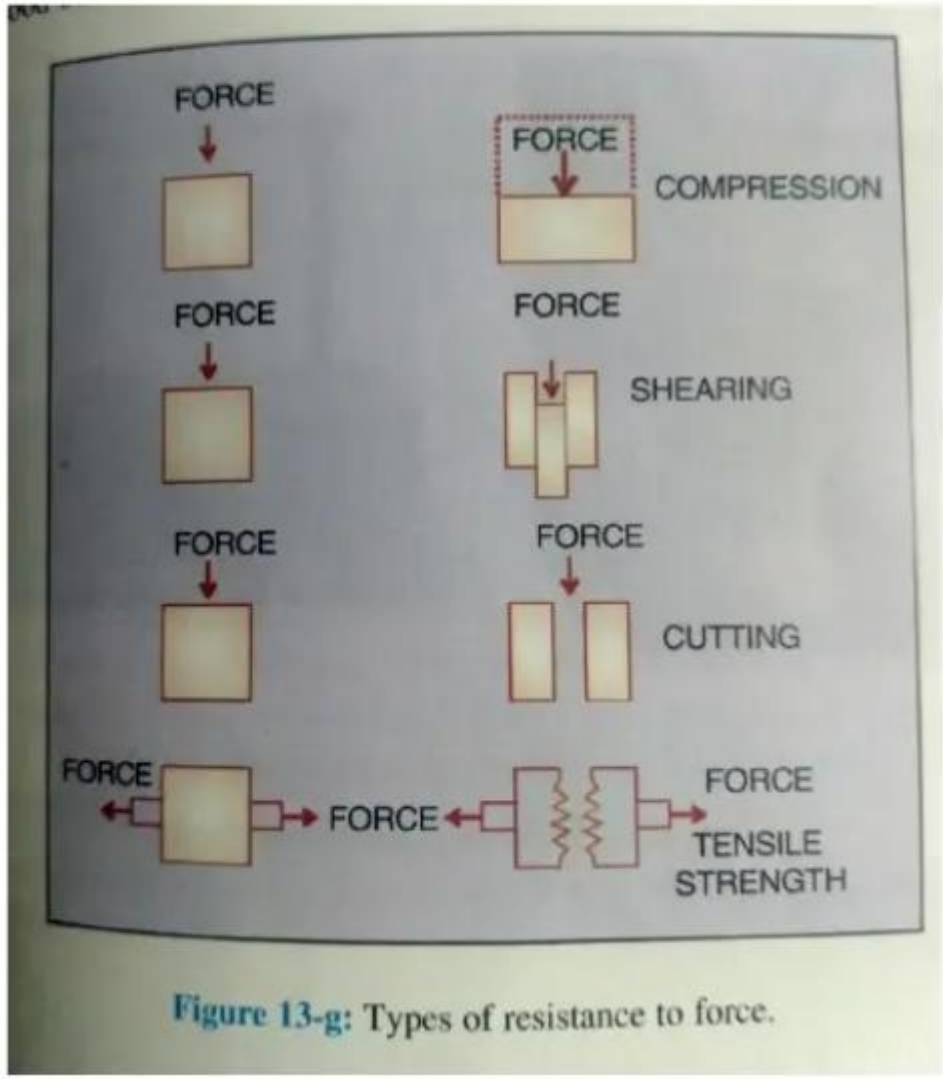


Figure 13-g: Types of resistance to force.

Bread

Chewing Gum

Cutting an Apple

Chapati

1. Magness Taylor Pressure Tester *(compression)*

- Plunger of variable diameter is pressed into the fruit to a given depth.
- The sprint attached to the plunger contracts and measures the compression force

2. Succulometer *(compression)*

- Squeezes the moisture from the food- i.e., juice, oil, other liquid components under controlled conditions of pressure and time.

Applications:

- Succulence/maturity of sweet corn
- Juiciness of apple, pear etc
- Moistness of canned fish, tuna

3. Tenderometer (compression and shearing)

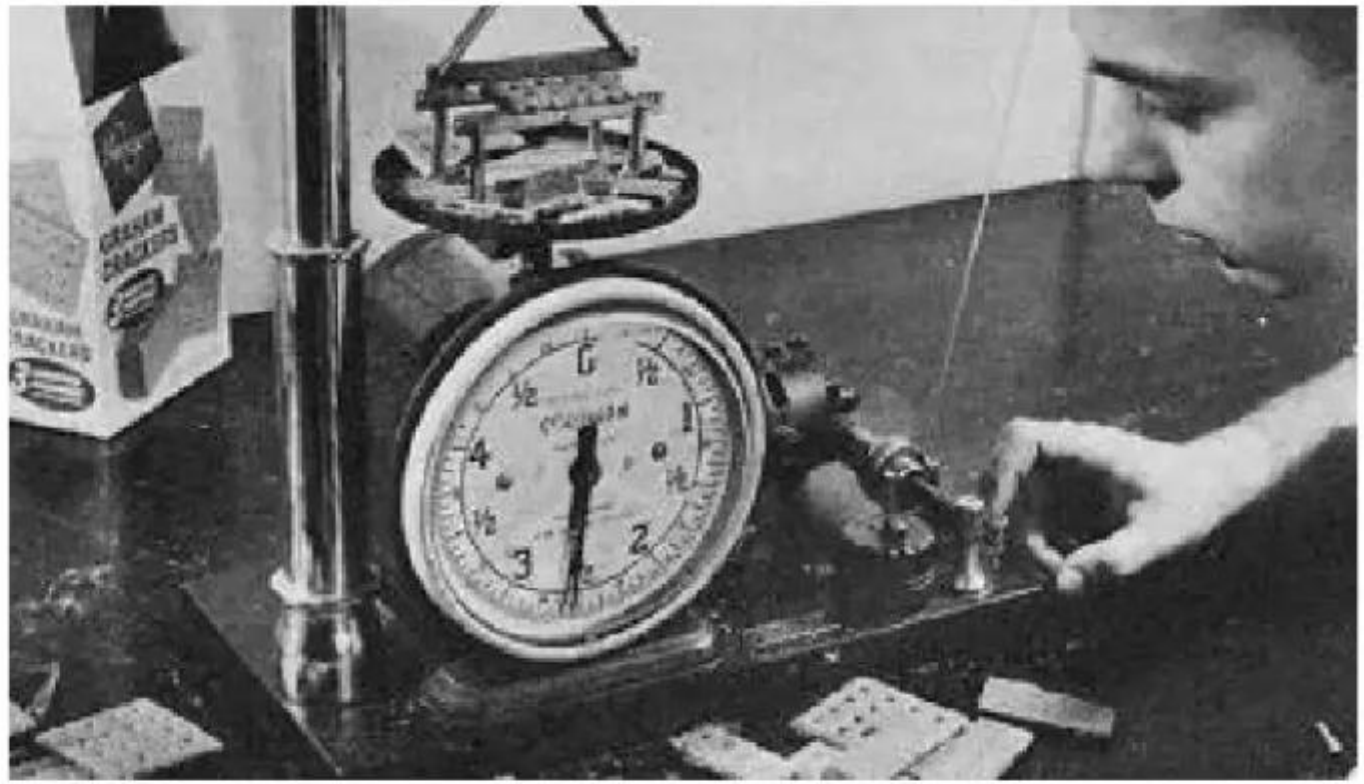
- Shearing followed by compression
- To test the suitability of peas for preservation, as peas lose tenderness and gain weight upon ripening

4. Fibrometer *(cutting)*

Helps differentiate mature stocks from tender stocks

e.g.; green beans

5. Shortometer



- Measures the tenderness of food sample.
- Sample rests on two parallel dull blades over a platform. The force required to break the sample by a motor-regulted third blade gives the measure of tenderness.

6. Kramer shear press

Many test cell assemblies with same power supply, to test the tenderness

7. Voldokevich bite tenderometer

- Imitates the action of teeth on food.
- It records the **force of biting** on a piece of food which results in deformation and rhis determines the total energy utilised for this deformtion.

e.g; meat and meat produccts

8. Warner Bratzler Shear

- Measures the tenderness of meat
- Meat samples of carefully controlled dimensions are placed through an opening in a thin metal plate and the force required for two parallel bars to shear the meat is recorded

9. Shear Press

- Measures the textural characteristics of some fruits and vegetables.
- Similar to Warner Bratzler Shear.
- It's a 3-in-1 device that compresses, extrudes and shears the sample at the same time

10. Universal Testing Machine

- Provides a record showing 7 aspects of texture from various food samples:

- Cohesiveness
- Adhesiveness
- Hardness
- Springiness
- Gumminess
- Chewingness
- Fructurability

Chemical Methods

- These are used for quantitative and qualitative evaluations, as well as determination of nutritive values in foods.
- Chemical substances also play an important role in food production and preservation.
- For instance, coloring agents make food more attractive, flavorings make food tastier and stabilizers prolong the shelf life of food while food supplements are used as sources of nutrition.
- The control of food quality and safety is based on the determination of chemical composition as well as chemical and metal contaminants such as heavy metals and other toxic substances which can lead to acute poisoning and other health effects.

Chemical Contaminants in Foods

- Chemicals of greatest concern for health are naturally occurring toxins, these include mycotoxins, marine biotoxins, cyanogenic glycosides and toxins occurring in poisonous mushrooms.
- Staple foods such as cereals (maize, sorghum, wheat) and nuts (peanut) can contain high levels of mycotoxins (aflatoxin and ochratoxin) produced by Aspergillus.
- Dioxins and polychlorinated biphenyls (PCBs) are example of persistent organic pollutants that can accumulate in the environment and human body.
- Dioxin is highly toxic substance that can cause reproductive and developmental problems, great human exposure to dioxin is through foods such as meat and dairy products, fish and shellfish.
- Health effects of dioxins to human include skin lesions and altered liver function. It may also results into compromised immune system, nervous system, endocrine system and reproductive functions.

Metal Contaminants in Food

- Heavy metals such as lead, mercury, arsenic, cadmium, chromium and nickel are naturally occurring chemical compounds, they can be present at various levels in the soil, water and atmosphere.
- Metals can also occur as residues in food as a result of human activities like farming, industrial operations and automobile exhausts.
- Exposure to these metals is through both naturally occurring and manmade chemical compounds present at various levels in the environment including contaminated foods and water.
- During food product development they must be checked to ensure food quality and safety.

Table 1: Heavy metals and their effects to human health

Metal	Acute exposure	Chronic exposure
Lead	Loss of appetite, headache, hypertension, abdominal pains, renal dysfunction, fatigue and sleeplessness	Mental retardation, birth defects, allergies, weight loss, paralysis, anemia, kidney and brain damage
Mercury	Diarrhea, fever and vomiting	Microtubule destruction, swollen gums and mouth, mitochondrial damage, nephrotic syndrome and lipid peroxidation
Cadmium	Pneumonitis (lung inflammation) and oxidative stress	Cancer (lung, liver, bladder and skin) and proteinuria (excess protein in urine)
Arsenic	Nausea, vomiting, diarrhea, Encepha-lopathy, arrhythmia and painful neuropathy	Diabetes, cancer and Hypopigmentation/ Hyperkeratosis
Chromium	Gastrointestinal hemorrhage, hemolysis, acute renal failure, breathing problems	Pulmonary fibrosis and lung cancer
Nickel	Allergic reactions	Reproductive and developmental effects

Microbiological Methods

- These methods are used in detecting food contamination by microorganisms such as bacteria and fungi (yeast, mold), also used to detect the presence of insect fragments, insect excreta and other foreign materials in food products.
- Microorganisms can cause food poisoning and spoilage which principally affect food quality, major pathogens for this include *Clostridium perfringens*, *Escherichia coli* (O157:H7) and *Shigella* spp.
- Microorganisms are all over the place and they are commonly found in faeces, soil and water; rats, mice, insects and pests; domestic, marine and farm animals (e.g. dogs, fish, cows, chickens and pigs); and human body parts (bowel, mouth, nose, intestines, hands, fingernails and skin).
- Soil-borne microorganisms such as clostridia are common on raw vegetables, while *Clostridium botulinum* are targeted when designing processing steps to destroy them.
- Many food borne microbes are present in intestines, hides, feathers of healthy animals which are raised for food.
- For example, *Salmonella* serotypes have been scientifically found to infect a hen's ovary.
- Salmonella spp have been a particular concern with foods of animal origin (e.g. meat, poultry, eggs and dairy products).
- For *Campylobacter* spp, the most common foodborne species are *Campylobacter jejuni* and *Campylobacter coli*.
- Members of this genus are susceptible to environmental stresses and cause gastroenteritis associated with headache, diarrhea, fever, abdominal pain and muscle pain.

- In food processing, food borne microbes can be introduced through humans who handle the food, or by cross contamination from some other raw agricultural materials and/or the establishment environment.
- Toxigenic pathogens create food “poisoning” by producing an enterotoxin in the food, a good example is staphylococcal enterotoxin induced illness.
- Common foodborne bacteria are Campylobacter, Salmonella (non-typhoidal), Listeria monocytogenes, E. coli (O157:H7), Clostridium perfringens, Staphylococcus and Shigella spp.
- On one hand, food spoilage can be caused by molds, these are the major agents especially in vegetables where bacterial growth is not favored (e.g. low pH).
- Yeasts, molds and lactic acid bacteria can as well spoil fermented vegetables such as sauerkraut and pickles, not only that but also other acid foods like salad dressings and mayonnaise.

i. Microbial analysis of Milk:

- In general market milk is sampled in the container in which it is sold.
- Sterile plunger is used for sampling and 10ml sample is taken. The collecting sample is put in sterile screw capped tube and immediately send to lab.
- Before performing test, the sample is mixed by inverting up and down for more than 10 times.
- For milk bottle, the top is flamed, cap removed with flame forceps.
- For plastic packets, the top and corner of packet is swabbed with spirit.
- After allowing to air dry, the swabbed area is cut with sterile scissors.
- The collected milk is tested by methylene blue test resazurin test, MPN test.
- Three routine tests prescribed for milk are:
    - Plate count at 32°C: serial dilution is made and pour plating is done from tubes of 10^{-2}– 10^{-8} dilution.
    - For raw milk, DMC is usually done.
    - Coliform test: It is done by MPN
- **Mesophilic aerobic bacteria in Milk:**
    - Raw milk should not exceed total plate count = 2x 10^5/ml
    - Pasteurized milk should not exceed total plate count = 2x 10^4/ml
    - At 37°C, coliform = 0 (best)
    - At 42°C, fecal coliform = 0 (best)

ii. Microbial analysis of Cheese:

- Cone sample is taken with the help of borer.
- The collected sample is made into finer pieces with a sterile grater. A grater is a device with a rough surface for grating food.
- The holes remaining after borings are sealed with paraffin wax.
- 10gm of grated sample is mixed with 90ml of warm diluent and homogenized in a blender.
- Serial dilution is performed.
- Plate count is performed on yeast extract milk agar. Similarly, coliforms can also be counted.
- For direct microscopic examination, thin film of slices of cheese are made. They are defatted with xylol. Xylol is washed and smear is stained and examined.

iii. Microbial analysis of Ice cream:

- If the ice cream is in packet of small size, it should be taken to lab in frozen condition (dry ice can be used).
- Melting ice cream should not be taken from the field.
- The wrapper is removed aseptically and content are put in sterile screw called tubes.
- The collected sample is allowed to melt in the lab below 20° C.
- 10ml sample is weighed in a screw capped jar and serial dilution is performed in 0.1% peptone water.
- Plate count is performed from each dilution.

iv. Microbial analysis of Butter:

- The sampling of butter is done by using sterile knife.
- 10g of butter is emulsified in 90ml of warm water (40-45°C) diluent and plate count is performed.
- Cultures are made on agar free nutrient medium.

v. Microbial analysis of Yoghurt:

- Yoghurt is sampled from the container in which it is fermented using spoon or spatula.
- Double dilution of yoghurt is prepared to 0.1% peptone water.
- 5ml of dilution is mixed with 5ml of melted LS differential medium.
- It is poured in plates, cooled, to solidify and incubated around 43°C for 48hrs.

II. Sampling procedure for meat and meat products:

- No. of field samples=5
- Method of analysis:
- Enumeration of mesophilic aerobic bacteria
- Detection of *Salmonella*

i. Microbial analysis of Carcass sampling (raw meat):

- Sterile large swab is taken and they are moistened in 0.1% peptone water.
- The carcass is wiped with the swab.
- The carcass is again cleaned with dry pad.
- The pads are taken and 250ml of diluent is added in the pad to disperse the microorganisms from the trap.
- Serial dilution is performed.
- Plate count is made ta 20°C.
- For detection of *Salmonella,* plating is done in selective medium.

ii. Microbial analysis of Chopped meat (raw meat):

- It may be fresh, minced or chopped meat.
- Several random samples are taken so as to detect universally distributed microorganisms.
- The sample is mixed with diluent and mixed well.
- Sample is serially diluted.
- Plate count is performed from dilutions 10^{-4} to 10^{-8}.

iii. Microbial analysis of Poultry:

- Swab with lengthy rod is taken and it is sterilized.
- For each chicken, 2 swabs are taken. One for swabbing outside the body and other for swabbing body cavity of chicken.
- The swabs are rinsed in 100ml peptone water.
- Sample is serially diluted.
- Plate count is performed for total count and coliform count using selective media.
- To test for *Salmonella,* the dilution should be enriched in selective or tetrathionate broth and sample is further processed.

iv. Microbial analysis of Fresh fish:

- The whole surface of fish is either swabbed or washed with sterile 0.1% peptone water +1% NaCl in sterile plastic bag.
- Appropriate dilutions are prepared and total count is performed in marine agar which is incubated at 20°C for 5 days.
- Cultures can also be done in glucose tryptone media, macconkey agar is or media containing 5-10% NaCl for halophilic bacteria.

v. Microbial analysis of Eggs:

- Outer surface of egg shell is swabbed with sterile swab. Sterile swab must be moistened in peptone water prior to swabbing.
- Then appropriate dilution is made from the swab.
- Inner portion of egg can be taken as sample and diluted.