Egg Powder and Its Quality Control

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Abstract

Eggs are an important source of protein in the human diet and are complete perfect foods. It is an ideal vital protective food, also termed as reference protein. Egg processing technology is by itself a challenging field of study enabling the preservation of the contents of the eggs by drying methods – especially the well advanced spray drying method. These products, both the raw and finished products are tested for their physical, chemical and microbiological properties as per their specifications and also do conform to International standards like USDA and EU regulations. Control over quality is further ensured by having controlled vigil on poultry farms and feed mills too. This in turn, ensures regularity of quality shell egg supplies.

INTRODUCTION:

Egg of all birds may be eaten, out of India, eggs of hen and duck are mainly used for human consumption. Egg is a complete and perfect food by itself. It is an important source of protein and an ideal protective food owing to presence of important essential amino acids. Our Indian diets are mostly deficient in leucine and methionine. Since eggs are rich in these amino acids, they supplement the diet and are hence termed as reference protein.

COMPOSITION:

Hen eggs on the average weight 57g and consist of 57 percent white, 32 percent yolk and 11 percent shell. This compares with an average weight for duck eggs of 78g, consisting of 52 percent white, percent yolk and 11 percent shell. Table.1 gives the average composition figures for the edible contents.

Table.1 Average composition of egg products

	Duct			**Hen**		
	Whole egg(%)	**Yolk (%)**	**Albumen (%)**	**Whole egg(%)**	**Yolk (%)**	**Albumen (%)**
Solids	24.5-	47.0-50.0	11.0-12.5	30.3	55.0	12.8
Protein	26.0	15.5-17.5	9.0-11.0	13.9	17.0	11.0
Lipid	11.8-	30.0-32.0	0.0-0.04	14.4	35.7	0.05
Ash	12.2	1.0-1.6	0.5-0.7	1.0	1.2	0.7
Carbohydrate	11.0-	0.2-0.5	0.4-0.9	1.2	1.1	1.0
Chloride(Nacl)	11.6	0.3	0.3	-	-	-
Phosphorus(P_2O_5)	0.8-1.0	1.38	0.05	-	-	-
pH	0.3	1.026	1.055	-	-	-
Specific gravity	0.5 7.7 1.048					

The shell of hen and duck eggs contains about 3.5 percent protein, 1.5 percent water and 95 percent of inorganic matter (mainly calcium carbonate with traces of magnesium carbonate and calcium phosphate).

The chemical composition of eggs has been reviewed by Parkinson (1966) and by Petersen (1978); data are also presented in food tables by Paul and Southgate (1978). The main proteins that have been identified in egg white are ovalbumin (over 50 percent), conalbumin, ovomucoid, globulins and ovomucin.

Galyean and Cotterill (1979) fractionated egg white using DEAE cellulose chromatography followed by polyacrylamide gel electrophoresis. Minor changes in protein structure following spray drying were noted.

The yolk contains simple proteins (livetins) and phosphoproteins (vitellin and vitellenin). Most of the phosphoproteins are present in loose combination with phospholipids as lipoproteins. The lipids of egg yolk include about 62 percent triglycerides, 21 percent lecithin, 7 percent cephalin, 4 percent cholesterol and 0.5 percent FFA.

Table 2: Typical fatty acid percentage composition for egg total lipid is:

C14:0	0.6	C16.0	25.8	C16:1w9	0.8
C16:1w7	3.4	C17.0	0.3	C17:1w8	0.3
C18:0	8.6	C18.1w9,11	41.1	C18:1w7	2.4
C18:2w6	11.2	C18.3w3	0.5	C18:1t	0.7
C20:1w9	0.4	C20.4w6	2.2	Others<0.3	1.7

Polyunsaturated fatty acid composition varies with hen's diet.

CHANGES DURING STORAGE:

The egg starts deteriorating soon after it is laid. Therefore eggs should be refrigerated promptly after they are collected. The air cell in a good-quality egg is less than 0.3cm deep. The yolk is in the centre. When the egg is broken the condition of yolk and white can be observed. The yolk is firm and stands up in the centre of white, which is viscous. The egg white forms a definite ring around the yolk and thick white holds its shape. No blood spots are present and there is no bad odour (Mudambi and Shalini, 1993)

Factors which affect quality of eggs include age, atmosphere and temperature of storage, relative humidity and any pre-treatment given before storage.

A number of changes occur in egg during storage. These include:

1. The air cell increases in size due to loss of moisture.
2. Carbon dioxide is lost resulting in increased pH.
3. Water passes from white to yolk, thus the size and fluid content of yolk increase. Due to pressure of the enlarged yolk the vitelline membrane weakens and eventually breaks.
4. The thick egg white becomes less viscous and it changes to a watery white fluid which runs easily.

The extent of spoilage in eggs can be assessed both by external and internal examination. Externally the egg is examined for a good shape of 74-75 Index and must weigh around 55-58g with a sound and clean shell. The criteria given here indicate the extent of quality of egg. The egg can be termed as spoiled if the air cell size, albumin and yolk index, yolk index and thickness of shell used to determine the spoilage in eggs are given in Table.3

Table.3: Indicators to determine spoilage in eggs

Criteria	**Range**
Air cell size	2-3cm
Albumin index	0.08-0.1

Yolk index	0.35-0.45
Haugh (unit score)	80 or above
Thickness of shell (mm)	0.35 or above

DETERIORATION DURING STORAGE: Fertile eggs get deteriorated more rapidly than infertile eggs. Eggs when stored at room temperature undergo deteriorative changes. The weakening of the yolk membrane occurs after 2 days storage at 37^{o}C, or after 5 days at 25^{o}C, or 20 days at 16^{o}C, 100 days at 2^{o}C. These changes that occur during deterioration may be grouped as physical and chemical changes.

Physical Changes:

- Egg white becomes less viscous and spreads rapidly.
- The size of the air cell increases.
- Water passes from the white to the yolk thus increasing the volume and water content of the yolk resulting in breaking of vitellin membrane.

Chemical Changes:

- Loss of water
- Loss of carbon dioxide
- Change in pH 7.6to 9.7 in egg white
- The breakdown of proteins
- Increase in the amount of free ammonia
- Increase in water soluble inorganic phosphorus
- Increase in free fatty acid in yolk fat
- Deterioration in the flavour of eggs occurs by the invasion of microorganisms and by the changes that taken place in fat and protein

Bacterial Decomposition: As an egg ages the porosity of the cell increases making possible the infiltration of bacteria and moulds. The alkalinity of egg white and the lysozyme serve to reduce this spoilage caused by the microorganisms.

LEGISLATION:

The EC has made three regulations on marketing standards for eggs, Regulation 2772/75 sets three quality classes, class A (fresh eggs), class B (second quality or preserved eggs) and class C (non-graded manufacturing eggs). Class A may be described as 'EXTRA' if they meet certain fairly stringent conditions. The seven weight grades for class A and B eggs are as follows (Class C eggs need not be weight graded:

Grade	**Weight per egg (g)**
1	70 or over
2	65-70
3	55-60
4	50-55
5	45-50
6	Under 45

The eggs (Marketing Stands) Regulation 1985, SI No. 1271, as amended by SI No. 1184,1987, provide the enforcement of Regulation (EC) No. 349/86 (which amends Regulation 2772/75) by redefining eggs as follows:

01 Eggs means hen eggs in shell suitable for direct human consumption or for use in the food industries, except for incubated eggs.

02 Industrial eggs' means hen eggs in shell other than those defined as 'eggs' including incubated eggs.

03 'Grade' C eggs' shall be eggs which do not meet the requirements applicable to eggs in grades A or B. They may only be passed to egg processing plants or to industry.

Regulation(EC) No.1943, 1985 defines minimum criteria to be met by producers for eggs labelled as free range, semi-intensive, deep litter and brown.

Examination: The shell is not impervious, but contains numerous minute pores. These are essential for the interchange of oxygen, etc., between the growing embryo and the atmosphere, but unfortunately also permit the entry of bacteria and moulds. The yolk of the egg should be firm and surrounded by a strong vitelline membrane. The white consists of three distinct layers, namely inner thin white (30 percent), thick white (50 percent) and outer thin white (20 percent). In a newly-laid egg the thick white is attacked to the shell membranes at the ends and the yolk is anchored to the thick white by the chalazae. The vitelline membrane is semi-permeable and during storage water diffuses slowly from the white to the yolk. When a good-quality egg is cracked on to plate the yolk is tall and compact and stands centrally in a thick layer of white. A thin white surrounding a flattened yolk indicates a lower quality egg. The height of the albumen can be expressed in Haugh units (Brant et at al., 1951).

Eggs are examined by holding against the aperture of a candling lamp, broad end uppermost, before twirling to and from round the long axis. The internal is best judged from the visibility ease of movement and shape of the yolk. As the internal structure weakens, the closer can the yolk approach the shell and the more visible it becomes on twirling. During storage air replaces the evaporated water and in genera the air space should not exceed 7 mm in depth. Candling should also reveal blemishes such as blood spots, blood eggs and meat spots (MAFF, 1958). Candling will also incubate eggs that will not hatch (incubator reject eggs). At present the addition of such eggs (less than 6 days old) to egg products is allowed in the EC but is forbidden in the USA and Canada (but see below, under egg products). The sealing of eggs with waterglass and its detection are discussed by Nicholls (1931). Preservation of eggs by treatment with epoxide vapour and storage in sterile mineral oil has been described by Wilcox (1971).

The pH of the white of a newly-laid egg is about 7-8, but due to carbon dioxide diffusing out rises to 9-3 after 3 days and remains constant. Change in the ammoniacal nitrogen and fat acidity during storage of course affect the odour and taste. Since duck eggs are often laid near ponds and stagnant pools they are more likely to be contaminated by Salmonella species than are hen eggs. Romanoff and Romanoff (1949) have published data on eggs from a range of avian species.

PRESERVATION OF THE CONTENTS OF EGGS:

Freezing: Egg breaking, separation and pasteurization and freezing are the steps involved. Eggs are pasteurized to kill all Salmonella organisms. The usual pasteurization practice for liquid whole egg involves heat treatment at 60^{o}C for not less than 3 ½ minutes. Increasing the acidity of the egg whites before pasteurization seems to protect the proteins from damage to heat.

The functional properties of raw egg whites are not altered by freezing and thawing. Frozen egg yolks become viscous and gummy on thawing unless they are mixed with sugar, salt or syrup before freezing. Freezing process destabilizes the surface of the tiny lipid protein particles (lipoprotein) in egg yolk. The fragments that are liberated then aggregate together on thawing to form a meshy type structure or gel. Cooked egg white is not stable to freezing and thawing. The gel structure of the coagulated protein is damaged by ice crystal formation. Syneresis occurs on thawing.

Drying: It is a satisfactory method for preserving eggs, either whole or as separated yolks or whites. Spray dried egg whites and egg yolks have long shelf lives. To retain their functional properties, as well as good colour and flavour, dried whites require treatment to remove the last traces of glucose. They help to control the Maillard reaction during storage. Dried eggs keep best if the initial moisture content is low and if they are kept in a tightly sealed container. Low storage temperatures are also important in maintaining the quality of the dried products. For reconstitution dried egg should be sprinkled over the surface of like-warm water, stirred to moisten and then beaten until smooth.

PLANT AND PROCESS:

Egg processing is carried out in a fully automated and controlled (bacteria free) environment.

1 Eggs are received and tested in a fully equipped quality control laboratory before being accepted for processing.
2 They are then washed in hot water with approved detergents followed by rinsing in 100-200 ppm chlorine water.
3 Cleaned eggs are broken in the egg breaking machine.
4 The liquid is filtered, chilled, pasteurized in a UHT triple tube pasteurizer, fermented (only for albumen liquid), spray dried and subsequently packed.

QUALITY CONTROL MONITORING FLOWCHART:

	Egg Receiving	→	Physical and Microbiological analysis
	↓		
	Egg storage Room	→	Cooler Room Temperature & Microscopic exposure
	↓		
Breaking room ← Chlorine ppm	Transfer Room	→	Temperature of Egg washed water
	↓		
Whole egg, Yolk ← and Albumen liquid	Tank Room	→	Temperature, Total solids of egg liquids in the storage (Surge) Tank
	↓		
	CIP Room	→	Concentration of santizers (Sodium hypochlorite in water, phosphoric acid, hot water (40-50^{o}C) & pH
	↓		
	Pasteurization of whole egg and yolk liquid	→	After pasteurization, liquid samples are checked for microscopic, c-Amylase and total solids
	↓		
Shelf flakes after ← dried	Drying of whole egg and yolk liquid after pasteurization	→	To check physical, chemical,microbiological analysis of finished products
	↓		
	Fermentation of	→	To check the sugar and pH

albumin liquid		during fermentation
↓		
Drying	→	To test moisture, pH and solubility
↓		
Hot room treatment	→	After this treatment, physical, chemical and microbiological analysis is done

1. Plant Hygiene Monitoring.
2. Process Water Analysis.
3. Effluent Treatment Plant (E.T.P.) Water analysis.
4. Humidity & Temperature of all Rooms.

THE PRODUCTS:

A. Pasteurized Spray Dried Hen Whole Egg Powder:

1. Test Parameter		**Standards**
Physical		
Moisture(%)	Max.	4.0
Ph		7.0-9.0
Fat(%)	Max.	40.00
Protein(%)	Min.	45.00
Total Ash	Max.	4.00
Solubility(%)	Min.	86.00
Reducing Sugars(%)	Max.	0.3
Taste		Normal
Odour		Normal
Colour		Normal
Impurities		Nil
Granulation (100% Through)		100% through No.18 mesh
Additives		Nil
Microbiological		
Standard plate count/g	Max.	5000 count
Coliform count/g	Max.	0.3
Enterobacteriaceae count/g	Max.	10
E Coli/g		Negative
Salmonella Sps/250g		Negative
Staphylococcus aureus/g		Negative
Yeast & Mold count/g	Max.	10
Heat Resistant Bacteria/g	Max.	10

2. **Packing:** In Export worthy 5 ply CFB boxes.
3. **Storage:** Dry at 20 Degree Centigrade
4. **Applications:** Cakes, Pastries, Pancakes, Mixes, Pasta, Mayonnaise, Omelettes, Cooked dishes, Baby foods, Bakery and Confectionery products, Ice Creams, Salad Dressings etc.
5. **Directions for use:** Mix one part of whole Egg Powder with three parts of water by weight. Preferably the whole Egg Powder should be mixed with other dry ingredients before adding water.

B. Pasteurized Spray Dried Hen Egg Yolk Powder:

1.Test Parameter		**Standards**
Physical		
Moisture(%)	Max.	4.0
Ph		6.0-7.0
Fat(%)	Min.	57.00
Protein(%)	Min.	30.00
Total Ash	Max.	4.00
Solubility(%)	Min.	86.00
Taste		Normal
Odour		Normal
Colour		Normal
Impurities		Nil
Granulation (100% Through)		100% through No.18 mesh
Additives		Nil
Microbiological		
Standard plate count/g	Max.	5000 count
Coliform count/g	Max.	0.3
Enterobacteriaceae count/g	Max.	10
E Coli/g		Negative
Salmonella Sps/250g		Negative
Staphylococcus aureus/g		Negative
Yeast & Mold count/g	Max.	10
Heat Resistant Bacteria/g	Max.	10

2. **Packing:** In Export worthy 5 ply CFB boxes.
3. **Storage:** Dry at 20 Degree Centigrade
4. **Applications:** Cakes, Cake mixes, Doughnut mix, Sweet doughs, Pastries, Pies, Delicacies, Ice Creams, Mayonnaise, Salad Dressings, Egg Noodles, Pasta and all bakery products, Products of Canning Industry, Cooked Dishes, Cosmetology etc.
5. **Directions for use:** Mix one part of whole Egg Powder with 1.25 parts of water by weight. Preferably the whole Egg Powder should be mixed with other dry ingredients before adding water.

C. Pasteurized Spray Dried Hen Egg Yolk Powder:

1.Test Parameter		**Standards**
Physical		
Moisture(%)	Max.	8.0
Ph		7.0-8.0
Fat(%)	Max.	0.02
Protein(%)	Min.	78.0
Total Ash	Max.	6.00
Solubility(%)	Min.	95.0
Reducing Sugars(%)	Max.	0.3
Taste		Normal
Odour		Normal
Colour		Normal
Impurities		Nil

Granulation (100% Through)		100% through No.80 mesh
Additives		Nil
Microbiological		
Standard plate count/g	Max.	5000 count
Coliform count/g	Max.	0.3
Enterobacteriaceae count/g	Max.	10
E Coli/g		Negative
Salmonella Sps/250g		Negative
Staphylococcus aureus/g		Negative
Yeast & Mold count/g	Max.	10
Heat Resistant Bacteria/g	Max.	10

2. **Packing:** In Export worthy 5 ply CFB boxes.
3. **Storage:** Dry at 20 Degree Centigrade
4. **Applications:** Sweets, Chocolates, Cakes, Pastries, Macaronies, Croquettes, Marshmallow, Candies, Angel Cakes, Bakery and Confectionery items, Health foods etc.
5. **Directions for use:** Mix one part of whole Egg Powder with seven parts of water by weight.

EGG PRODUCTS:

Legislation and Standards: A UN/ECE (United Nations Economic and Social Council and Economic Commission for Europe) standard for hen's egg products is set out in Table.5

Table 5 : Standards for egg products

	Egg solids (%min)	Fat (%min)	FFA of fat as oleic acid (%min)
Liquid and frozen whole	24.0	10.0	-
Egg	43.3	27.0	-
Liquid and frozen egg	10.5	-	-
Yolk	95.0	30.	3.5
Liquid and frozen egg	95.5	30.	3.5
Albumen	84.0	-	-
Dried whole egg	92.0	-	-
Dried egg yolk			
Pan dried egg albumen			
Spray dried egg albumen			

Council Directive 89/437/EEC (Obj No.L212,22.7.89,p.89) on the hygiene and health problems affecting egg products production and marketing requires (effectively from December, 1991) inter, alia, the monitoring for residues of products with pharmacological or hormonal action, antibiotics, pesticides, detergent or other harmful or deleterious substance, and the meeting of certain microbiological and chemical criteria. The chemical requirements are: 3-hydroxybutyric acid, not more than 10mg/kg d.b. (d.b.; on the dry solids basis).

Liquid Egg: The manufacture and treatment of liquid egg has been described by Heller (1964) and by Wilcox (1971). During the preparation of batches of liquid egg for manufacture, there is some possibility of the presence of salmonella due to the presence of a small proportion of infected eggs. Such organisms can, however, be destroyed by pasteurization at 64.4-65^{o}C (148-150^{o} F) without coagulating the egg or impairing the baking qualities (Knight, 1963). Monsely and Jones (1979) showed that

egg white can be pasteurized by heating at 57.2^{o}C for 2 ½ minutes. Shrimpton et al.(1962) showed that the reduction of activity of a-amylase by that could be made the basis of a simple routine test for assessing the adequacy of heat treatment. For the test the sample is incubated at 44^{o}C with starch. Any active amylase (present in unheated or insufficiently pasteurized egg) is able to break down the starch, so that addition of iodine will not give a blue colour. When the enzyme has been destroyed due to adequate pasteurization, the starch is unaffected and the normal blue colour develops. Subsequently, the liquid Egg (pasteurization) Regulations, 1963 (SI No. 1503) required that liquid egg should be heated to at lease 65.4^{o}C for at least 2 ½ min and the cooled product should comply with alpha- amylase test.

The regulations contain detailed conditions for the pasteurization process, sampling, transport and the analytic method for checking a-amylase activity (see below). They also apply to the separated components of egg (yolk and white) whether frozen, chilled or otherwise preserved.

Liquid egg and the separated or blended products may be stabilized by the addition of salt and preservatives such as benzoates or sorbates. Other additives may include vegetable oils as anticoagulants, acids and bases as pH adjusters, and phosphates as colour stabilizers (generally for yolk), emulsifiers and thickeners. Liquid egg contains about 0.4 percent carbohydrates. If present in the spray-dried product, this can cause browning reaction on storage. Liquid egg and liquid albumen is subjected to a desugaring process using glucose oxides/catalase before spray drying to reduce the glucose level to less than 0.01 percent in the final product. Conversely, the aerating properties of egg may be stabilized by sugaring at the rate of 1 part sugar to 2 parts of egg followed by pasteurization and evaporation to yield a concentrated product.

Frozen whole Egg: The product is prepared using freezing temperatures between -24^{o}C and -40^{o}C. Such temperatures, combined with air circulation, cause rapid freezing, which is important as it reduces bacterial multiplication and produces a more uniform product. After freezing, the product is stored below -9.5^{o}C. The product should contain less than 75 percent water, at least 10 percent of oil (extract) and the FFA of the fatty extract should not exceed 3 percent as oleic acid. Boric acid has been used as a preservative in frozen egg products.

Dried Egg: Dried eggs may be produced by spray –drying or the AFD process (Anon, 1968 a,b). The moisture content of fresh samples should not exceed 5 percent but it may rise during storage to as much as 9 percent. The other main constituents present usually fall within the flowing percentage ranges: protein (N x 6.68) 40.4-50.5, chloroform extract (fat, lecithin, etc.) 40.46, ash 3.2-4.2, phospholipid as P205 1.05-1.40.

The separated components are also available as dried products: dried yolk generally contains 3-4 percent moisture, 31.0-32.5 percent protein and 60-64 percent lipids; dried albumen contains 5-7 percent moisture, 82-84 percent protein and 0.5 percent; lipid. Anti-caking agents may be incorporated into dried egg mixes.

ANALYSIS OF EGG PRODUCTS:

Sampling: No simple rules can be adopted to cover the range of egg products since conditions differ widely. Eggs in shell are sample as individual units and a composite sample made by breaking in difference sized contained; in general a 300-500g sample is drawn and combined in a single sample jar. The sample is kept in a freezer in solid CO_2 until ready for analysis frozen egg is withdrawn from bilk with a corer or auger; composite samples are prepares from approximately 300-500g and the temperature of the sample is raised to approximately 40^{o}C to allow mixing before analysis A 300-

500g sample of dried egg is prepared by mixing the contents of a suitable number of small packets; for larger containers, small amounts of sample of sample are withdrawn and combined to give a composite sample. The power is mixed by passing through a domestic flour sifter, lumps are broken and the powder mixed. Flake albumen is ground to pass through a 60 mesh sieve. The combined sample is kept in a hermetically sealed jar in a cool place.

Total Solids: Four methods are available for determination of total solids. The AOAC method (5 hours in a vacuum oven at 98-100^{o}C) is generally regards as the most accurate procedure. Liquid products are per-dried on a steam-bath before the vacuum oven treatment. The weight taken for analysis carries (2g for dried egg, 2.5g for yolk, 5g for liquid and 10g for albumen). In the less accurate 'quick oven' method, the sample is dried for 1 hour. Infra-red drying instrument are used in quality control laboratories, and are suitable for future use provided they are carefully calibrated; analysis takes 10-40 minutes per sample. In plant quality control of total solids of liquid egg is carried out by refractometric reading; a pocket instrument calibrated over the range 0-50 percent sugar solids or an Abbe refractometer is used. Pour a well mixed 20 ml aliquot egg into a 25ml stoppered measuring cylinder. Add by pipette 1 ml 0.88 ammonia to the cylinder. Allow to stand for 5 min. Mix by inversion without aerated sample to the refractometer prism and read, note the temperature of the instrument (preferably the pocket instrument and sample should be maintained at the same temperature by immersion in a water bath). Liquid yolk is diluted 1:1 with water before clarification; liquid albumen may not need clarification before reading. Preferably the temperature of the sample should be adjusted to 20 ± 0.2^{o}C ; alternatively, a temperature correction must be applied according to the formula $R_{20}=R_T-0.08T$

R_T = refractometer solids at 20^{o}C

DT = 20^{o}C – T$^{o.}$

For pasteurized whole egg, ammonia clarified (15 drops of 0.88 NH40h to 20ml of egg), the liner relationship (± 0.5percent at 20^{o}C) using sugar refractometer is :

Refractometer reading	**Whole egg solids (percent)**
24.0	22.2
25.0	23.3
26.0	24.4
27.0	25.5
28.0	26.6

Lipids: Chloroform/ethanol(1:1) is used in the AOAC direct extraction procedure. Place 12 ml liquid whole egg (5 ml liquid yolk) into a 100ml volumetric flask. Add 25ml mixed solvent very slowly, shaking constantly until all the protein is coagulated and all lumps dispersed. Then add 60ml solvent. Shake at 5 min intervals for 1 hour, make to mark. Stand until clear. For liquid albumen, per-dry a 60ml sample on a steam bath. Dry at 98-100^{o}C for 90 min in an oven. Cool in a dessicator. Weight 5g of the solids into a 100ml volumetric flask and treat as above. In the case of dried egg products take 3g whole egg, 2g whole yolk, 10g, whole albumen. Test with chloroform/ethanol as above. Transfer a 50ml aliquot of the clear solvent into a beaker. Evaporate to dryness on a steam bath. Oven dry for 15 minutes at 98-100^{o}C. dissolve the residue in 10ml beaker. Wash with 10ml for 90 minutes. Weigh and calculate the lipid content.

The Soxhlet procedure may be applied to dried products. Chloroform/ethanol is used for extraction. Alternatively, the AOAC acid hydrolysis procedure (preferred by UN/ECE) may be used, the value obtained being approximately 90 percent of that

obtained by the directed chloroform/ethanol method. The acid hydrolysis method, three chloroform/methanol extraction procedures, a hexane/isopanol procedure and a fast-by-difference calculation have been compared by Fletcher et at. (1984). The isolation of egg phospholipids by TLC and acid column chromatography is described by Moschidis et at.(1984), and HPLC by Hanson et at.(1981). The free lipids are essentially triglycerides, whilst 'bond lipid' contains the phospholipids.

Egg oil has the following characteristic: refractive index at 20^{o}C, 1.4655-1.4670; saponification value, 188-198; iodine value, 60-70; unsaponifiable matter, up to 40 percent; phosphorus (as P_2O_5) 1.4 percent.

Lipid Phosphorus: The amount of organic phosphorus extracted varies with the solvent used (Manley and Lobley, 1984). Extract 3-101g dried sample for 2-3 hours with chloroform in a continuous extractor. The extract is then dried and weighed to ascertain the content. The extract is wet oxidized suing 2-5ml of sulphuric acid and nitric acid, the phosphorus determined ad phosphate for a further method employing methanol see the section on salad cream.

Protein: The Kjeldahl method is used; the AOAC recommends mercury/potassium sulphate mixture as catalyst but alternatively a mixture of 96 percent sodium sulphate(anhydrous), 3.5 percent copper sulphate and 0.5 percent selenium dioxide may be used. The following conversion factors have been recommended: white, N X 6.70; yolk, N X 6.62; whole egg, N X 6.69.

A correction for non-protein nitrogen may be applied. This takes into account the nitrogen that occurs mainly in phospholipid. The nitrogen in lipid is considered to be 0.6 percent. Lipid nitrogen as protein=0.006 N_F X fat percent where N_F-appropriate nitrogen factor.

Glucose: An enzymic procedure or Somigyi titrimetric method may be used. Deproteinisation is necessary but traces of sugars tend to be lost in the process. Desugared eggs normally contain less than 0.1 percent glucose but this level cannot be measured.

Free fatty acid in dried eggs: The sample (15g dried whole egg or 11g dried yolk) is mixed with 5g sodium sulphate (anhydrous) and extracted with 100ml chloroform/ ethanol (1:1) an aliquot of the solvent is titrated with 0.1m sodium hydroxide to a phenolphthalein end-point. The result is calculated in percent of the weight of fat.

Ash: Ashing is normally carried out in stages; liquid products are per on a bath followed by vacuum oven and 3g of dried solids are transferred to a tared dish. The dish is placed in a muffle furnace and the temperature is raised to 250^{o}C for 1 hour and then by gradual stage by 300^{o}C (20^{o}C/hour). When fuming ceases the char is broken with a fine probe and the ashing is completed at 500^{o}C.

α – Amylase: The sample is subjected to the test that is detailed in the Schedule to the liquid egg (Pasteurisation) Regulation 1963, to determine the efficacy of the pasteurization process. The regulations require the sample to be tested as soon as possible after receipt in the laboratory. Any sample that shows evidence of deterioration should not be subjected to the test.

pH: The pH is measured using a standard pH meter with glass/calomel electrode combination. Sample preparation is as follows:

Liquid egg products	-	measure pH directly.
Dried whole egg	-	mix 20g with 60ml water.
Dried albumen	-	mix 10g with 80ml water.
Dried yolk	-	mix 20g with 100ml water.
Frozen egg product	-	bring to room temperature and measure pH directly.

Incubator reject eggs: The presence of 3- or β – hydroxybutyric acid is an indicator of the presence of incubator reject egg in egg products. Proposed methods are GLC (Robinson et at. 1975) and enzymatic assay (Parry et at., 1980; BCL, 1987). Elenbaas et al. (1986) have shown that the two techniques give comparable results,. With detection limit of 0.5mg/Kg of 3-HBA. Uijttenboogart et al. (1986) found that incubator reject eggs held in incubators for longer than six days contained about 30mg/Kg 3-HBA, whereas table eggs contained about 0.7mg/Kg.

NIR: Osborne and Barrett (1984) have described the use of infra-red transmission spectroscopy for the analysis of protein, total lipid and total solids content of liquid egg products.

Solubility of dried whole egg: The solubility of dried whole egg can be assessed by the Haenni method. In the modification described by Hawthorne (1944), 1g of the powder is placed with 5ml of 5 percent sodium chloride solution (m/v) in a stoppered tube, which is then shaken thoroughly in a standardised manner. The refractive index of the dispersed sample and of the salt solution are both measured.

Haenni value= y =(N^{25}_D of sample soln-N^{25}_D of solvent) x 1000.

From Hawthorne's graph:

$$\text{Solubility} = \frac{\text{Log}_{10}Y - 0.445}{0.01}$$

Salt is used as it gives clearer solutions than water (cf.Fryd and Hanson, 1944). Alternatively, the following direct method may be used:

METHOD: Weigh 1g of sample into a dry beaker, add 10ml of water, allow the mixture to soak for 3 h and then heat on a water bath at 50°C for 30 min. Transfer the mixture to a centrifuge tube without washing the beaker and centrifuge for at least 1 minute. Pour off the upper layer without disturbing the sediment and then wash the beaker with 10ml of water at 50°C. Pour the water into the centrifuge tube and after mixing, re-centrifuge. Pour off the upper water and wash the sediment with a further 10ml of water. After this transfer the sediment to a tared filter or basin, dry and weigh. A good-quality fresh sample usually shows solubility of over 90 percent, but there is marked reduction during storage and with increasing moisture content.

SAMPLE PREPARATION:

The sample to be examined is prepaid for the test as follows:

1.	Pasteurised whole egg	-	the original sample
2.	Pasteurised liquid yolk	-	dilute 5ml yolk with 10ml water
3.	Dried whole egg	-	mix 20g dried egg with 60ml water, take 15ml for the test.
4.	Dried yolk	-	mix 10g dried yolk with 50ml water, take 15ml for the test.

REGENTS:

Starch Solution: Weigh an amount of soluble starch, of analytical reagent quality and of known moisture content, equivalent to 0.7g of dry starch. Mix the starch to a thin cream with cold water. Transfer the cream to about 50ml of boiling water, boil for 1 min and cool by immersion in cold water. Add three drops of toluene and dilute with water 100ml in a volumetric flask. The solution is stable for 14 days.

Solution of iodine: Dissolve 0.1269g iodine and 3.6g potassium iodide in 1 litre of distilled water. Prepare freshly before use. The solution may be made by dilution from a stronger solution with appropriate adjustment of potassium iodide concentration.

Solution of trichloroacetic acid: Prepare a 15 percent m/v solution of tricholoroacetic acid in water.

METHOD: Weigh out 15.0g of the prepared sample into a small flask. Add 2.0mlof the starch solution and mix thoroughly. Place this mixture for 30 min in a water bath maintained at 44 ± 0.5^{o}C. Remove the mixture jar. The sample is kept in a freezer of packed in solid CO_2 until ready for analysis. Frozen egg is withdrawn from bulk with a corer or auger; composite samples are prepared from approximately 40^{o}C to allow mixing before analysis. A 300-500g sample of dried egg is prepared by mixing the contents of a suitable are withdrawn and combined to give a composite sample. The powder is mixed by passing through a domestic flour sifter, lumps are broken and the powder mixed. Flake albumen is ground to pass through a 60 mesh sieve. The combined is kept in a hermetically sealed jar in a cool place.

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