



# E G G S



THE PRODUCTION, IDENTIFICATION  
AND RETENTION OF QUALITY IN EGGS



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BY EARLE S. SNYDER

*Department of Poultry Science*

ONTARIO AGRICULTURAL COLLEGE

GUELPH, ONTARIO

## *foreword*

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This bulletin, "EGGS—The Production, Identification and Retention of Quality in Eggs", written under the authorship of Professor Earle S. Snyder of the Department of Poultry Science, Ontario Agricultural College, Guelph, represents a bringing up to date of a former bulletin printed under the same name. As the original bulletin was very popular for many uses and as there has been an extensive demand for it, before and after the supply was exhausted, arrangements have been made for the reprinting of this new and up-to-date edition. The poultry industry and those associated with it are grateful to Professor Snyder for the effort he put into the preparation of this very enlightening bulletin. With the permission of the author and the Ontario Department of Agriculture the bulletin is being reprinted for wider distribution by the Canada Department of Agriculture.

The following extract from the foreword prepared by Professor Snyder describes pertinent details related to the publication.

"Much of the included material is the result of studies conducted by the author and associates working in the Department of Poultry Science at the Ontario Agricultural College. Recourse has also been made to the extensive literature on the subject, and direct references are acknowledged where used. A sincere attempt has been made to state, describe, and illustrate the pertinent present knowledge and practices having to do with the production, identification, and retention of quality in eggs. It is hoped that the reader will find the material informative and helpful."

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# I N T R O D U C T I O N

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Eggs have long held an important place in the human diet. They have many uses, are easy to prepare, and are liked by most people. Thus, a more or less satisfactory market has been regularly available. Until recently, competition among foods has been relatively mild. In consequence, availability, price, and attractiveness of appearance have been the chief factors influencing their inclusion in the Canadian family diet.

This is no longer true. Extensive and continuing nutritional investigations have served to make many housewives rather intensely food conscious. Furthermore, on every hand, people are advised to remain slim—for reasons of both health and appearance. As a consequence, the health guardian of Ontario homes—the housewife—increasingly buys foods with an eye to their nutritional value. Vitamin and mineral content are studied, and most certainly their calorie value. The quality of protein, the kind, amount, and digestibility of fat, and the ease and economy of preparation are matters of great importance. Flavours are delicately tested and even fitness in the meal's colour scheme is a matter of concern.

But, this is not all. Breakfast in many homes is no longer a carefully prepared meal enjoyed in unison by the whole family. Breakfast is a rush-time affair. Individual members often “eat on the run”, and at different times, dependent upon the time for arrival at work or school. In consequence, less time is taken for preparation. Ready-prepared and easily and quickly prepared foods receive preference. Also, in numerous homes, Mother works out. Therefore, the forenoon “coffee break” is used to supplement a hasty and all-too-often inadequate breakfast.

Food processors and advertising agencies have been quick to take advantage of these modern trends. Low calorie, ready-to-use, and ready-mix preparations have become legion. Time-saving qualities, attractiveness, as well as actual and assumed nutritional qualities of the various foods, are extolled. Every known means of illustration, story, jingle, and favour is used to attract the busy housewife and her family. Breakfast foods are an interesting example where various types of favours have been used extensively to attract children.

The result of all this — a keen competition in the use of foods dependent upon their nutritional and other qualities. In this competition for place in the family diet, eggs are not exempt—especially is this true of the family breakfast.

Fortunately for the egg industry, the results of numerous carefully conducted scientific studies of their nutritional qualities have assured for eggs a continuing important role in the production of nutritionally sound diets for all members of the family—from infancy to maturity and even old age. This was well borne out by the importance attached to the use of eggs in the diets of both the armed forces and civilians during the Second World War. The carefully devised Canadian Nutritional Standards recommend a minimum of three eggs per week and many nutritionists advise, for optimum nutrition, an egg per day per capita. Canadian consumption compares very favourably with that of most other countries, being exceeded only by that of the United States and Israel. However, a careful study of official American and Canadian egg consumption figures indicates a slow but continuous decline during recent years in per capita use of eggs. This is to be regretted, and indicates need by the Poultry Industry for a more aggressive research, advertising, and sales programme to counteract successfully this apparent trend.

III THE CANADIAN EGG INDUSTRY

Canada is fortunate in having a highly developed poultry industry. Because of our very extensive agriculture and fisheries, there has long been an abundance of grain and of animal and fish by-products. Canada produces about 50 per cent of its soya bean oil meal requirement—and the supply is increasing. This has made possible the provision of balanced diets for Canadian flocks, any additional requirements being readily available in the United States.

Due to the tremendous and urgent need during the Second World War for eggs for Britain, the armed forces, and increased domestic use, Canadian farmers and poultrymen were at that time encouraged to enlarge their flocks and increase production. Egg production reached its peak in the period of 1945 to 1947, following which a moderate but definite recession developed in the industry—though exports continued at a high level until 1949. When, as a result of Britain’s austerity programme, the British egg contract was finally terminated on December 17th, 1949, this recession was accelerated, and exports dropped (Table 1). However, implementation of a moderate support programme by the Canadian Government in January, 1950, served to reassure a rather bewildered industry; this, along with an expanded exploitation of other export outlets, prevented excessive liquidation of laying stock.

TABLE 1 — CANADIAN EGG EXPORTS BY PERIODS AS PERCENTAGE OF TOTAL PRODUCTION

Period	Percentage of Production
1935-39	1
1940-44	11
1945-49	22
1950-54	3
1955-60	3

Canada’s egg industry became increasingly competitive throughout the 1950s; paying prices to producers declined an average of 1.8¢ per dozen per year, from 1951 to 1960, for all grades of eggs sold to Registered Grading Stations. During the same period, improved husbandry—larger



FIG. 1. Few, if any, foods are more appetizing and nutritious than a Grade A egg with its attractive colour, high percentage of thick white and mild, delicate flavour.

flocks, mechanization, more productive stock—enabled producers to offset narrowing margins of profit per dozen. As a result, the support price set in 1950, though considered inadequate by many, gradually became an incentive price.

“New technological developments in marketing and changes in financial arrangements and over-all management because of contract production and integration in its various forms” were further factors, “particularly in areas relatively close to the large consuming centres” (1). Thus a profit became practically assured for efficiently operated flocks—especially those of moderate to large size. As a result, flock size tended to rapidly increase and egg production, thus stimulated, soon considerably surpassed Canadian consumptive capacity. “It was evident that at any level, within reason, at which a price was established involving a guarantee to purchase (by Government agency) unlimited quantities of eggs, either at the time or shortly after, was an incentive price”. Narrowing and more competitive export markets necessitated storage of an ever-increasing surplus production which in 1959 rose to “truly unmanageable proportions” (1). Final disposal was possible only at substantial loss, and to a considerable extent only after processing.

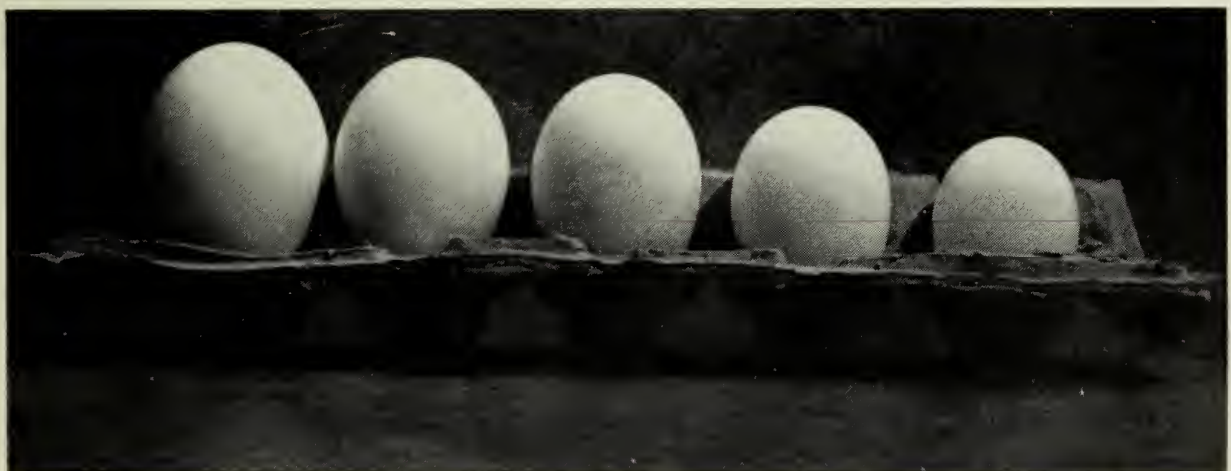


FIG. 2. Both white- and brown-shelled eggs come in several sizes. From L. to R.—extra large, large, medium, small, and peewee, thus enabling consumers to choose for economy and expected use.

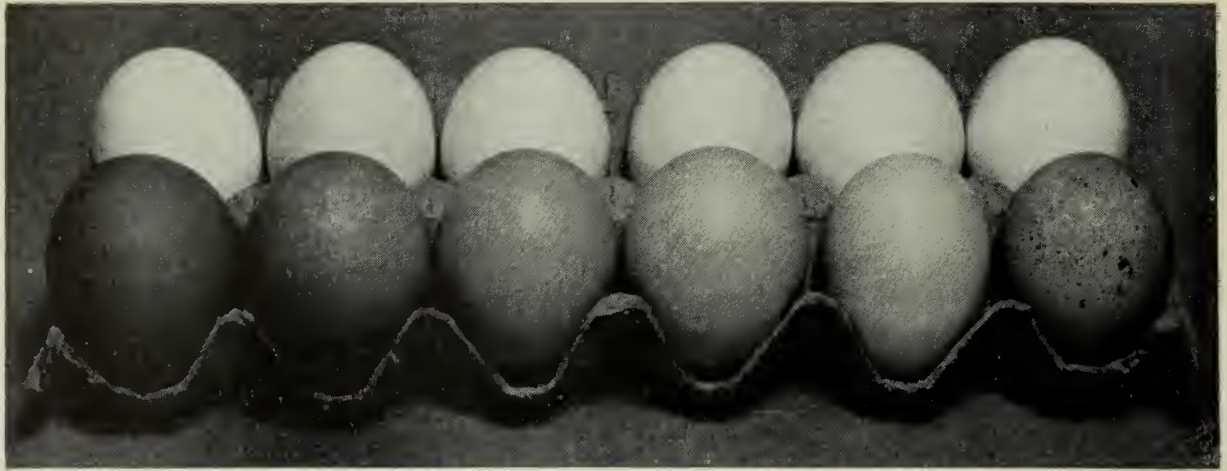


FIG. 3. Shell colour has psychological value but does not condition interior quality.

To terminate this condition, the Canadian Government introduced in October, 1959, a new form of stabilization—a deficiency payment programme. By limiting deficiency payments to 4,000 dozen Grade A large and Extra-large-size eggs from any one flock and so provide a smaller degree of support, it will be less likely to induce production expansion, particularly of large-size flocks. The deficiency payment method also makes it unnecessary for the Government, through the Price Stabilization Board, to buy eggs and take part in the business of marketing. The marketing of eggs is, therefore, returned to the Trade, and prices once more find their level on the basis of supply and demand.

Canadian egg production and price trends are shown in Table 2. The effects of wide use of modern laying stock and improved husbandry are readily apparent. A steadily decreasing laying population, judged by the smaller number of chicks hatched year by year for egg production, is producing more eggs each succeeding year. Note the decline in prices to producers for eggs and fowl, with some improvement evident in 1960 following the return to “supply and demand” pricing for eggs. The Canadian market receives a reasonably steady supply of eggs the year ’round. Factors other than supply and price account for the slightly downward trend in per capita consumption of eggs, also shown in Table 2.

TABLE 2—CANADIAN EGG PRODUCTION AND PRICE TRENDS

Canada	Chicks Hatched(1) millions	Eggs Produced(2) mil. doz.	Eggs Consumed(3) dozens	Egg Prices(4) ¢ per doz.	Fowl Prices(5) ¢ per lb.
1956	68.9	404.3	24.3	38.1	20.4
1957	66.7	446.5	25.4	31.4	16.1
1958	60.9	449.8	24.8	32.7	16.6
1959	57.7	460.0	24.0	29.2	12.5
1960	52.7	451.1	24.0	29.8	12.9

(1) For egg production, mixed sexes

(4) To producers, weighted average,  
all grades, at Registered Stations

(5) 4 to 5 lb. live, average 5 cities

(2 & 3) Estimates by Dominion Bureau of Statistics

} From Canada Dept. of Agriculture

What does the future hold for Canadian producers, handlers, and consumers of eggs? The economic urge to increase flock size while rate of lay itself is increasing, alone assures plentiful supplies of eggs at relatively modest prices for years to come. Uniform quality of supply is becoming the key factor as merchandising shifts more and more into the hands of chain store and other mass buyers. They are beginning to rely more on controlled management of flocks and product, and less on candling of individual eggs, to service their requirements. This brings business interest to the production level and often with it financing, contracts, and all-out promotion of production. Does this mean that "egg factories" will replace our family farm flocks? Modern trends in marketing tend to restrict the outlet for product from small and casually managed flocks. It is gratifying to note, however, that Ontario owners of semi-specialized farm flocks appear to be meeting rather well the challenge of the times with respect to efficiency and quality of production.

IV AN EGG — NATURE'S MASTERPIECE

The hen's egg is an amazing phenomenon. It can truly be called Nature's masterpiece. You ask why? Because present in a fertile egg are all the nutritional ingredients required to transform a tiny microscopic cell into a lusty baby chick, the only additional requirements being air and heat. Not only is this true, but the newly hatched chick carries in its body enough food to enable it to live for 96 hours, and even longer, without any additional supply. Indeed, it is this fact that makes possible the successful

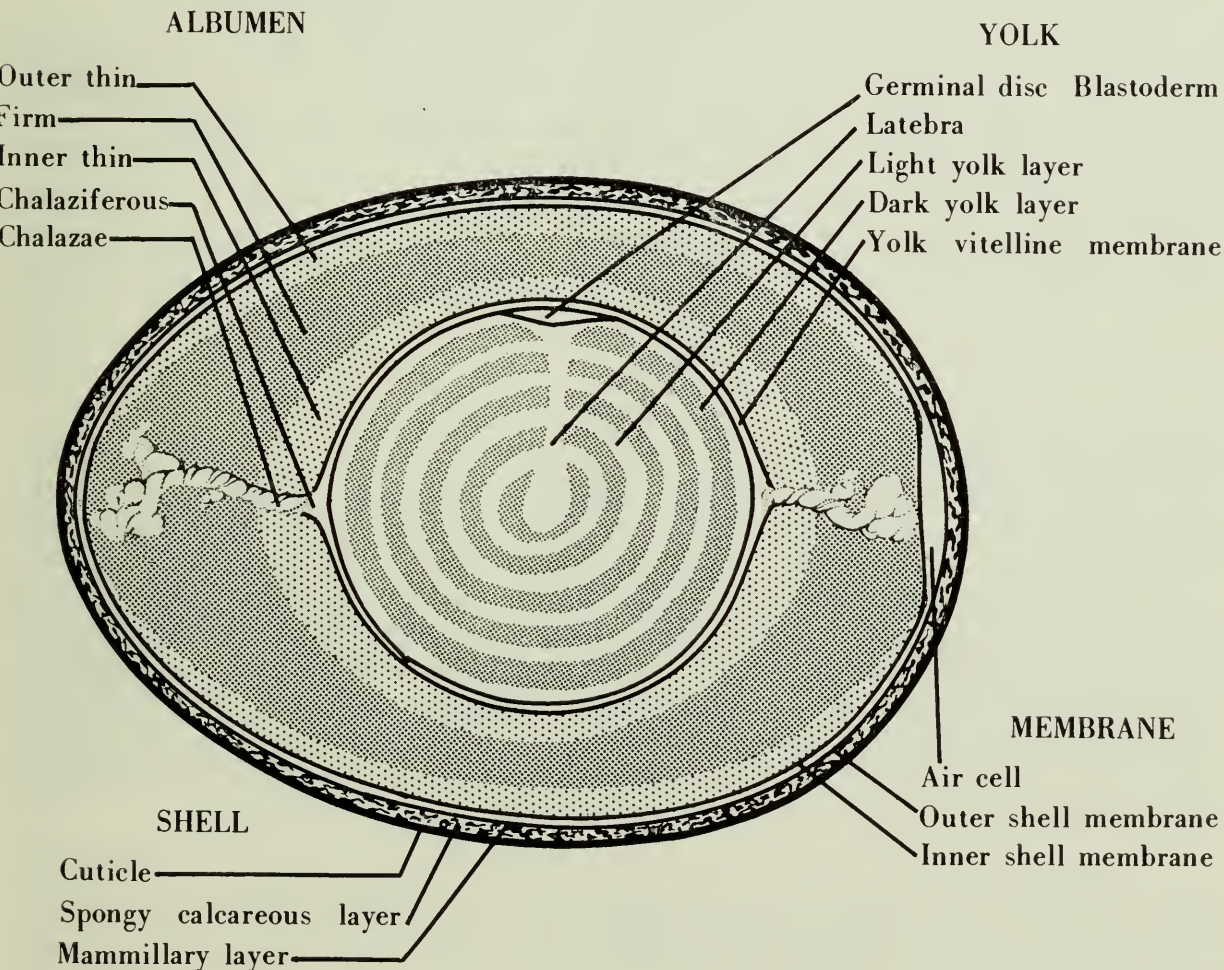


FIG. 4. Structure of the egg.

shipment of baby chicks, without food, to distant points by rail, and even to Europe and other continents by air. It is not surprising, therefore, that avian eggs have long been prized as a food by man—and many beasts and birds also, when fortunate enough to gain access to them. It is also well to keep in mind that most eggs, when laid, are either sterile, or practically so, and that they are ready-packaged in a shell which not only facilitates handling, but, in addition, affords a considerable degree of protection from outside contamination.

V THE EGG — STRUCTURE AND COMPOSITION

The egg is comprised of five main parts, namely: the shell, the two shell membranes, the egg white or albumen, the yolk, and the germinal vesicle, or germ spot. In addition, there is an air space which develops only after the egg has been laid and commences to cool.

The Shell

The shell, with adhering membranes, consists of an organic matrix or meshwork of delicate, interwoven fibres and granules within the interstices of which is laid down a mixture of inorganic salts. In Table 3 are shown the relative amounts, by percentage, of the major mineral compounds (2).

TABLE 3 — RELATIVE AMOUNTS OF MAJOR MINERAL COMPOUNDS IN TOTAL ASH OF CHICKEN, DUCK, AND GEESE EGGS

Species of Bird	Major Minerals		
	Calcium Carbonate	Magnesium Carbonate	Tricalcium Phosphate
	%	%	%
Chicken	98.43	0.84	0.73
Duck	98.60	0.88	0.52
Goose	98.76	0.49	0.75

Parts of the Shell

The shell structure may be divided into four parts, namely: the mammillary layer, the spongy layer, the pores, and the cuticle, or bloom.

The mammillary and spongy layers consist of differently shaped and arranged particles of inorganic mineral compounds, mostly calcium carbonate. The mammillary layer is the innermost part of the shell, consisting of a single stratum of tightly compressed, somewhat conical, knob-like particles closely adhering to the outer surface of the shell membrane, and partly embedded in it. The spongy layer is the outermost and thicker layer, comprising about two-thirds of the total shell thickness.

The pores are minute, rounded openings in the surface of the shell. They vary in size, and are the openings to tiny irregular pore canals through the shell. The canals and pores serve to facilitate gas interchange necessary during incubation.

The cuticle, or bloom, is an extremely thin, transparent, protein layer known as keratin. It covers the outside of the shell and, in a freshly laid egg, closes the pores. The reaction brought about by carbon dioxide ( $\text{CO}_2$ ) escaping from the egg and combining with water vapour in the air serves to gradually dissolve this cuticle, thus allowing for the evaporation of moisture through the pores of the shell when the egg is held or stored.

### **The Shell is Fragile**

The purpose of the shell is to give protection to the microscopic fertilized egg and its surrounding food supply during the period of incubation. It must be strong enough to hold the weight of a setting hen but still fragile enough for the release of a hatching chick.

Egg shells are not constructed to withstand the rough handling to which eggs are so often subjected in commerce. Furthermore, the many pores allow for rapid evaporation and may allow entrance of moulds and spoilage-causing bacteria. This porosity also facilitates absorption of undesirable odours and flavours.

It is for these reasons that eggs should be handled gently, and should at all times be kept clean and handled under sanitary conditions away from musty and other pronounced odours.

### **Shell Membranes**

Both shell membranes consist of two or three layers of a more or less unorganized, interwoven network of organic fibres consisting of keratin and mucin. The fibres are cemented together by an albuminous cementing material to form the two closely adhering, thin, but surprisingly strong, shell membranes that, together, line the inside of the shell and adhere very closely to it. Though not impervious to either gases or micro-organisms, because of the presence of fine pores, the shell membranes serve as a second line of defence against both moulds and bacteria entering the egg. It appears, however, that passage of gases and liquids occurs mainly by osmosis or diffusion (2).

### **The Air Cell**

There is no air cell in an egg at the moment it is laid. The contents completely fill the shell. However, as the egg cools, the contents contract. The slight vacuum thus created serves to draw air in through the porous shell to form an air space between the two shell membranes. While this air space is usually formed at the large end of the egg, because of greater shell porosity at this point, it may sometimes occur at some other point, depending on where the shell membranes separate most easily. Air-cell size increases slowly or rapidly with time, dependent upon the temperature and humidity at which eggs are held, and also upon the thickness and porosity of the shell. Evaporation of egg contents is hastened by high temperature and low humidity.

### **Albumen, or White, of the Egg**

As shown in Figure 4, the albumen consists of four fractions — chalaziferous layer, the inner thin layer, the structural or firm gel-like layer, and the outer thin layer. The albumen is high in water content and rich in protein, and is usually tinted a faint greenish yellow in colour.

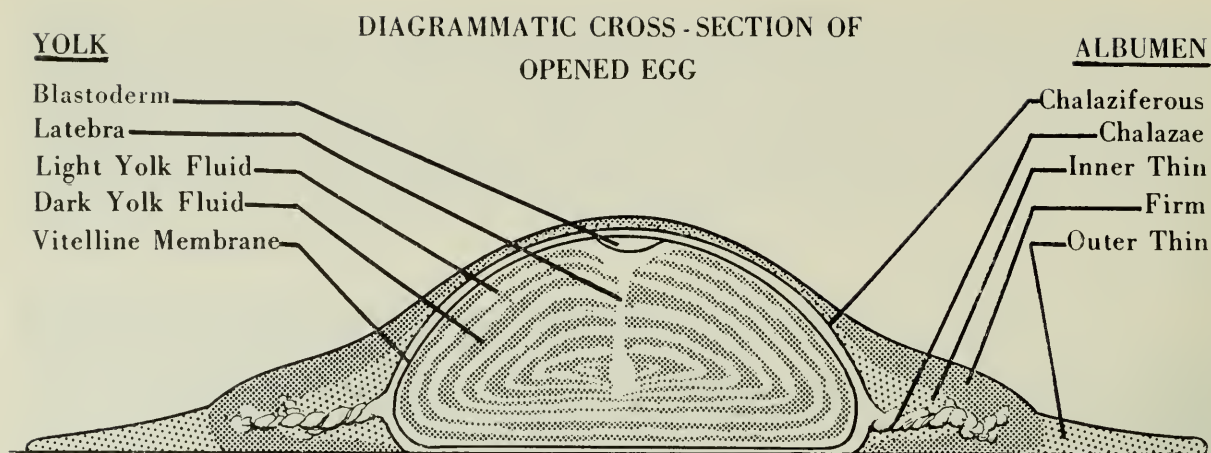


FIG. 5. Diagrammatic cross-section of opened egg. Note the location of the inner white surrounded by firm white; also note that the chalazas are a portion of the egg white.

#### (a) *Chalaziferous layer*

This very thin layer of very thick albumen closely surrounds the yolk, and on opposite sides of the yolk branches into the two chalazas extending out into the thick white. These chalazas lie in the long axis of the egg, serve as anchors to retain the yolk centrally and to prevent its rapid rise towards the shell when the egg is at rest. They have also been reported to be a factor in egg quality retention because of their relatively high lysozyme content, with its antibiotic effect on bacteria. The chalazas are twisted whitish cords, the one at the large end usually having a clockwise twist and that at the small end a counter-clockwise twist (Fig. 4). Uninformed consumers often consider the chalazas objectionable and a factor in causing a dislike for eggs. Actually they can well be considered an indication of high quality.

#### (b) *Inner thin and structural; firm or thick white layer*

The inner thin layer surrounds the chalaziferous layer and is in turn surrounded by the firm white layer, which, in some eggs, adheres to the shell membrane at one or both ends of the egg, and renders such eggs more difficult to break out (Fig. 4). Rupture of this envelope of firm white will allow the inner thin to escape and mix with the outer thin layer of the broken-out egg.

#### (c) *Outer thin layer*

This layer lies just inside the shell membranes, except where the firm layer may be attached at each end. The albumen comprises about 58 per cent of the egg's weight. The chalaziferous, inner, firm, and outer layers comprise approximately 3, 21, 55 and 21 per cent respectively of the albumen.

### The Yolk

The yolk consists of alternate layers of dark- and light-coloured yolk material surrounded by a containing yolk (vitelline) membrane (Fig. 5). Yolk size varies with season and age of the bird (3) and may vary somewhat between breeds and between individual hens. At onset of laying, as many as 3,000 or more small yolks (ova) may be counted on an individual hen's ovary. Development takes place in a few of these at a time in such rotation or rhythm as to produce clutches. Food material carried to the developing ovum by the blood circulation in the follicle permits rapid increase in yolk size from very small to maturity during the last seven to

ten days. The timing and growth of these ova are regulated by an intricate system of endocrine glands in the hen's body which supply the necessary hormones to activate the whole process. The amount and intensity of the light supply to which the hen is exposed is also an important factor.

### The Germ Spot (blastodisc or blastoderm)

The germ spot, or blastodisc (blastoderm if fertilized), present in every egg, lies on the upper surface of the yolk just beneath the vitelline membrane, and at the apex of the latebra (Figs. 4 and 5). This is the point at which, in a fertile egg, the embryo commences its development when such egg is subjected to incubation temperatures (68°F. or above). In a freshly laid or properly stored egg, the germ spot is inconspicuous and shows no enlargement or development.

## VI HOW IS AN EGG PRODUCED?

Production of an egg is the function of the hen's reproductive system, which consists of an ovary and oviduct (Fig. 6).

Each egg starts as a single specialized cell (ovum) deeply imbedded in the ovarian tissue of the ovary, which appears as a cluster of these tiny ova. Each ovum is contained in a thin *vitelline* membrane and it, in turn, in a highly vascular coating known as the *follicle*. As the ovum or yolk increases in size through rapid cell division and addition of yolk material, it is suspended in its follicle, which remains attached to the ovary by a slender follicle stalk. When fully mature, the ovum is released through rupture of the follicle in a sparsely vascularized area (the stigma) and is directed to, and engulfed by, the upper end of the oviduct (infundibulum).

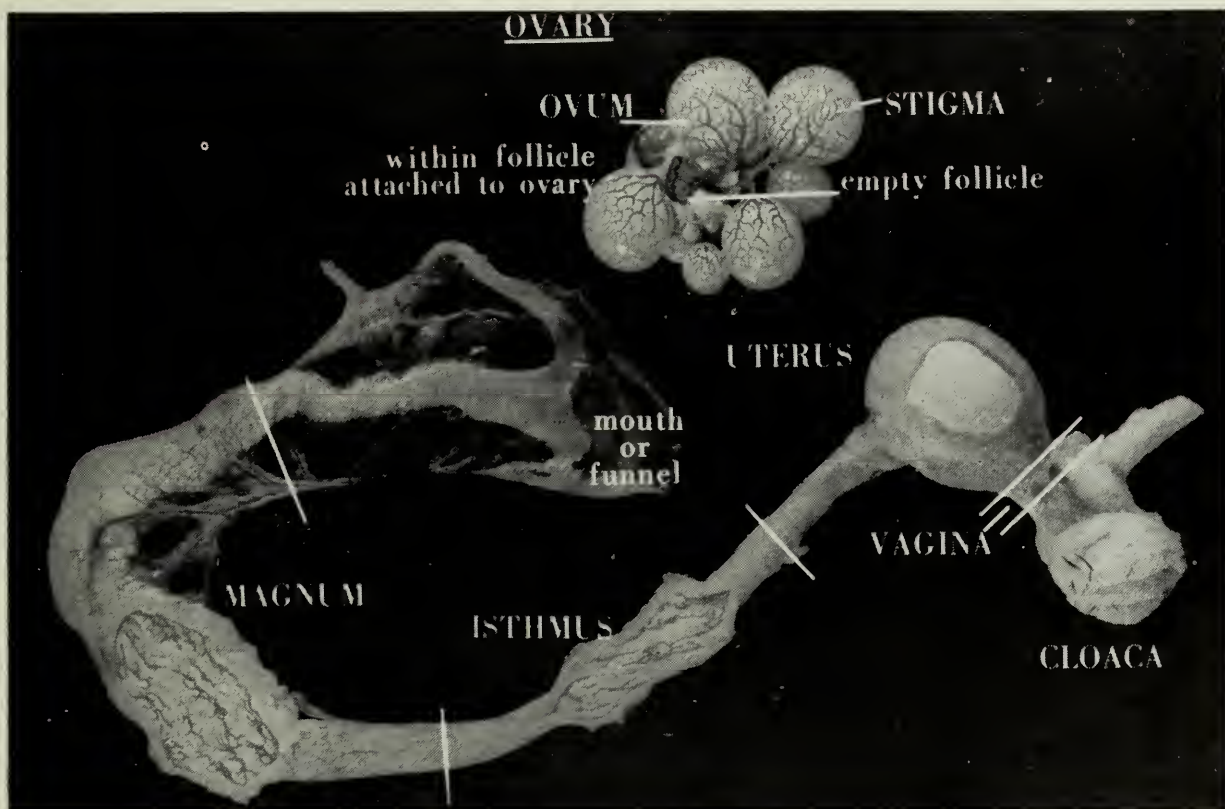


FIG. 6. Reproductive system.

The funnel (infundibulum) receives the mature ovum as it is released from the follicle through a rupture along the unevasculated stigma. Specialized glandular structures in each section of the oviduct secrete the albumen, shell membranes, and shell in turn as the "egg" is propelled along its length to completion.

In the oviduct, through which the developing egg is carried by peristaltic action, specialized glandular structures in each section serve to secrete the several remaining parts — chalaziferous and some thin white in the magnum, shell membranes in the isthmus, and shell in the posterior part of the uterus. Interesting features are the determination of the egg's shape in the isthmus and the secretion of much of the thin white following formation of the shell membranes. This albumen is absorbed through these membranes by osmotic action and this serves to completely plump the egg prior to development of the shell.

As also illustrated, the glands of the oviduct are so placed (somewhat like the rifling in a gun barrel) as to rotate the "egg" while passing down its length. This rotary movement is a factor in producing the chalazas and in causing the one chalaza to be coiled clockwise and the other counter-clockwise.

Both the ovary and oviduct receive a generous blood supply while birds are in laying condition; this supply furnishes the material from which these organs secrete and form all the various parts of the egg.

The time interval between the ovulation or freeing of a yolk from the ovary and the laying of the completed egg varies from about 23 hours to as much as 30 hours. Table 4 lists the time spent by the yolk and its accruing additions in the various parts of the oviduct.

TABLE 4 — SECRETION OF ALBUMEN (EGG WHITE)

Section of Oviduct	Approx. Length in Centimetres	% Albumen Secreted	Approx. Time Spent by Yolk
Mouth .....	5.0	.....	.....
Funnel .....	4.0	.....	18 mins.
Magnum .....	33.0	40-50%	2 hrs., 54 mins.
Isthmus .....	10.0	10%	1 hr., 14 mins.
Uterus .....	12.0	40-50%	20 hrs., 40 mins.
Vagina .....	12.0	.....	.....

Data of Warren and Scott, 1935.

Asmundson and Burmester, 1935.

It may be of interest to note that most eggs (variously reported as from 70 to 90 per cent) are laid caudal or small end foremost.

## VII QUALITY IN EGGS — What Is It?

Quality in eggs may be viewed from several angles, as for example: chemical composition, hatchability, nutritive value, physical composition, functional properties—such as cooking, baking, and whipping behaviour—and grade.

### Chemical Composition

In Table 5 is shown the chemical composition as reported by each of two investigators. While such tabulations are influenced by method of procedure and are, at best, averages of many single observations, they do indicate, within a fairly narrow margin, the egg's gross chemical composition.

It is not considered within the scope of this publication to go into detail as to the exact known kind and amount of the several amino acids, fatty acids, minerals, and vitamins.

TABLE 5 — COMPOSITION OF AN EGG

	The White		The Yolk		Combined White and Yolk		Whole Egg	
	%		%		%		%	
Water .....	87.8*	87.9**	49.0*	48.7**	73.7*	73.6**	65.5*	65.6**
Protein .....	10.0	10.6	16.7	16.6	13.4	12.8	11.9	12.1
Fat .....	0.05	0.9	31.6	32.6	10.5	11.8	9.3	10.5
Ash .....	0.8	0.6	1.5	1.1	1.0	0.8	0.9	10.9
Carbohydrate .....	0.5	1.0	....	trace	0.3	1.0	....	0.9
Shell .....	....	....	....	....	....	....	11.2	....

\* R. V. Boucher, Penn. State Univ.  
\*\* L. E. Dawson, Mich. State Univ.

Though the chemical composition of eggs does not vary widely, certain variations do occur, chiefly in mineral and vitamin content and, to perhaps a lesser degree, in protein content.

As an example, it has been shown recently that the amount of protein in egg albumen declines with advancing bird age. Furthermore, bird age was found to have a highly significant effect on the variation of phosphorus, chlorine, and protein present in egg white—calcium content being affected to a lesser degree. Bird age had no effect on the sodium and potassium content (3). Season, these investigators found, has a highly significant effect on the variation of sodium, calcium, and chlorine in egg white, but has little or no effect on the potassium, phosphorus, and protein content.

Hatchability

Hatchability varies chiefly with regard to vitamin and mineral content and shell quality.

Nutritional Value

Nutritional value of eggs varies mostly in regard to vitamin content. Logically, a good hatching egg is of the best nutritional value. Vitamin and trace mineral content can be most influenced by the hen's diet. Therefore, hatching rations are well fortified in these respects. Diets for commercial egg production are usually less well fortified because of the additional cost factor. Present knowledge offers little, if any, conclusive evidence indicating significant loss of nutritional value in eggs with age—within the range of quality included in the official Canadian egg grades offered for sale on the retail market.

Physical Composition

In the following table is shown the percentage of the several parts of the egg as reported by Brooks and Taylor (4).

TABLE 6 — PHYSICAL COMPOSITION OF HENS' EGGS

	Percentage of Egg		Percentage of Contents	
	Mean*	Range*	Mean*	Range*
	%	%	%	%
Shell .....	11.0	8.7—13.9		
Edible contents .....	89.0	86.1—91.3		
Albumen .....	57.1	47.8—63.7	63.9	54.4—69.8
Yolk .....	31.9	27.6—40.0	36.1	31.8—45.6

\* 8 Independent reports.

A

B

C

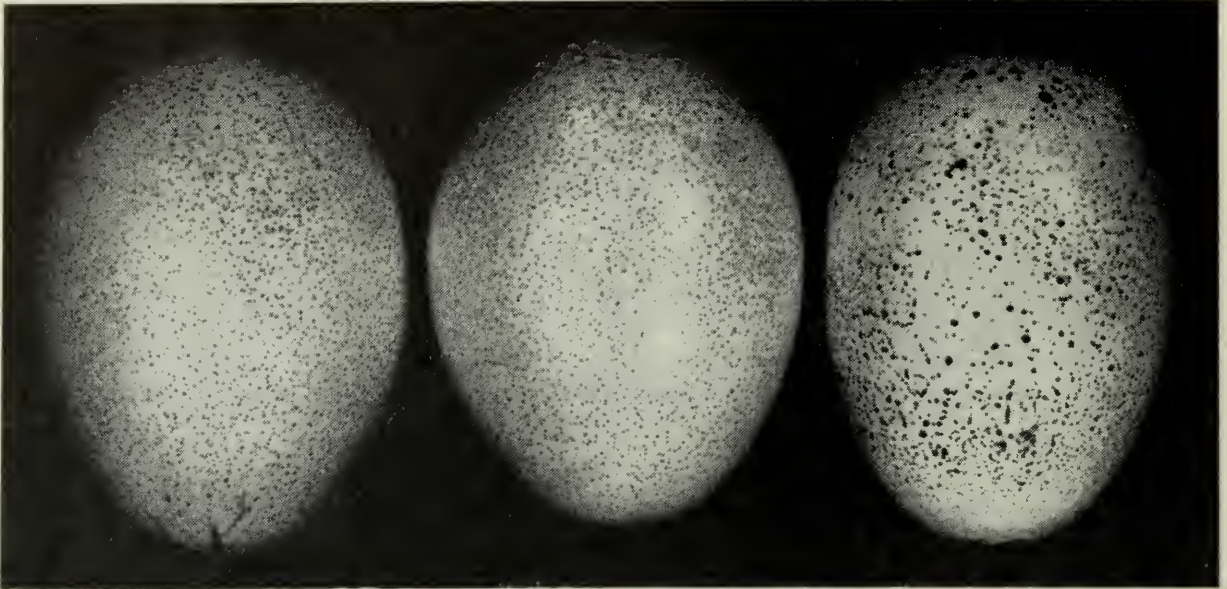


FIG. 7. Two strong, dense shells (a and b) and a weaker, more porous shell (c). After removal of the shell membranes by scraping, the shells were filled with dye. Penetration by the dye rendered the pores plainly visible. The larger pores and more open structure of the weaker shell allowed the dye to work through more readily. An average shell has from 6,000 to 8,000 pores. The pores tend to be larger and more numerous at the large end of eggs—the normal location of air cells. Evaporation is greater through weak and porous shells than through strong dense shells.

Yolk size and amount of albumen have been shown to vary somewhat with season and with age of layer. However, the relative proportions per egg are not influenced by the seasons of the year but, as birds advance in age, the percentage of yolk per egg is increased (3).

The percentage of thick and thin albumen in eggs varies with individual birds, freshness, holding temperature, and holding time, and is therefore often considered to be an indication of quality. The higher quality eggs contain 55 per cent or more of thick white—the less thick white, the poorer the quality is considered to be.

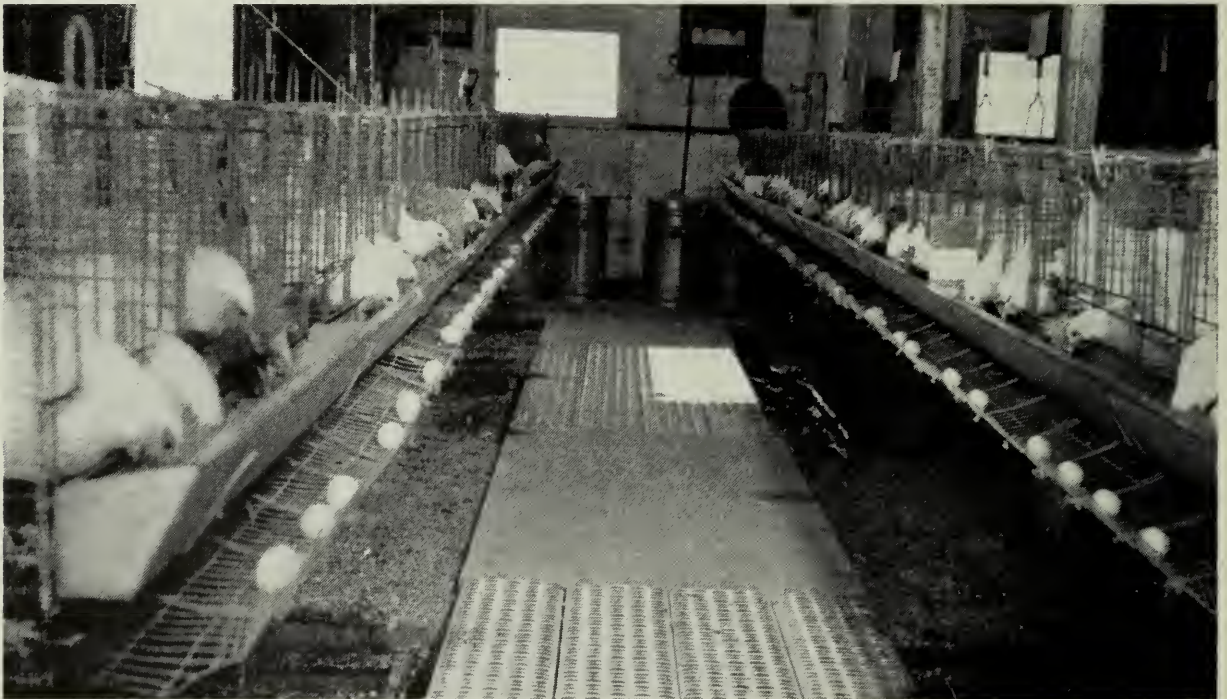


FIG. 8A. Cage-housed layers. Cage floors must be kept dusted and clean to prevent dust and wire marks.

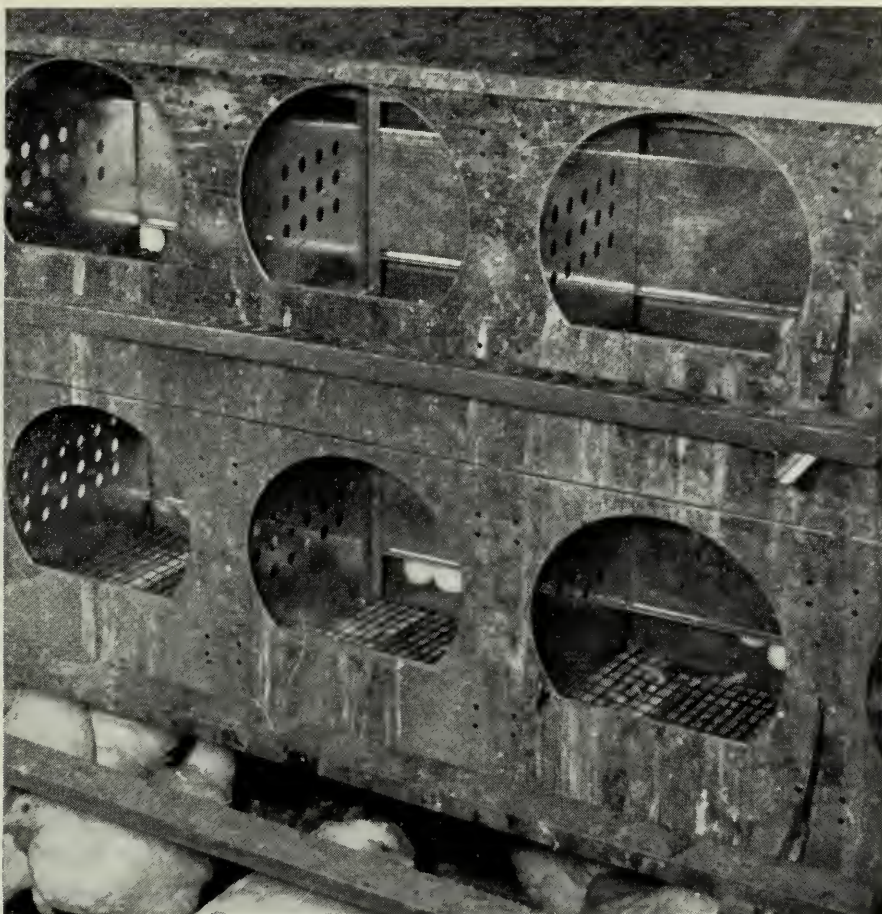


FIG. 8B. Roll-away nests. The eggs are not sat upon and kept heated by succeeding layers.



FIG. 8C. Mechanical egg gatherer serving two rows of roll-away nests. Belts must be kept clean. Egg quality deteriorates noticeably in eggs left too long on belt in a warm house.



FIG. 9. High quality eggs are compact and attractive when poached. (Grades A1 and A)

### Cooking, Baking, and Whipping Properties

Certain cooking results vary with quality, as illustrated in Figures 9, 10, and 11. The leavening properties of egg yolk are measured by means of baking tests, as with sponge cake; and of egg white, as with angel cake. In this, the most important factor is cake volume, but other criteria are tenderness, texture, moisture, flavour, and appearance.

Whipping tests may also be made. By this means the speed and time required to produce maximum foam volume is determined, as well as foam stability and its specific gravity—important factors in the use of egg products.



FIG. 10. Medium quality eggs spread out more when poached. (Grade B)



FIG. 11. Low quality eggs are not suitable for poaching or for frying. The white spreads and tends to disintegrate. The yolk separates out. (Grade C)

The value of egg yolk as an emulsifying agent is well known. Egg yolk that produces a mayonnaise mixture showing the least separation of liquid from solids is considered of highest quality.

It should also be stated that eggs and egg products may vary somewhat in their functional properties, such as emulsifying and beating qualities, dependent upon method of cleaning, shell treatment (such as oiling), and length of storage. Furthermore, *not all eggs are of the best quality even when freshly laid*. Many factors influence quality, as quality is currently understood — some prior to laying, others in the interval between production and consumption.

## VIII HOW THEN MAY EGG QUALITY BE DEFINED?

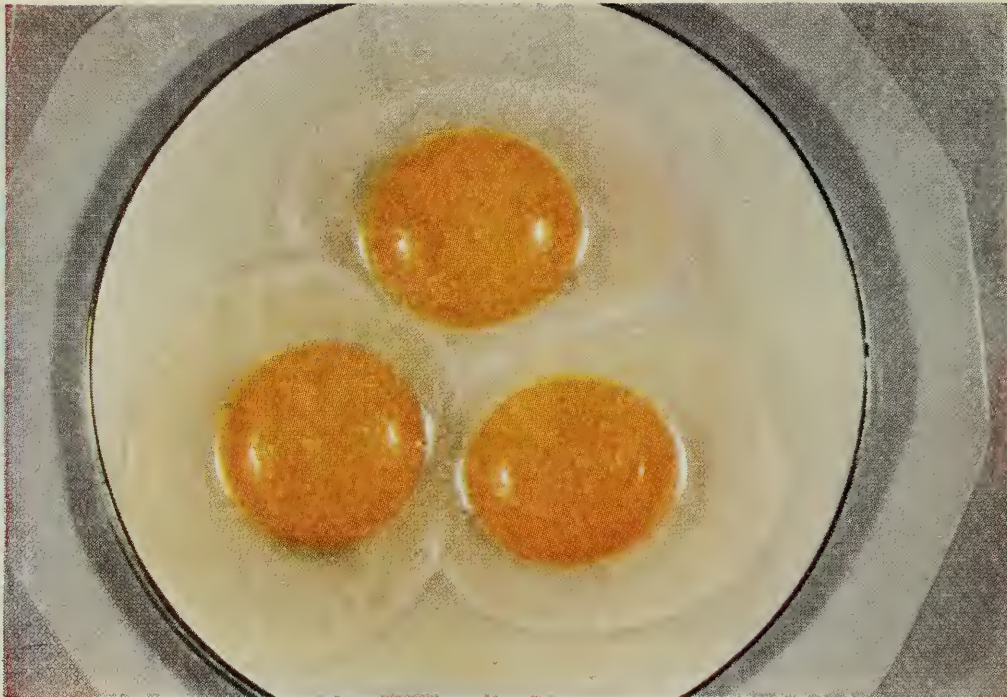
It is those conditions in an egg which:

- (a) make the egg most attractive in appearance to the consumer, both in the shell and broken out, and both raw and cooked;
- (b) produce the best results in cookery practice;
- (c) render the egg of the highest nutritional value;
- (d) give the consumer maximum satisfaction, and thus induce consumer demand and assure a satisfactory market to the producer.

## IX BY WHOM AND HOW IS EGG QUALITY RECOGNIZED?

### By the Producer

Chiefly on the basis of shell quality, egg size, and percentage of top grades, as determined in his own grading operations or at the grading station receiving his eggs. These factors mean dollars and cents to him; therefore, his assessment of quality centres on these points.



**FIG. 12.** Confinement and feeding of an all-mash diet or a controlled mash and grain diet will result in the production of yolks of uniform colour. Any desired shade of colour is made possible by controlling the quality and amount of grass and clover meal, alfalfa leaf meal, and yellow corn products included in the diet.



**FIG. 13.** Excessive green feed or other pigment-carrying material included in the diet will result in deep yellow, orange, reddish orange or even green-coloured yolks, dependent upon the kind and amount of such material consumed.



**FIG. 14.** One day's eggs from a pen of layers: the result of uncontrolled feeding combined with access to rape in an outside run. Such eggs lack uniformity and eye appeal.



**FIG. 15.** The Fletcher Colour Scale—for measuring egg yolk colour. This scale is comprised of 15 concave, coloured aluminum discs with handles. The 15 standard colour graduations range from light yellow No. 1 to deep orange No. 15.



FIG. 16. Identifying the exact shade of yolk colour by use of the numbered Fletcher colour rings.

### By Grading Station Operators and Egg Dealers

On the basis of shell cleanliness, quality, and colour; on *uniformity* of high interior quality; and on *ability to retain this high quality*. Why? Because it is more time-consuming and costly to handle and grade eggs of poor or indifferent and non-uniform quality. Also, such eggs retain quality less well through the marketing channels and, furthermore, cause more retailer and consumer complaints—even when expertly graded and well handled. Retailers desire satisfied repeater customers.

### By the Housewife

Her judgement, and that of consumers in general, is based largely on an egg's appearance, odour, and performance. She wants a clean egg with a sound shell. Dirty eggs repel her. Some housewives prefer white-, others brown-shelled, eggs, for reasons each considers sound. It is the housewife that sees the egg first, when broken out. Quality to her involves an attractive over-all appearance, including yolk colour, condition of albumen, and freedom from, what is to her, any abnormal appearance. She is also influenced by odour, and certainly by the way eggs perform in her cookery practices—how they poach, fry, whip, and peel when hard-cooked.

### By Grading

Commercially, egg quality is determined through the operation of grading. This is the method universally used in Canada since 1921, and the basis on which Canadian eggs are both bought and sold, according to Canadian standards.

BROKEN OUT APPEARANCE OF EGGS OF  
CANADIAN GRADES

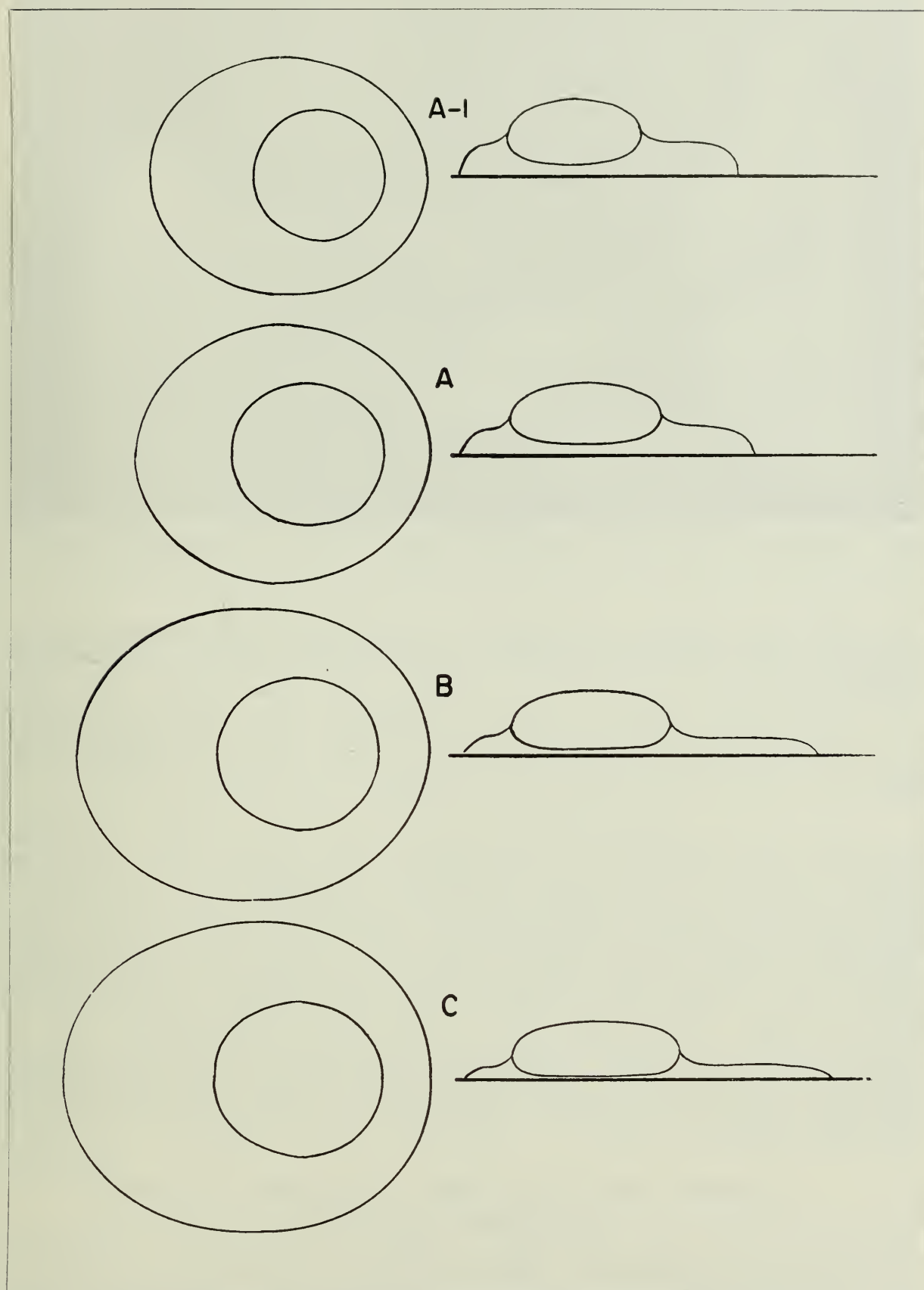


FIG. 17. Variation in thick white according to grade. Drawn from average measurements of a group of eggs of each grade as candled by a member of the Federal Egg Inspection Service.



FIG. 18. A satisfactory poultry farm arrangement for candling, weighing, and packing eggs—whether in crates or cartons.

Exterior quality is determined by handling and observing each egg for shell soundness and cleanliness, while interior quality is ascertained by candling.

Egg size is determined by the feel of each egg in the grader's hand or, more accurately, by use of some type of egg-weighing machine (Fig. 18).

The type of candling lamp used, as well as the eyesight, alertness, experience, and judgement of the operator, are all important factors in efficient grading. To overcome this factor of human error, and also to lower costs involved in individual hand candling, considerable effort has been made during recent years to develop electronically operated weighing and mass candling devices. These efforts are meeting with considerable success. New equipment of this type has been installed in some of the larger grading stations, especially in the heavy egg-producing areas of Ontario, Quebec, and Nova Scotia. However, further refinements are still required and best results are achieved only with eggs from fairly large flocks and where flock breeding, feeding, health, and management are of the highest order.

## **X REASONS FOR CONSUMER PURCHASE OF EGGS BY GRADE AND SIZE**

It is the best means by which to be assured of quality and economy.

- (a) The grade and size most suitable for the purpose desired may be purchased.

- (b) Economy is easily possible, with little if any appreciable sacrifice of food value, by use of the lower, less expensive grades for cooking, baking, and food mixes. The more expensive grades are desirable for egg-nogs, poaching, and other uses where top quality only is satisfactory.
- (c) At certain seasons, the market price of eggs of Grade A Large size is out of line with that of the smaller sizes of Grade A. Intelligent buying is therefore economical. Also, *these smaller sizes are of equally excellent quality and are more economical for use with young children.*

## XI BASES ON WHICH CANADIAN EGGS ARE GRADED

**The Size Factor**—Extra large, large, medium, small, and peewee sizes in Grade A—in other grades as shown in Table 7.

**The Shell Factor**—This includes shell cleanliness and quality. Eggs with an amount of stain and/or soiling, those of abnormal shape, and those with ridged, rough, or thin shells are faulted according to degree of blemish.

**Interior Quality Factor**—Determined by candling, which involves the rotation of each egg either before a candling lamp or over a brightly lighted track or area to reveal the position, movement, size, shape, and prominence of yolk shadow, the size of air space, and condition of albumen, also any germ development and abnormalities such as blood and meat spots.

Every producer and consumer should be familiar with Canadian egg grades and their requirements, and should sell and purchase respectively on a graded basis only. Grading protects both producer and consumer, and helps build confidence, mutual respect, and goodwill in merchandising.

Shown on page 28 are the grades and standards as of 1961. They are subject to change, but are included for reference (5).

## XII MODERN TRENDS IN GRADING

It must be understood that the eggs from healthy, well-bred flocks of layers that receive a proper diet and are well and intelligently managed will be, with few exceptions, of superior quality when gathered. The chief qualifying factor in this situation is the age of bird.

It is true that some eggs may have soiled shells. These can and must be cleaned. A few will have cracked shells. These must be separated out. Other than this, and the occasional presence of a few blood and meat spots, eggs from such flocks require little if any individual candling. Their uniformity of quality renders individual candling expensive and uneconomical.

The recent rapid increase in the number of such flocks in Ontario and in some other parts of Canada, coupled with the increasing size of such flocks in some areas, is seriously testing the economy of the ordinary type of egg-grading station and has opened the way for the introduction and use of a more modern mass candling method.

TABLE 7 — GRADES AND STANDARDS FOR CANADIAN SHELL EGGS

	Grade A1	Grade A	Grade B	Grade C	Grade Crack
The shell is	(1) clean (2) normal in shape and free from rough areas or ridges (3) sound in construction	(1) may have up to three stain spots if each spot does not exceed an area equivalent to $\frac{1}{8}$ " by $1\frac{1}{16}$ " and is otherwise clean (2) practically normal in shape but may have rough areas and ridges other than heavy ridges (3) sound in construction	(1) may show spots of dirt if the aggregate area of dirt does not exceed $1\frac{1}{16}$ square inches and stain spots if aggregate area of the stain does not exceed $\frac{1}{2}$ square inch (2) may be slightly abnormal in shape and may have rough areas and definite ridges (3) sound in construction	(1) free of cracks	(1) cracked but the internal contents are not leaking
The egg weighs	Extra Large Size = $2\frac{1}{4}$ oz. Large Size = + 2 oz. Medium Size = $1\frac{3}{4}$ - 2 oz. Small Size = $1\frac{1}{2}$ - $1\frac{3}{4}$ oz.	Extra Large Size = + $2\frac{1}{4}$ oz. Large Size = + 2 oz. Medium Size = $1\frac{3}{4}$ - 2 oz. Small Size = $1\frac{1}{2}$ - $1\frac{3}{4}$ oz. Peewee Size = less than $1\frac{1}{2}$ oz.	At least $1\frac{3}{4}$ oz.		
On candling shows	(1) an indistinct yolk shadow (2) a small round yolk which maintains its position in the central part of the egg (3) absence of mottled or grass yolks, visible germ spots, meat spots, blood spots or any congealed albumen (4) an air cell that is not in excess of $\frac{1}{8}$ " in depth and is immobile	(1) an indistinct yolk outline (2) a round yolk which is reasonably well centred (3) absence of mottled or grass yolks, germ development, meat spots, blood spots, or any congealed albumen (4) an air cell that is not floating and is not in excess of $3\frac{1}{16}$ " in depth	(1) may show a distinct yolk outline (2) may show a yolk which is moderately oblong in shape and which floats freely within the egg when twirled (3) absence of grass yolks, meat spots, blood spots or any congealed albumen, but may have very slight degree of germ development (4) an air cell that is not in excess of $\frac{3}{8}$ " in depth	(1) may show a prominent yolk outline (2) may show a yolk which is definitely oblong in shape but which does not adhere to the shell membrane (3) does not show meat or blood spots in excess of $\frac{1}{8}$ " in diameter and shows absence of dark grass yolks	(1) the egg meets standards for at least Canada Grade C.



FIG. 19. Mass candling. The eggs are lifted from the crates by vacuum, 30 at a time, and released on the six-rowed grading "belt".

In addition to a mass candler (Fig. 20), such a system includes: vacuum cup handling (Fig. 19), electronic sizing (Fig. 21), carton set-up and positioning, and cartoning (Fig. 22). A travelling belt delivers the cartoned eggs through a carton closer to a revolving packing table (Fig. 23). Tray-packing facilities are included and oil-spraying and carton-sealing equipment may also be added (Fig. 23). An accurate electronic bloodspot detector is now available to be inserted in the line. Such equipment is uneconomical for use with small flock production. The production of flocks with a minimum size of 800 to 1,000 or more layers is required. The eggs from smaller flocks must be individually candled by hand (Fig. 24). Currently both methods are used in the same stations. Several types of mass candlers are now in successful use and further improvements can be expected—including such as will make possible economical mass candling of even relatively poor quality eggs.

These newer stations have ample refrigeration and modern, efficient equipment for loading and handling eggs in volume. Being specially constructed for the purpose, they are roomy and more easily kept clean. Moreover, such stations can fit well into a break-out system for weekly farm egg quality tests of their supply flocks (Fig. 25A).

A necessary factor in the operation of grading stations of this type is an experienced field man. It is his responsibility to regularly check the health and management of all egg supply flocks, and assure enough of the right type of flocks to supply the 3,000 or more cases of eggs needed weekly per individual machine unit, and to keep such plants in efficient single or

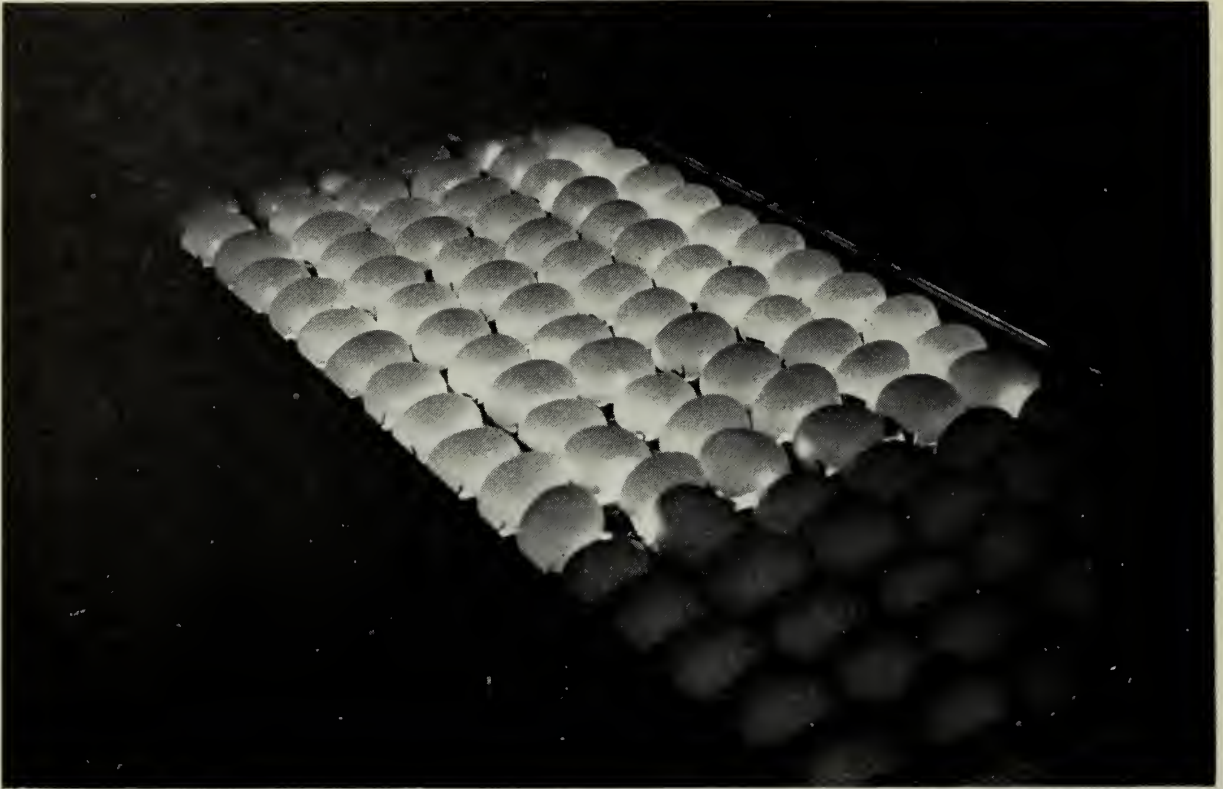


FIG. 20. Flash candling. Eggs passing over the brightly lighted candling area employed in one type of mass candler. As they pass, the eggs are automatically rotated several times, thus enabling detection and removal of undergrades.



FIG. 21. Electronically operated in-line egg weighing.

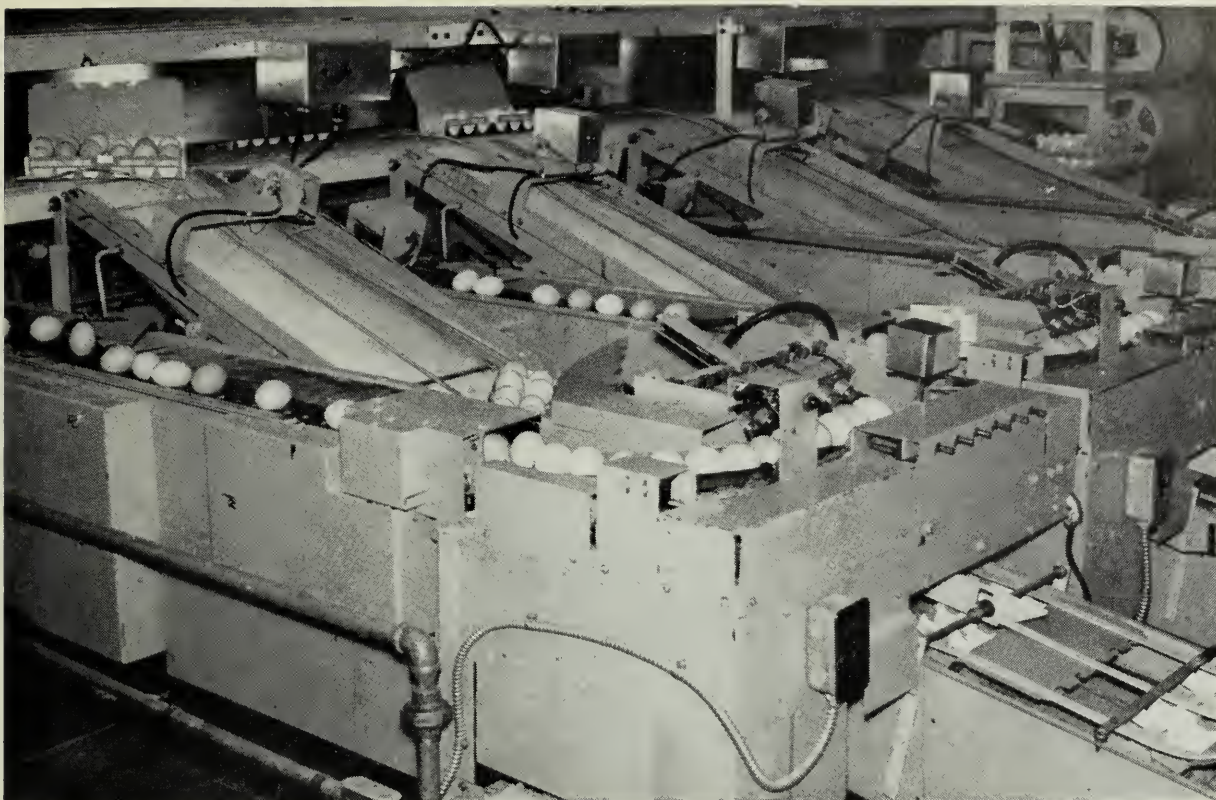


FIG. 22. Electronically operated equipment for cartoning four sizes of eggs simultaneously. Eggs from the size (Fig. 21) are aligned and carried to a vacuum-operated carton filler and deposited, 6 eggs at a time, into mechanically delivered cartons. The filled cartons are then carried up past a counter and safety gate to a delivery belt, which conveys the cartons to a closer and packing table.

double shift operation as required. Well-insulated trucks travel regular routes to bring in supplies. Twice per week pick-ups per farm are increasingly the rule, and refrigerated storage of eggs on the farm is encouraged. By this system, any slip in quality of the eggs from any flock can be immediately detected, investigated and, where possible, rectified. Eggs from flocks failing to meet the necessary quality and uniformity standards to qualify for grading by this method must either be separately hand graded or the flocks rejected.

It would appear that such a programme fits well into the rapidly developing large-volume, uniform-quality requirements of modern chain store merchandising. Moreover, it may be the logical alternative to the large corporation-type egg farms of 100,000 hens or more.

The eggs involved are still graded on, paid for, and sold on the basis of grade. However, the egg's quality is not based solely on its candled grade. It is based, to a much greater degree than has been customary, on the flock size, age, and condition, and on the care received by the eggs on their accelerated way to market. Thus much of the emphasis is on the flock and its care, rather than on the individual egg.

Changing conditions do not necessarily mean elimination of the smaller side-line farm flocks. It is to be hoped that many of these flocks will continue to be a source of revenue to farm families. It may, and probably does, mean that to continue at a profitable level, such flocks will either be increased in size or be used mainly to supply the family table with poultry products. There will also, no doubt, always continue to be a

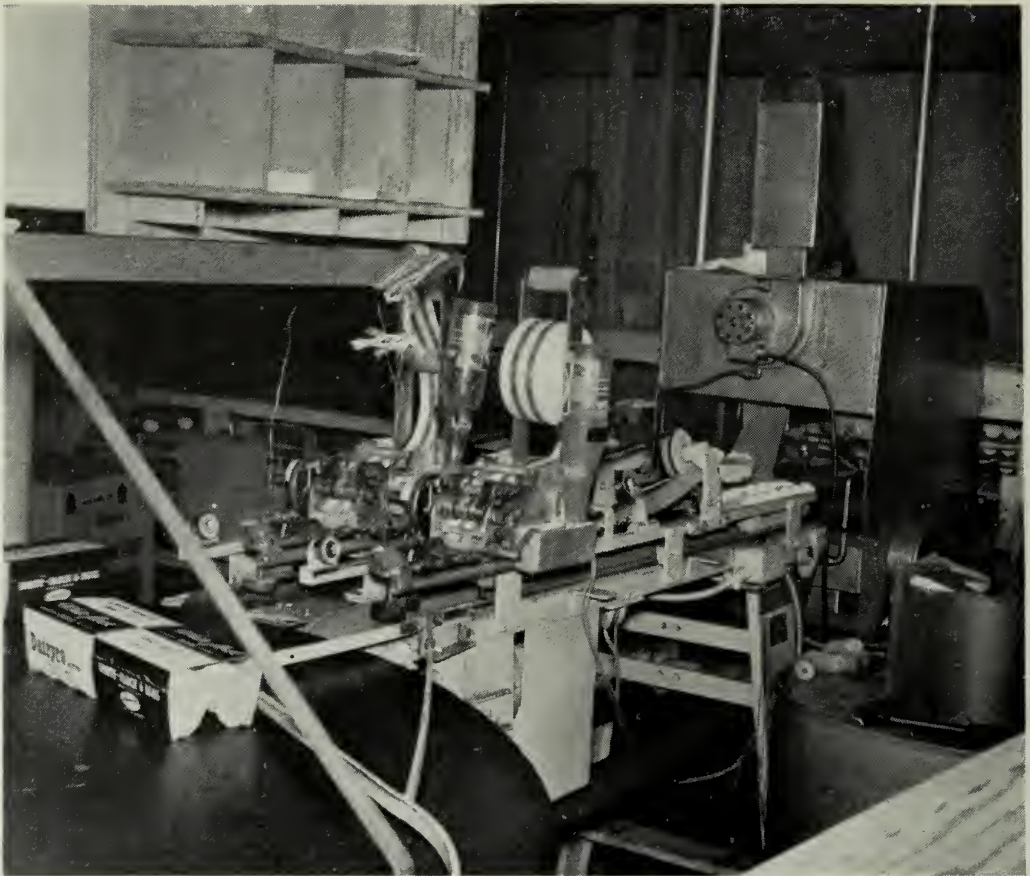


FIG. 23. An automatic closer closes the cartons, which are then tape-sealed and dated prior to delivery to a rotating, circular packing table. Equipment for oil spraying the cartoned eggs prior to closing is shown on the right.



FIG. 24. Grading station hand candling. Grading machine is fitted with automatic counters. Cartoning for belt delivery is done in lighted area on far side of partition.

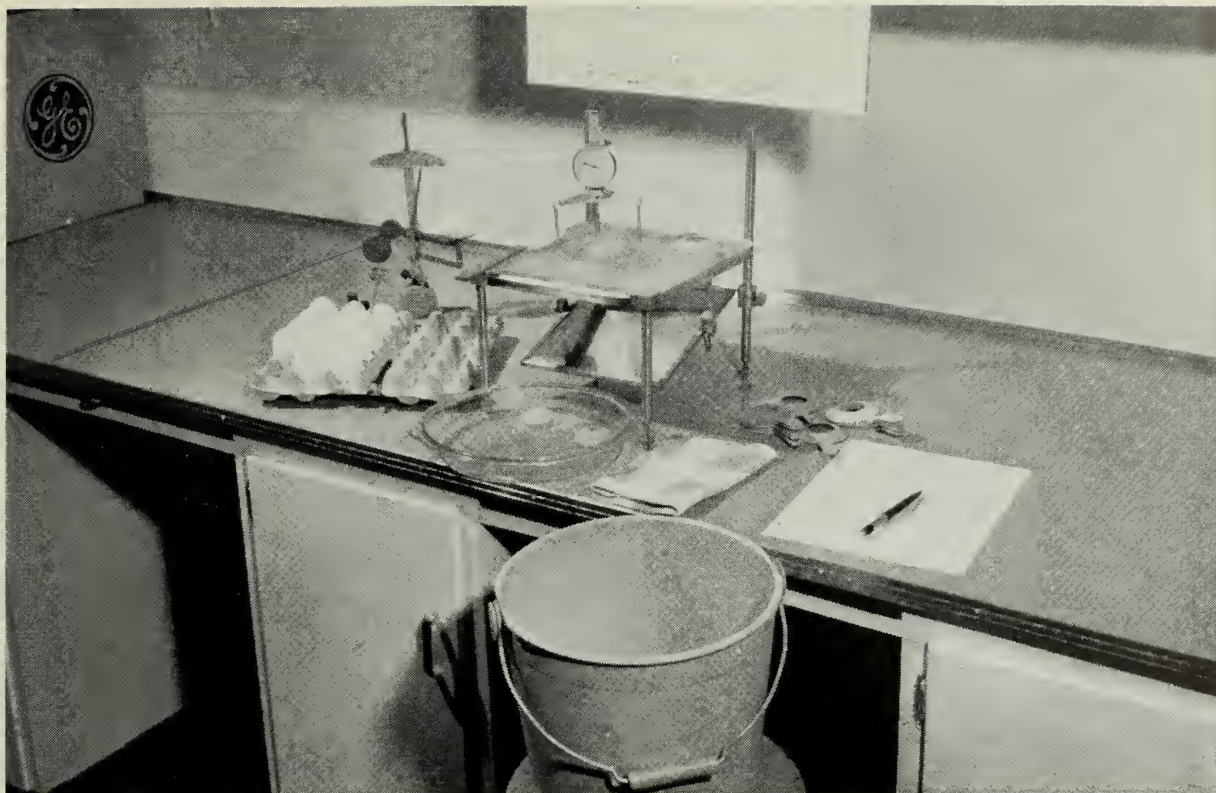


FIG. 25A. Equipment required for determining egg quality on a break-out basis. Scales, inside egg temperature thermometer, break-out table, micrometer, Haugh Unit conversion chart, record forms, and receptacles for eggs and shells. Yolk colour discs are optional.

direct retail market for many such eggs. The relatively small side-line farm flock owner with his low overhead can, by using the same methods as his larger-flock competitor, produce equally fine quality eggs at a competitive price. Also, by more frequent delivery direct to the grading station or through retail sale, he can continue to be a very important factor in the Canadian egg industry.

### XIII OTHER CRITERIA OF EGG QUALITY

#### Yolk Colour

The yolk colour of eggs has proved to be an important factor in conditioning consumer acceptance. For yolk colour comparisons in research, and for poultry feed manufacturers, an accurate yolk colour standard can be a very useful tool. Such a standard in the form of concave disks painted in a graduated colour series has recently been introduced. This standard was developed by paint specialists of the National Research Council staff, Ottawa, Canada, with direction from research specialist D. A. Fletcher of the Poultry Division of the Canada Department of Agriculture. The "Fletcher Yolk Colour Standard" (Fig. 15) replaces a somewhat more elaborate American-produced "Colour Rotor", now apparently unavailable.

#### Haugh Unit Value or Score

This is a relatively new but much-used method of determining egg quality. It is a value that represents the height of albumen, with correction made for the egg weight, by means of a formula devised by a research

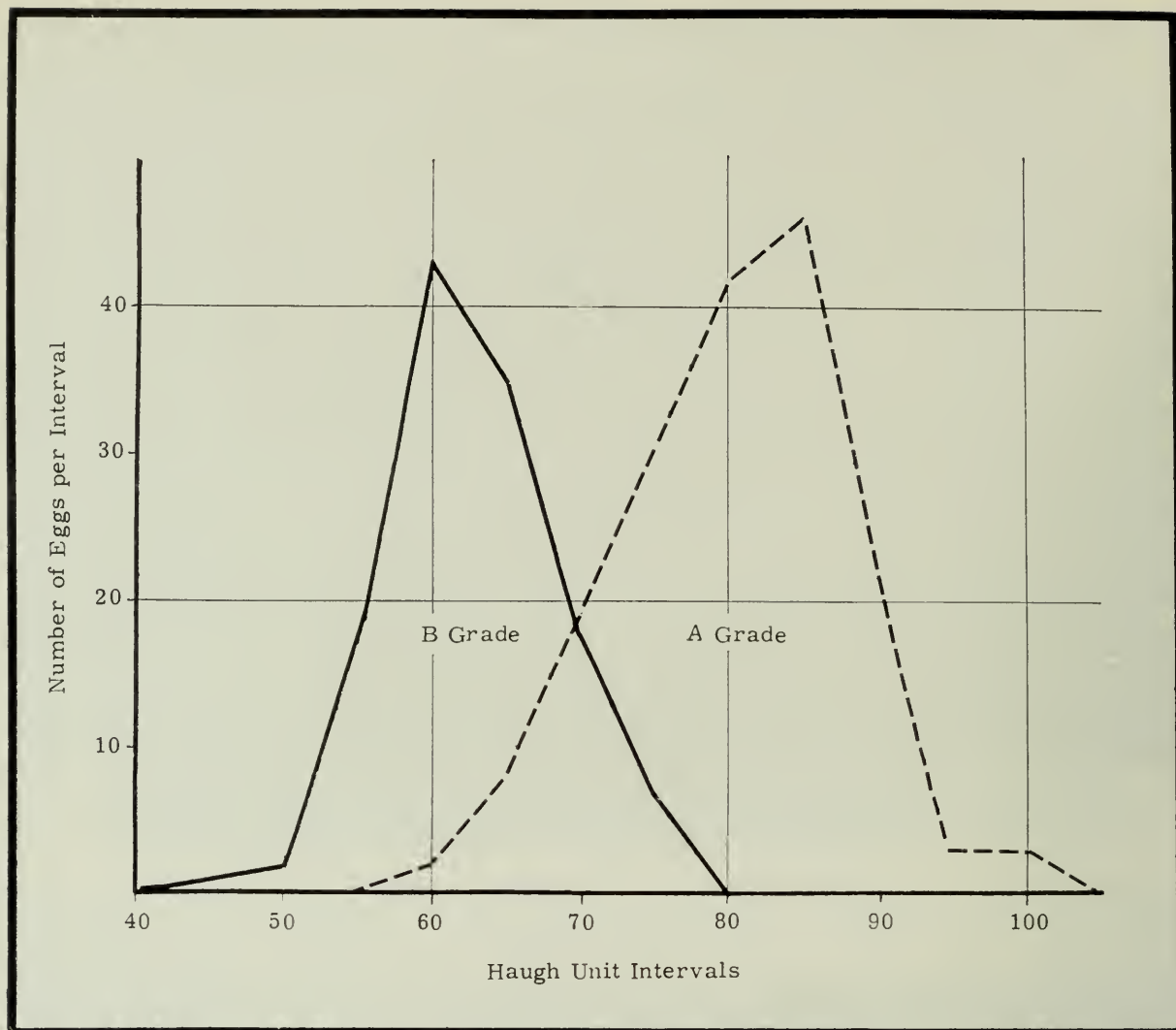


CHART 1. Relation of Grade to Broken-out Quality.

While the average quality of Grade A and Grade B eggs will usually vary by 20 to 30 units, there is always some overlapping at the dividing point.

worker named Haugh (6). An egg to be tested is first weighed on fine balances either in grams (28.35 grams in an ounce) or to the nearest ounces per dozen weight. It is then broken out on a smooth, level surface and the albumen height measured, away from the chalazas, at a point about midway between the inner and outer edges of the thick white. This is done by means of a micrometer graduated in millimetres and mounted on a tripod (Fig. 25B). Conversion tables have been worked out for both gram and ounce per dozen weights, by use of which albumen height and egg weight value relationship may readily be converted to a Haugh unit value or score.

Recognized by research workers as a standard for quality measurement, this method has come into further prominence through its use in the recently introduced American "Fresh Fancy" controlled-egg-quality programme. Haugh unit values range from 0 to 110. In O.A.C. studies of the relationship of these values with present Canadian egg grades, it has been found that values up to about 40 H.U. represent Grade C; from 40 H.U. to about 66 H.U., Grade B; and values above 66 H.U., Grade A quality eggs (Chart 1). Further studies now under way will serve to determine the place of such a weekly, random sample breakout test per flock in any contemplated Canadian controlled-quality programme.

GRADE AS RELATED TO HAUGH UNIT SCORE

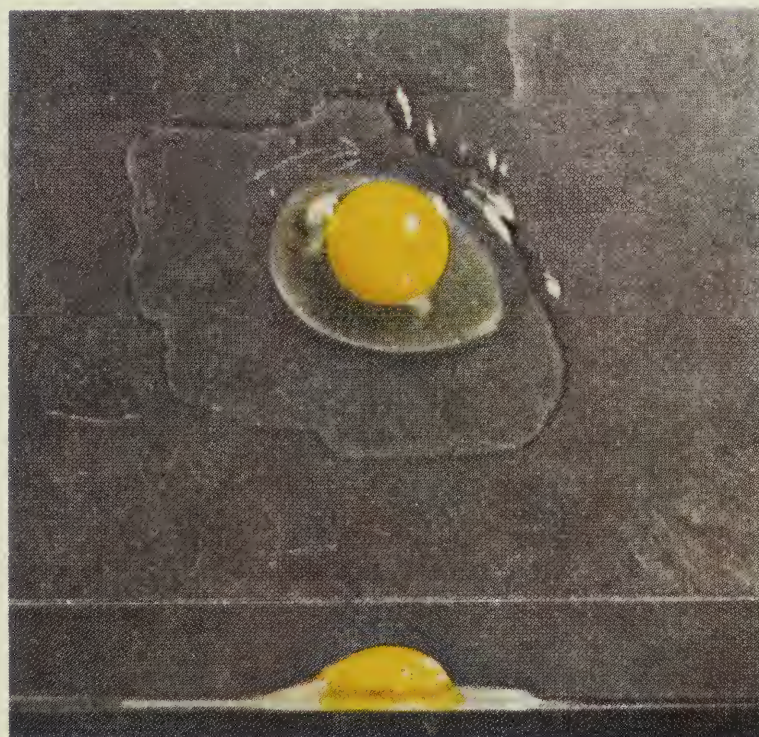
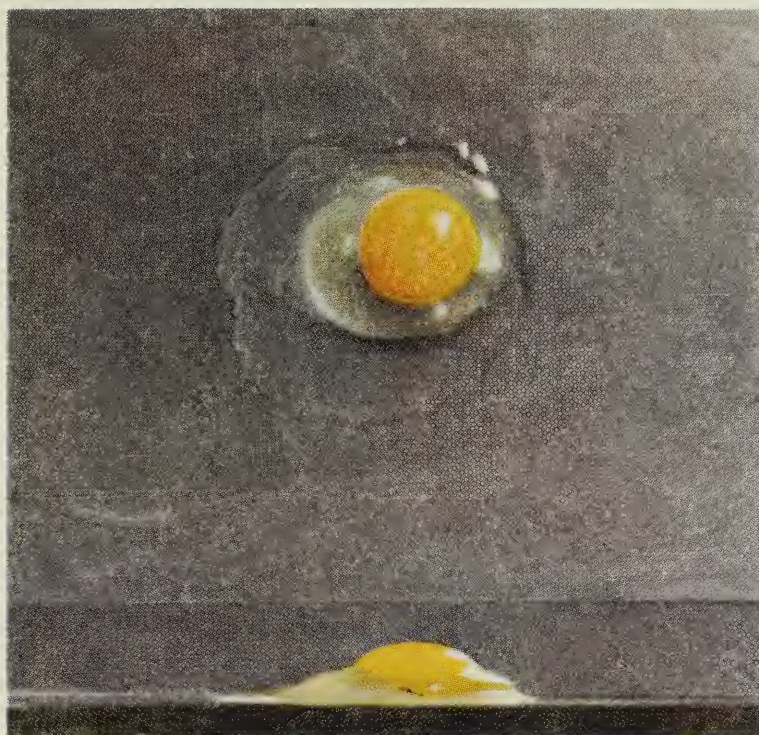


FIG. 26. (a) A top-quality egg (97 Haugh Unit score). Note the height and curve of the yolk and the small diameter of the thick white. There is little thin white and the yolk is well centred.  
(b) A high Grade A egg (76 Haugh Unit score). Good height and curve of yolk; good height and condition of thick white.

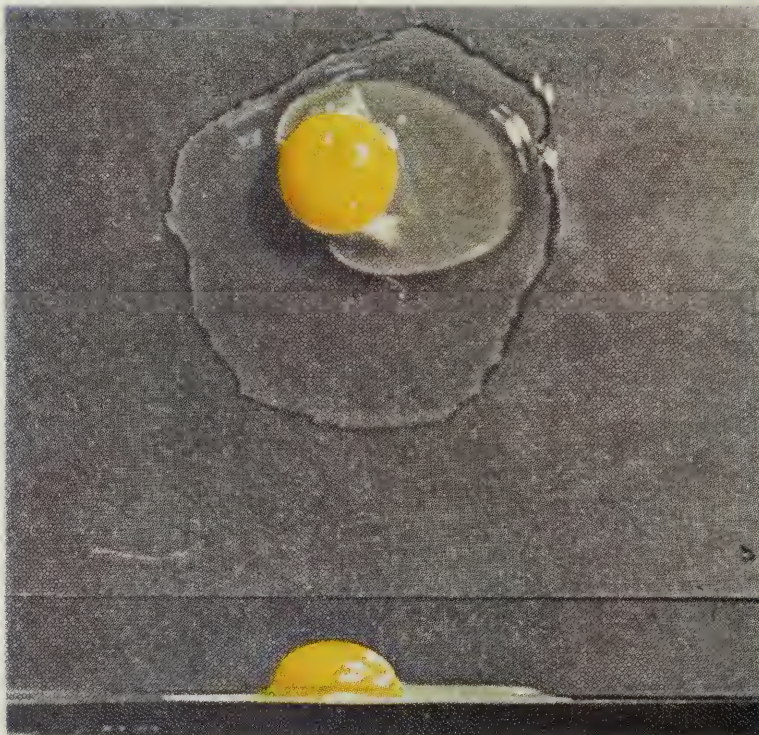
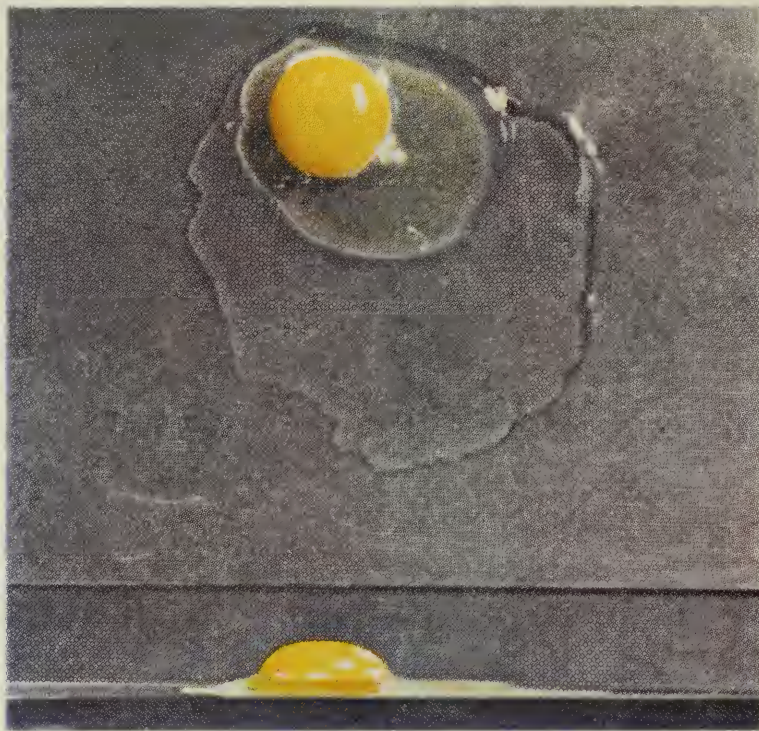


FIG. 27. (a) A medium Grade A egg (72 Haugh Unit score). Yolk is flattening and white more spreading.  
(b) A high Grade B or low Grade A egg (65 Haugh Unit score). Note the increased spread of both thick and thin white.

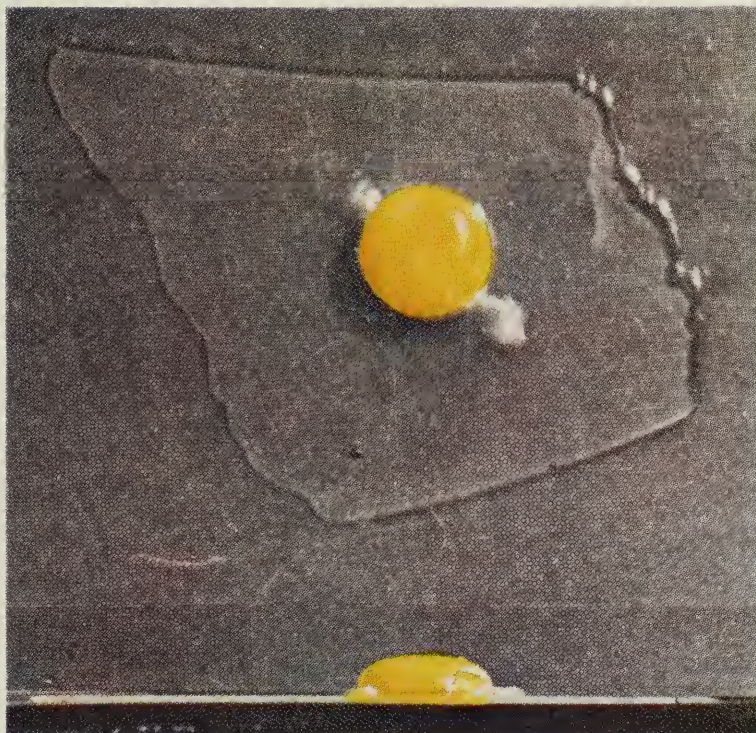
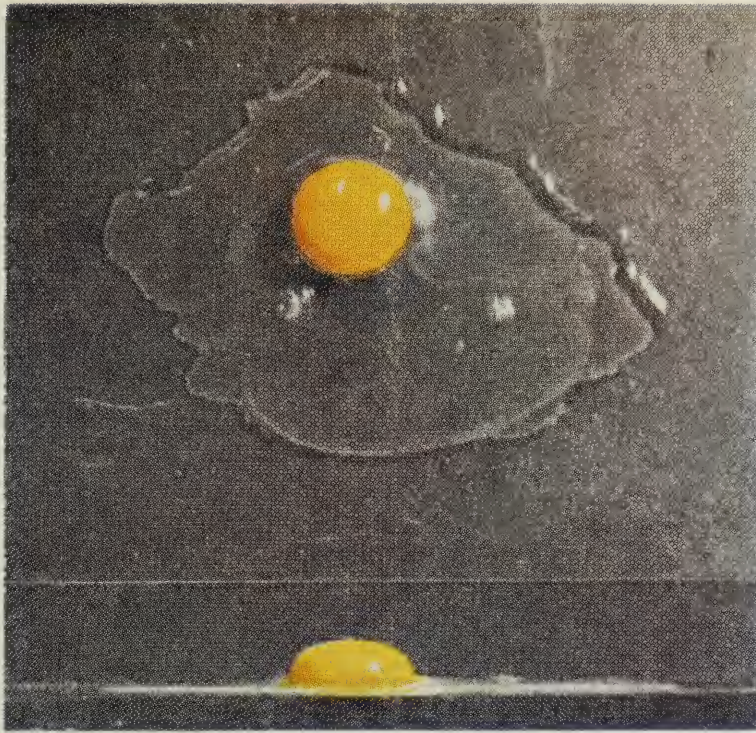


FIG. 28. (a) A Grade C egg (46 Haugh Unit score). Note particularly the condition of the thick and thin white. A good cooking egg, but of poor quality for poaching, frying, or similar uses. (b) A low Grade C egg (30 Haugh Unit score). An egg that once may have been of high quality. There is no thick white, the yolk membrane ruptures easily—the result of faulty management and holding conditions.

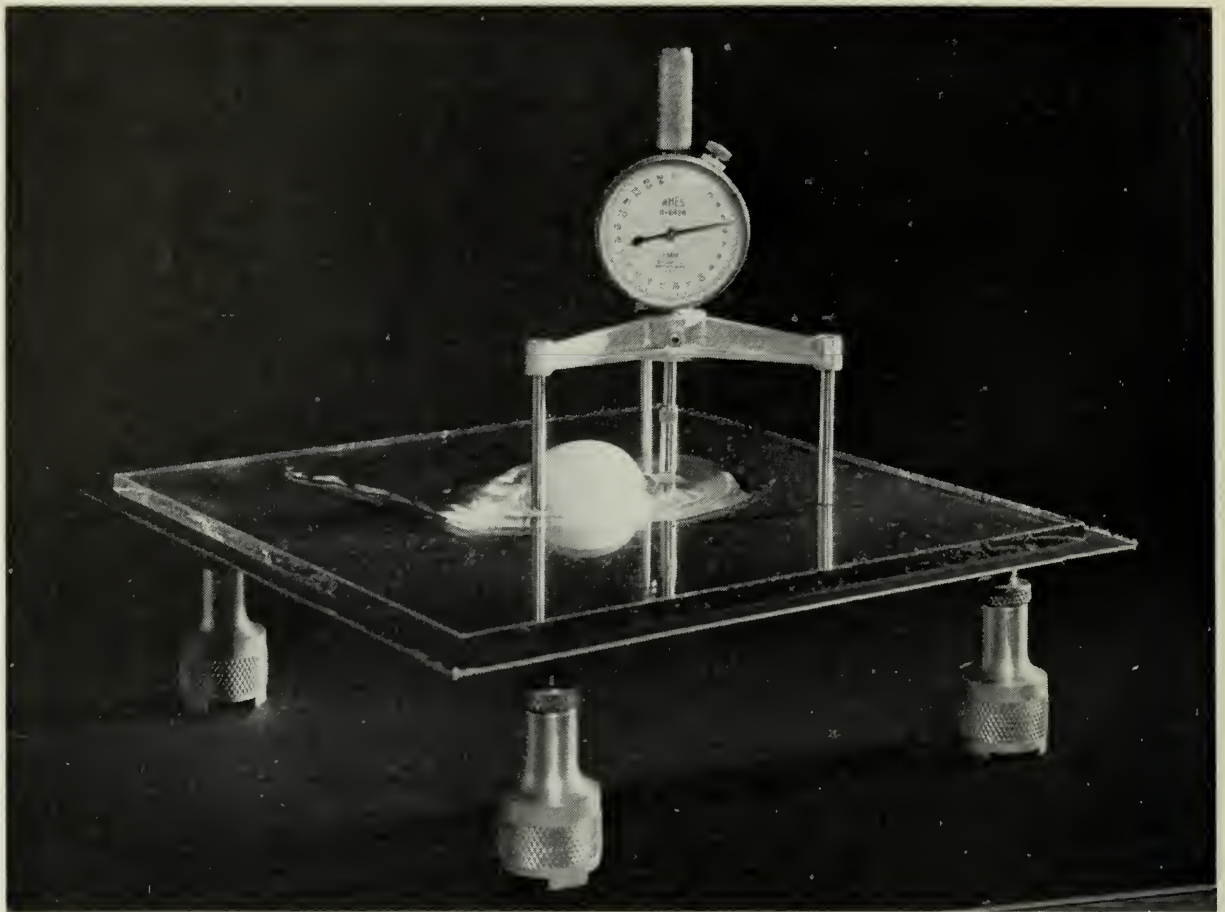
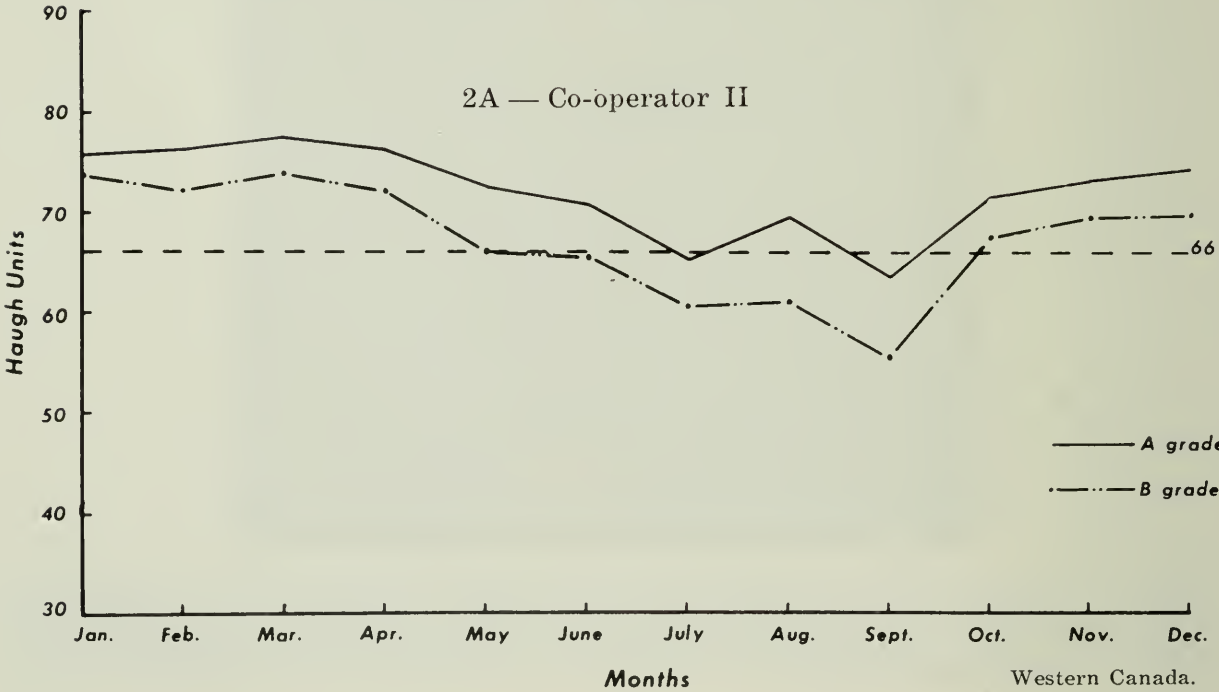
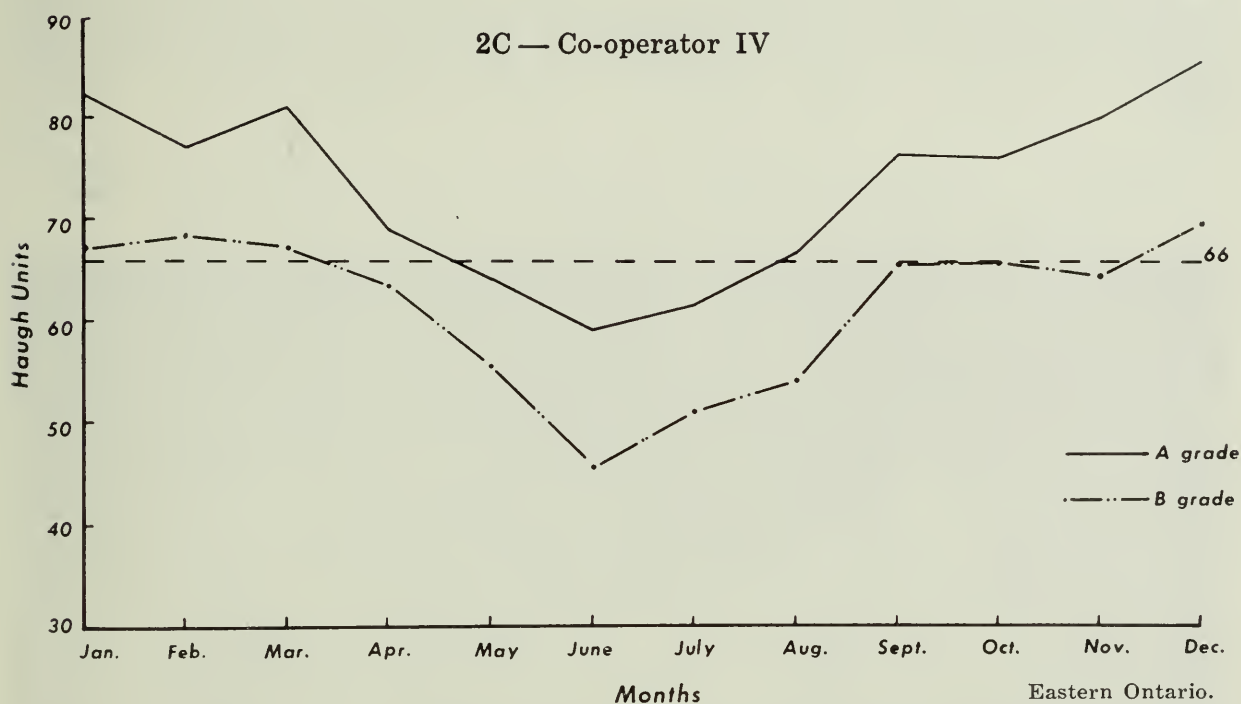
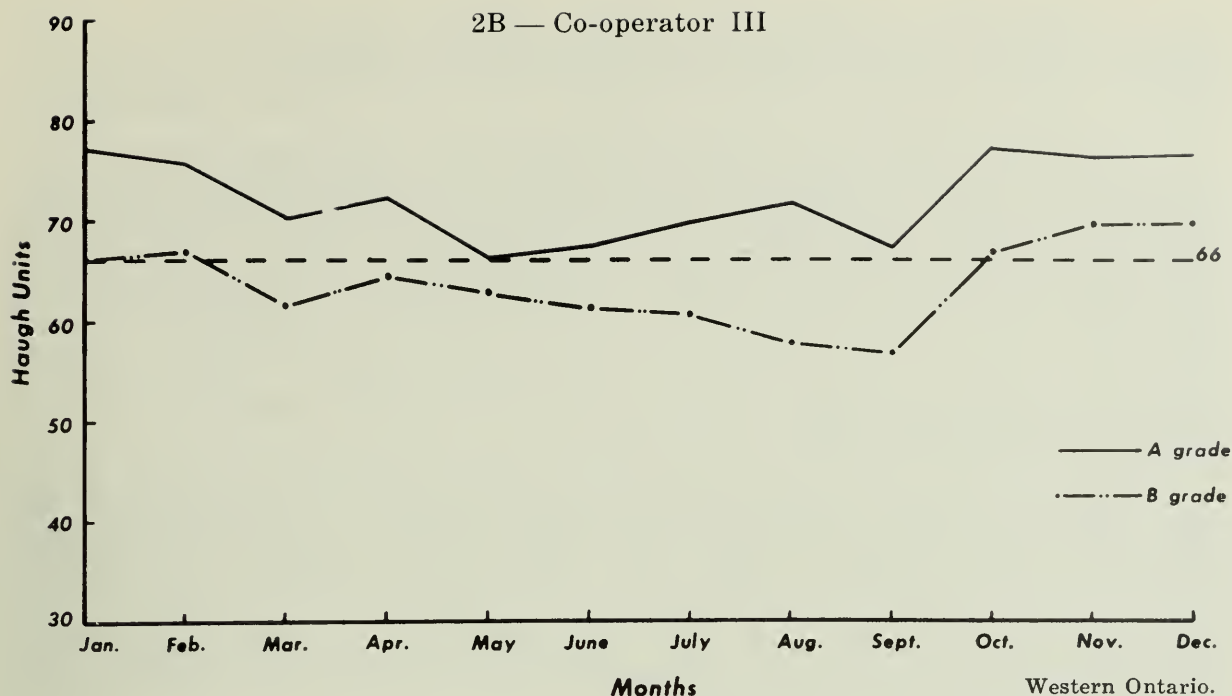


FIG. 25B. Measuring albumen height by means of a tripod mounted Ames Micrometer.

CHART 2 — RELATIONSHIP BETWEEN CANDLED GRADE AND HAUGH  
UNIT VALUE IN CANADIAN EGGS

average of 3 stations (2 graders each) per co-operator





From the above charted data, it may be deduced that the quality dividing point between Grades A and B occurs at about 66 Haugh Units. Charted data for Co-operators I and V are not here included.

#### XIV

#### STUDIES OF GRADING ACCURACY

In 1956-57, the accuracy of grading eggs for quality as practised in Canada was studied by breaking out five dozen Grade A and five dozen Grade B eggs each month over a period of 12 months, from each of two graders at each of three grading stations in each of five areas across Canada, and determining their Haugh Unit values. It was found in all

areas studied that, on the average, the graders were well able to distinguish between the two qualities of egg grades, as indicated by the correlation found between grade and Haugh Unit value (Chart 2 a, b, and c).

As shown in Charts 2a, 2b and 2c, it is evident that the grading standards as applied in practice are flexible; otherwise the lines representing the two grades would be straight lines. Graders adjust, whether consciously or unconsciously, to the factors of distance from market, seasonal differences, and the general quality of eggs available. In consequence, as indicated in these charts, the actual quality of eggs, as measured in Haugh Unit value, varied considerably over a period of time in the two grades studied. In spite of this, all graders still succeeded in separating the better from the poorer eggs (6A).

The accuracy of using a weekly random sample breakout test of the eggs from each flock, as compared with the grades of the complete flock production, was studied in 1960 (7). This study included one grading station in each of four Ontario areas; it involved 14 to 15 flocks at each station and was continued for a period of 20 weeks, commencing in early July and ending in November. One station employed hand candling; the other three, machine mass candling.

In Table 8 is shown, by stations, a summary of the over-all grades of 314,185 dozen eggs marketed from these four groups of flocks during this period; also, the average Haugh Unit values per station of the flock samples drawn from each week's eggs. These samples comprised 13,347 eggs.

TABLE 8—AVERAGE FLOCK\* GRADINGS OF EGGS MARKETED, AND  
AVERAGE HAUGH UNIT VALUES OF WEEKLY SAMPLINGS  
AT FOUR ONTARIO GRADING STATIONS  
(TWENTY WEEKS, JULY TO NOVEMBER, 1960)

	Grade A %	Grade B %	Grade C %	Cracks %	Rejects %	Haugh† Units
Station 1**	89.07	3.12	1.90	4.86	1.05	71.92
Station 2***	90.62	2.35	6.38****	....	.66	69.34
Station 3*** Young	90.56	2.52	.43	5.71	.77	77.69
Old	89.69	4.76	.59	4.13	.82	68.99
Average	90.29	3.21	.48	5.22	.79	74.05
Station 4***	91.94	2.17	.51	4.05	1.32	77.08

Dept. of Poultry Science, O.A.C., Guelph, 1960.

\* 14 to 15 flocks at each station.  
 \*\* Eggs hand graded.  
 \*\*\* Eggs mass candled.  
 \*\*\*\* Grade C and Cracks not separated.  
 † Average Haugh Unit values of the randomly selected egg samples from each shipment from all test flocks supplying each station during the 20-week test.

While these studies seem to indicate a considerable degree of relationship between Canadian grade standards as properly understood, and actual broken-out quality, there is still room for an improved relationship. Present knowledge indicates that the most likely means of improving this relationship is by a flock control programme.

Eggs are merchandised in several ways

### In the Shell

It is in this form that most eggs leave the farm. Shell eggs are readily handled in trays or baskets during cooling and cleaning, in 15- or 30-dozen-size crates for marketing, and in cartons of suitable size for retailing. All commercial grading is done while eggs are in this form, though increasingly supplemented by random sample breakout tests.

### Broken-out and Frozen

Frozen egg meats, as whole eggs or with the yolks and whites separated, are extensively used, particularly in the baking, ice-cream, candy, noodle, and salad dressing trades. Stored at 0°F. in special standard-sized containers of 10 to 38 pounds net, such egg material keeps for long periods with minimum loss of food value and great saving of space. This broken-out egg material is known in the trade as egg melange.

Eggs used for this purpose are broken out by trained workers or by machine under highly sanitary conditions and expert supervision. They are then mixed or churned into a homogenous product, strained to remove bits of shell and chalazas, packaged, and quickly frozen, preferably in an air blast at -10°F. or lower, to prevent sour cores in the cans. Both whole eggs and separated yolks and whites are prepared in this way. Care is necessary during separation to avoid including with the albumen any yolk material, thus retaining maximum whipping quality. Lengthy churning may also adversely affect albumen whipping quality. Furthermore, churning speed is controlled so that no air is beaten into any of these products.



FIG. 29. Hand breaking eggs for freezing.

Courtesy Midwest Produce Co. Ltd., Winnipeg, Manitoba.

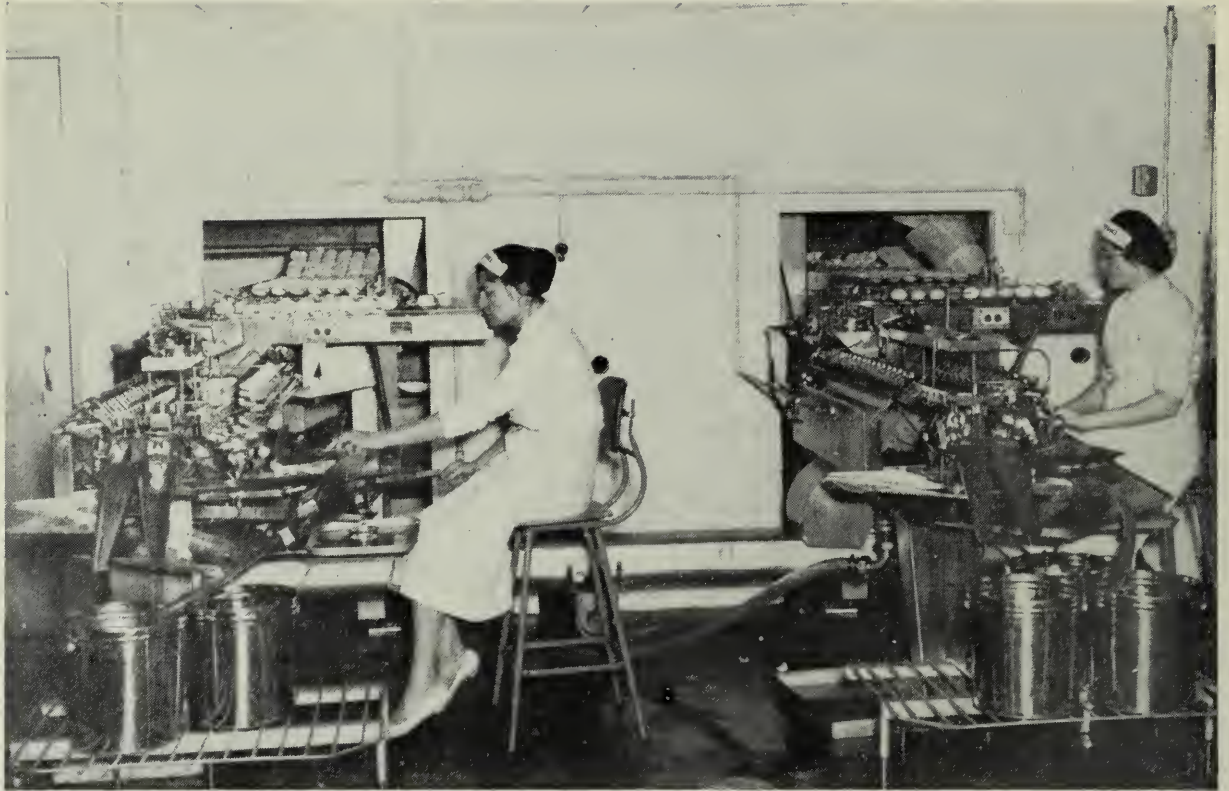


FIG. 30. Machine breaking eggs for freezing.

Courtesy Midwest Produce Co. Ltd., Winnipeg, Manitoba.

Modifications in preparation result in products for special requirements such as adding up to 10 per cent of sugar to egg yolk to improve its texture, or adding 5 to 10 per cent of salt.

In addition to using clean eggs and practising the usual strict sanitation, pasteurization of the product may be employed as an additional safety measure in cases where the presence of *Salmonella* organisms is feared.

While eggs of Grade B and C quality are those most commonly used for breaking-out purposes, the several sizes of Grade A eggs are also used, dependent upon supply and price. This is especially true where frozen egg of the very best quality is required as, for example, in baby foods. Frozen egg may be defrosted and used for drying when and as required. It requires 8 to 12 hours to defrost a 30-pound can in a stream of cold running tap water, after which the melange should be used promptly to prevent bacterial growth. Thorough stirring prior to use is necessary to secure uniform results in the products made from such melange.

Egg-breaking operations for the production of frozen eggs are increasing in Canada, and more uses are continually being found for this quality product. In 1960, approximately 525,870 cases of eggs were used for this purpose. Firms producing this product may now be found from Quebec city, west to Vancouver.

In Canada, all frozen egg is traded on a graded basis, thus assuring quality. In two provinces, registration is now required of all frozen egg operations within the province, and this may become general. Other



FIG. 31. Frozen egg melange is stored at a temperature of  $0^{\circ}$  to  $-5^{\circ}\text{F.}$  until required for delivery to consumers.

Courtesy Midwest Produce Co. Ltd., Winnipeg, Manitoba.

changes are also developing. Hand breaking (Fig. 29) in several plants has been partially or completely replaced by automatic breaking machines (Fig. 30). Also, a few western firms have recently installed pasteurizing equipment for the pasteurizing of all of the products passing through their plants. Since an effective method of pasteurizing whole egg melange is now known (8), this practice is likely to become general.

### Dried Eggs (egg powder, egg solids)

The practice of producing dried egg powder was common in China prior to World War II. Cheap labour and the availability of large quantities of cheap eggs enabled foreign interests to operate in China at a cost that discouraged outside competition. European countries and the United States were the chief markets.

Canada did not enter this field extensively until forced to do so by the shortage of refrigerated shipping space, resulting from ship sinkings by enemy submarines during World War II. Dried eggs keep better and require only about one-seventh of the shipping space necessary for shell eggs. Urgent war-time needs resulted in greatly improved technology and a rapid rise in production. As a result, large quantities of Canadian and American egg powder were produced for use overseas by the British people and the Allied armies. Later, further large shipments went to European countries, as liberated, where the product proved of inestimable value. Since the war, production in Canada has greatly declined, but less so in the United States, where there is still a very sizeable production. Because of its convenience, bakers and other users of frozen eggs would no doubt use more dried egg powder if it were less costly.



FIG. 32. Egg dryer and packaging equipment. The latter includes sifter, delivery tube, and scales.

Courtesy The Borden Company Limited, Winnipeg, Manitoba.

Quality eggs, correct temperatures, and extreme sanitation are essential in the preparation of a first-grade egg powder. Such a product has fine flavour, a low bacterial count, high solubility, and a very low moisture content. By packing it in vapour-proof containers under partial vacuum, and with air replaced by carbon dioxide and nitrogen, the quality can be retained more or less indefinitely. Preparation under proper facilities and according to up-to-date practice results in a minimum loss of food value, and separate drying of whole eggs, albumen, and yolks makes many uses possible. The addition of water or milk to whole egg powder enables one to prepare scrambled eggs, omelets, custards, and numerous other dishes.

Liquid whole egg and yolk are generally dried by a vacuum spray process, quite similar to the drying of milk. Glucose removal from whole egg and white, before drying, improves quality by reducing discoloration and by increasing solubility. Egg white is more difficult to dry; hence, it is dried in shallow pans, stacked in heated chambers until nearly dry, then finished at room temperature prior to being crushed into crystals or ground into powder.

TABLE 9 — DRIED EGG PRODUCTION IN CANADA

Year	Weight
	lb.
1954	940,000
1955	1,122,000
1956	1,061,000
1957	901,000
1958	693,000
1959	1,400,000

Figures supplied by Bureau of Statistics Industry and Merchandising Division.

## XVI EGGS — THEIR PLACE IN THE HUMAN DIET

### They are Important, because a Protective Food

They are rich in well-balanced proteins.

They are rich in vitamins.

They are an important source of essential minerals.

Because of this, eggs, along with milk, cheese, fruits, vegetables, and some red and glandular meats, are classed by nutritionists as *protective foods*. Protective foods are so called because of their ability to balance diets commonly over-rich in starches, sugars, and fats and all too frequently lacking in balanced proteins, minerals, and vitamins.

Well-controlled animal experiments have demonstrated that the liberal use of protective foods will serve to:

- (a) give better support for the mother and a better start in life for the young;
- (b) speed maturity and produce better development;
- (c) produce a high level of adult vigour; and
- (d) extend the average *useful* span of life.

Protective foods are a vital factor in the rearing of Canadians with strong, healthy bodies and alert minds; therefore, their extensive use in the Canadian diet is amply justified. *Eggs are one of the protective foods.*

### Eggs are Rich in High-Quality Proteins

Egg protein is unique in that it contains all of the ten amino acids considered essential for growth and for maintenance of body tissues. It is known, therefore, as a balanced protein which when added to other foods, serves to complement the nutritive value of foods with unbalanced proteins disproportionately. In fact, the quality of egg protein is a standard against which the proteins of other foods are measured.

### Eggs are Rich in Easily Digested Fat

Egg fat is in an emulsified form readily digestible not only by adults but even by children as young as 3 months of age. This is true of few other fats. Egg fat is rich in phosphorus and in essential fatty acids. It is also the carrier of much of the egg's vitamin content.

## **Eggs are a Good Source of Vitamins**

This is particularly true of vitamins A, D, and riboflavin. One group of investigators has stated that "no other animal tissue approaches the egg yolk as a source of vitamin A except liver, which is generally more than twice as rich, weight for weight, as egg yolk" (9). As a natural source of vitamin D egg yolk is second only to fish liver oils. It is also a good source of the growth vitamin riboflavin, which is the only vitamin found in appreciable amount in egg albumen and which, when present, is the source of the slight yellow-green colour of egg albumen. Egg yolk is a fair to good source of several other vitamins and vitamin-like compounds. In fact, eggs contain most of the known vitamins with the notable exception of Vitamin C (10).

## **Eggs are a Valuable Source of Minerals**

The iron content of eggs is relatively high in comparison with other foods and is in a readily available form. Most of the iron is stored in the yolk. Eggs contain some calcium and are a good source of phosphorus. Copper, iodine, and a number of other minerals are present in useful amounts. The feeding of Vitamin D to layers, in the form of cod liver oil or Vitamin D<sup>3</sup>, has been shown to increase the iron and copper content of eggs. Iron content of eggs may also be influenced by the individual bird's breeding.

## **Eggs are Palatable and Useful in Special Diets**

Most people eat eggs because they like them, especially when attractive in appearance and mild in flavour. Also they can be prepared in a number of interesting and appetizing ways. Few foods known to man provide a higher ratio of nutrient value to calories than do eggs. "An egg contains twice as much protein as one slice of bread, but with less calories. Eggs are suitable for people who want to lose weight. The method of cooking alters the speed of digestion, but does not lessen the amount of digestion and absorption. Fried and scrambled eggs are digested more slowly than boiled eggs, but are digested to the same extent." (11). Physicians frequently prescribe eggs in the diet of invalids and convalescents, and in the treatment of a number of diseases. Eggs are excellent in the diet of the pregnant mother and the growing child.

## **Eggs are Almost Indispensable in Cookery Practice**

Eggs are adaptable in cookery practice. Served alone or in combination with other foods, which they often help to enrich, they are palatable and attractive. They have a leavening effect in making cakes and omelets; because they prevent the clustering of ice crystals, their use results in smooth-textured ice-cream. Their emulsifying properties are important in mayonnaise dressing; they also thicken custards, gravies, and sauces. They serve as a binding agent in meat loaves and adhere crumbs to chops and fish in breading. Sliced, diced, or minced, they are a decorative agent and, when added to coffee, they serve to clarify. It is for these reasons that they are considered so necessary in cookery practice.

Thus a single egg supplies a very considerable amount of the daily requirement of all except one of the essential nutrients most likely to be deficient in the average human diet. The missing nutrient, Vitamin C, is found plentifully in most fruits and vegetables.

TABLE 10 — WHAT EGGS CONTRIBUTE TO OUR DAILY  
FOOD REQUIREMENTS\*

Food Nutrients	One Egg Contains	% of Daily Requirement for Average Adult Supplied by One Egg
Protein .....	6.7 grams .....	10%
Calories .....	70.0 .....	2- 3%
Calcium .....	0.03 grams .....	5%
Phosphorus .....	0.11 grams .....	10%
Iron .....	1.55 mg. ....	10%
Vitamin A .....	200- 800 I.U. ....	4-16%
Vitamin D .....	10- 50 I.U. ....	2-12%
Thiamine (B <sub>1</sub> ) .....	60- 120 mcg. ....	1- 5%
Riboflavin .....	100- 500 mcg. ....	5-23%
Niacin .....	760 mcg. ....	5-11%

\* According to Dr. E. W. McHenry, School of Hygiene, University of Toronto.

The following statement by Dr. E. W. McHenry, Professor of Nutrition, School of Hygiene, University of Toronto, well summarizes the food value of eggs:

“Eggs are an important protective food. They are a fair to good source of Vitamin A and D and the B Vitamins (thiamine, riboflavin and niacin); they are a valuable source of iron and contain some calcium and phosphorus; eggs supply an appreciable amount of protein of high biologic value. The fat in eggs is in emulsified form and hence, is readily digested by even young children. Egg fat is rich in phosphorus, in essential fatty acids and is the carrier of Vitamins A and D.

It has been claimed that eggs should not be eaten because they contain considerable cholesterol. It has been said that the generous eating of eggs causes an increase in blood cholesterol and consequently makes likely an attack of the kind of heart disease known as coronary thrombosis. It has not been proven that an increase in blood cholesterol will produce coronary thrombosis. Cholesterol intake in food has relatively little effect on blood cholesterol. Cholesterol can be, and is, made in the body from carbohydrate and the amount produced varies inversely as the intake. A reduction in cholesterol intake leads to an increase in the production of cholesterol in the body. It is neither advisable nor necessary to stop eating eggs to prevent coronary thrombosis.”

## XVII FACTORS INFLUENCING THE PRODUCTION OF SUPERIOR QUALITY EGGS

Quality in eggs is influenced by a number of factors, the most important of which are: housing, breeding, nutrition and management, medication and seed treatment, disease, and age of bird.

### Housing — as it affects egg quality

Housing influences egg quality chiefly as it affects the number of dirty eggs. A nest containing clean nesting material should be supplied for every four or five birds housed. Cages, wire-floored roll-away nests, and

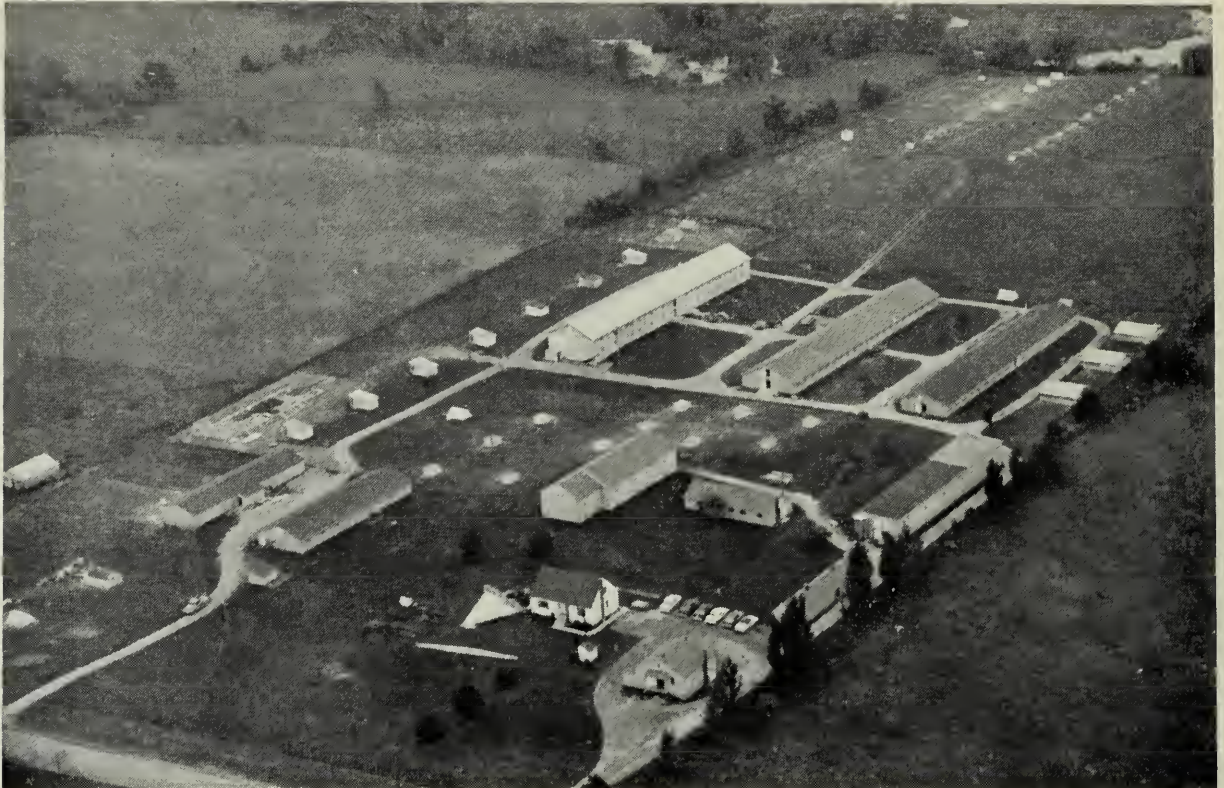


FIG. 33. Air view of the parent experimental breeding farm of a Canadian poultry breeding establishment. Courtesy Shaver Poultry Farms, Galt, Ontario.

mechanical egg-gathering equipment should be frequently dusted. Floor litter should be kept dry at all seasons, and roosting condition should be such as to prevent soiled feathers. Otherwise the soiled feet and feathers of the layers will result in a marked increase in the percentage of dirty eggs gathered. It is possible to minimize the number of soiled floor eggs by developing proper nesting habits in the pullet flock through careful attention to this matter when the birds first come into lay. Less directly, housing is also a factor as it affects the flock's health and resultant egg quality.

### **Breeding — as it affects egg quality and appearance**

At least six factors have been shown to be influenced greatly by breeding, namely: egg size, egg shape, shell colour, shell thickness, blood and meat spots, and interior quality. Properly conducted selective breeding in regard to these conditions can, therefore, bring about fruitful results. As few poultrymen now breed and hatch their own stock, much of this selective breeding must of necessity be conducted on the several large breeding farms which supply the breeding stock from which most commercial chicks are now produced (Fig. 33). Nevertheless, it is important that commercial egg farmers be very alert to the economic possibilities of these factors in the stock they purchase.

#### **(a) Egg Size**

Rapid improvement can readily be made in the average egg size of a flock by using only breeding males whose sisters and daughters produce eggs of the desired size. In Chart 3 is demonstrated the effectiveness of

such selective breeding. Quinn and Godfrey (12), selecting for egg size in a flock of White Leghorns, were able to secure an increase of 2 ounces per dozen in the span of five generations.

TABLE 11 — IMPROVEMENT IN EGG SIZE ACCOMPLISHED IN FIVE GENERATIONS OF SELECTION

Generation	Ounces per doz.
First	23.2
Second	23.6
Third	24.0
Fourth	24.8
Fifth	25.3

Quinn & Godfrey, Beltsville Exp. Station, Beltsville, Maryland, U.S.A.

The setting of pullet eggs weighing 24 ounces or more to the dozen over a period of several years will result in improved egg size from the flock. To secure comparable results with hen eggs, only eggs weighing about 25½ ounces or more should be used.

(b) **Egg Shape**

Only eggs of normal shape are suitable for incubation. Eggs too long or too short in shape are difficult to pack commercially without excessive breakage. Abnormally shaped and rough-shelled eggs are unattractive in appearance and therefore undesirable. While it is difficult to achieve perfection, considerable improvement generally follows selection for desirable shape in the eggs to be incubated.

(c) **Shell Colour**

*Egg shell colour is mainly a breed and individual bird characteristic and is not related to either flavour, nutritional value, or the keeping quality of eggs.* Some breeds such as the Leghorns lay white-shelled eggs while others such as the New Hampshires lay brown or tinted eggs; the difference depends on the presence or absence of a pigment-secreting mechanism in the posterior part of the uterus or shell gland where the shell material is secreted and the shell is laid down. The pigment involved is known as proporphyrin (Fig. 3).

(d) **Shell Quality**

Shell thickness, strength, and texture are important in the handling of eggs and for eye appeal. By means of selective breeding, good and poor quality shell lines have been and can readily be developed. In one such case, cracks occurring during routine handling of the eggs of the poor shell line exceeded by 31⅓ times those occurring in the good shell line (12). Weight loss in eggs of the poor shell line exceeded by 60 per cent that in the good shell line, when infertile eggs of both lines were heat stressed at 100°F. for a period of 14 days. Shell thickness may be measured readily by means of a specific gravity test or by use of a finely graduated paper gauge. Shell thickness is not necessarily a measure of shell strength, but is often considered a measure of shell quality. Increasing the shell thickness (as indicated by specific gravity test) by heavy additions of calcium carbonate to the diet of a flock at O.A.C. in 1959 had a moderately adverse effect on egg albumen quality as measured by Haugh Unit value.

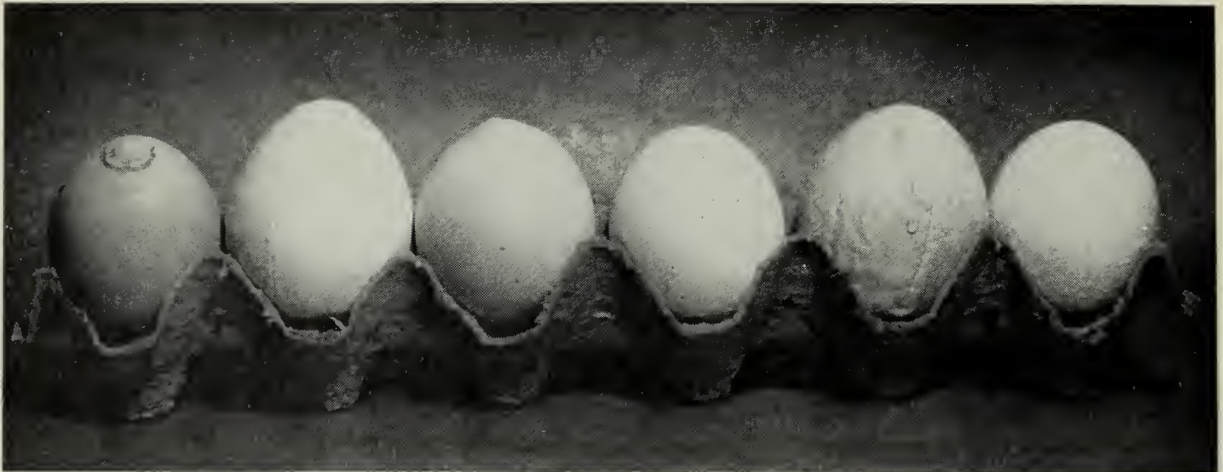


FIG. 34. Faulty in shape and shell strength, thin-shelled eggs are of salvage value only—sold at a discount as melange, or used on the farm. Selective breeding, proper diet, and cool laying-pen temperatures will reduce their incidence.

#### (e) Incidence of Blood Spots

It has also been proved possible to develop from a common origin two lines of layers varying in blood spot incidence. After seven years of selection, 80 per cent of the eggs from the one line contained blood spots in comparison with 20 per cent in the other line (12).

#### (f) Thick Albumen Quality

Selection within stock of common origin has resulted over a period of years in developing a high line, the eggs of which averaged 65 per cent of thick white when laid, as compared with a 40 per cent thick white content in the low line. The eggs of crosses between the two lines measured 54 per cent thick white (12). The same workers also were able to develop, by selection within a flock of White Leghorns, a strain of birds with thick white of such superior quality that it stood up unusually well for 14 days at a temperature of 100°F., as compared with albumen from other lines.

The final reports of the Fourth and Fifth Annual Production Tests concluded at Ottawa in 1959 and 1960 well illustrate, by the differences which exist in the several strains, the effect of breeding for certain traits associated with egg quality. The maximum and minimum values for certain traits occurring between the strains entered in the test are shown in Table 12.

TABLE 12 — MAXIMUM AND MINIMUM VALUES FOR CERTAIN EGG QUALITY TRAITS OCCURRING BETWEEN STRAINS AT THE FOURTH AND FIFTH CENTRAL PRODUCTION TESTS (1959 and 1960)

Traits	Haugh* Units		Percentage of large blood spots		Percentage of large meat spots		March egg weight in ounces per doz.	
	1959	1960	1959	1960	1959	1960	1959	1960
Maximum	78.44	68.84	15.1	13.7	14.1	13.0	27.8	28.38
Minimum	61.65	56.96	0.0	0.4	0.6	0.8	24.6	25.27

\* Measurements of albumen strength taken on eggs stored for 7 days once quarterly throughout the laying year.

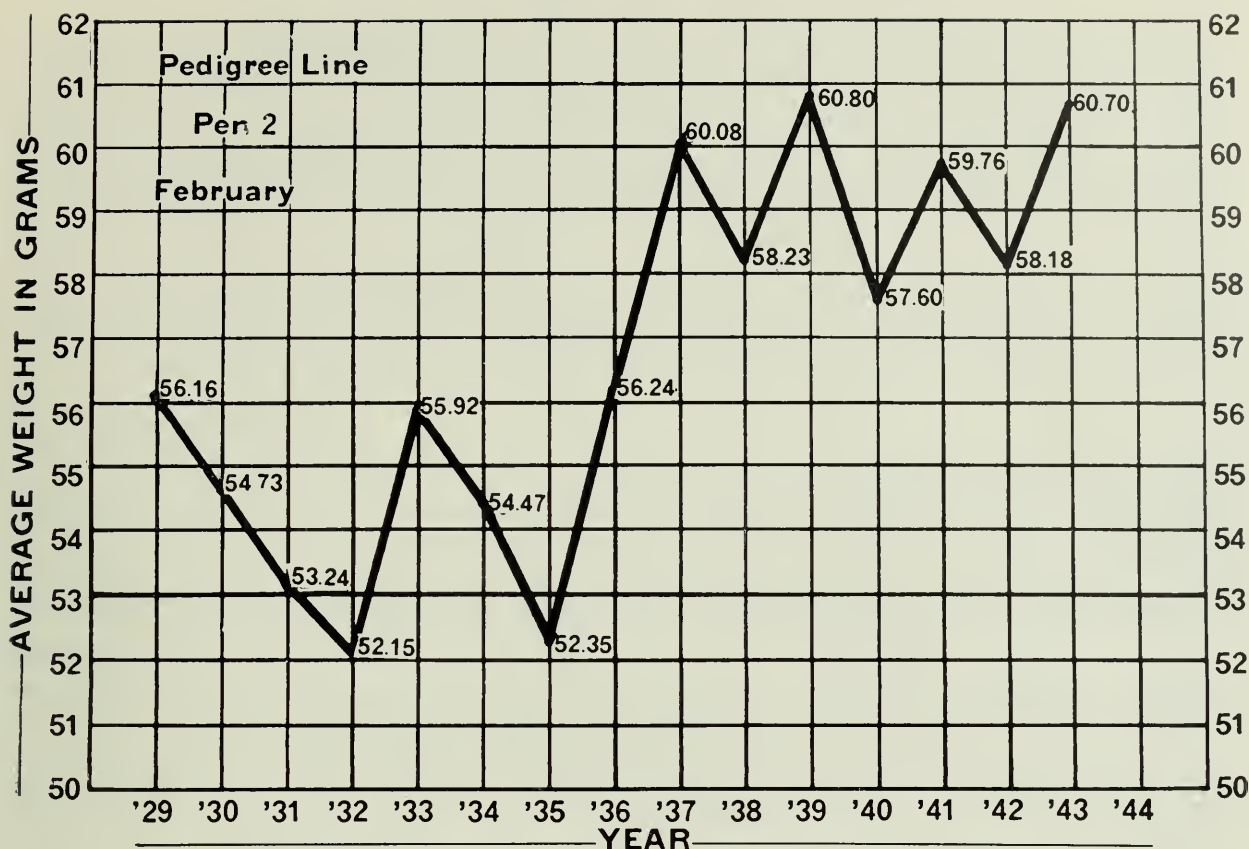


CHART 3. Effect on Egg Size of Breeding and Selection in Barred Plymouth Rocks.

Selection for egg size was initiated in 1935. Some variation in size from year to year is unavoidable. A 2-ounce egg weighs 56.7 grams.

These data indicate that the commercial egg producer can go a long way toward improving his egg quality by simply choosing a strain or strain-cross having an inherent ability to produce eggs of superior quality. New information is constantly appearing. The wise poultryman keeps up to date.

### Nutrition — as it affects egg quality

The hen's diet may influence food value. It affects the quality of the shell, the colour of the yolk and albumen, the quality of albumen and its keeping quality in storage, the incidence of blood spots, and egg flavour.

#### (a) Food Value

The extensive literature on egg quality contains much evidence of the effect in eggs of diet on the content of Vitamins A, D, and the several B Vitamins, particularly riboflavin. The content of these vitamins can be considerably varied at will, dependent upon the amount of the vitamins in the hen's diet. The content of other vitamins, with the exception of Vitamin C, is probably similarly affected. Commercial diets usually are adequately supplied.

#### (b) Egg Size

It has been known for many years that the level of protein in the diet influences egg size. Recent results (13) indicate that with Canadian type all-mash rations, 15 per cent protein in the diet is adequate for lay-

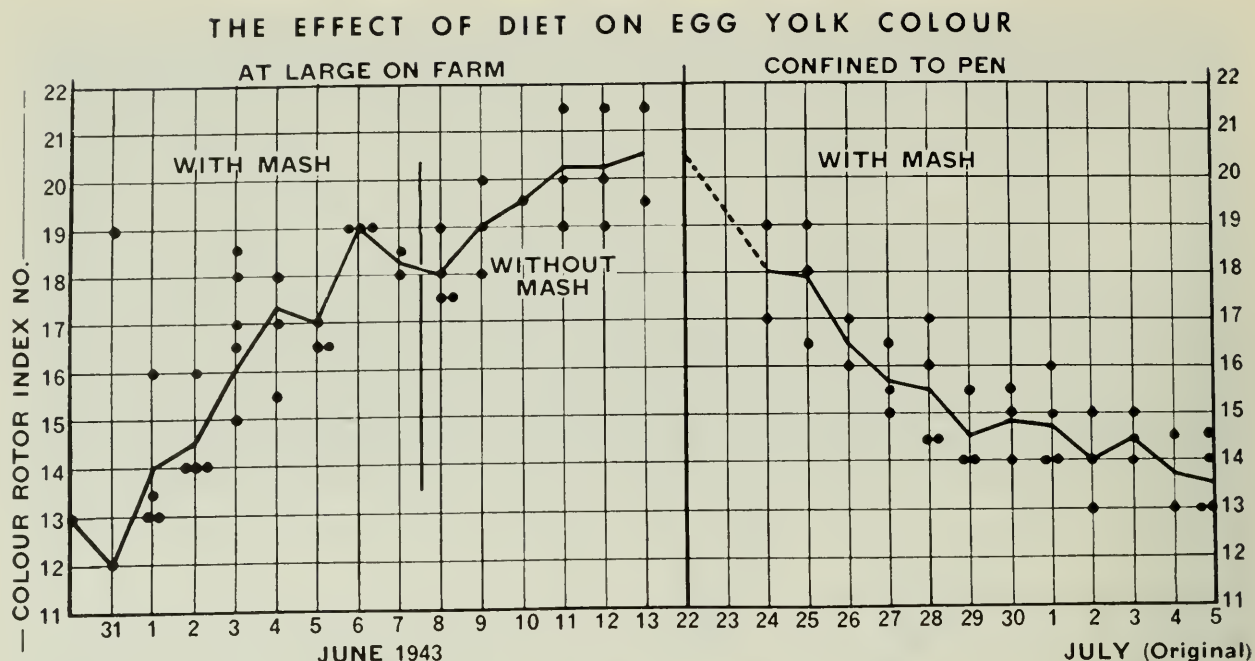


CHART 4. A change in management from confinement and controlled mash feeding to free range with mash, then without mash, was quickly reflected in increased yolk colour. Return to the former desirable colour followed return to confined housing and mash feeding.  
(Colour values according to Heiman-Carver colour rotor scale.)

ing hens. A lower protein content was found inadequate to maintain egg weight when relatively high energy diets were fed. It is interesting to note that the protein requirement for maximum egg weight is higher than for maximum egg production.

### (c) Yolk Colour

Egg yolk colour is controlled directly by the diet of the hen (Chart 4). It is a well-established fact that yolk colour is governed by the xanthophyll content of the diet, though related carotenoid pigments such as zeaxanthin, cryptoxanthin, and, more rarely, capxanthin are also involved (14). Dehydrated green feed, yellow corn, and corn gluten meal are the important sources of xanthophyll for practical rations in Ontario. Careful control of such ingredients is necessary to produce the shade of yolk colour most desired and to prevent down-grading of eggs because of prominent yolk shadows when eggs are candled.

A recent (1960) survey of consumer preference conducted jointly at the Royal Winter Fair by the Canada Department of Agriculture, the Poultry Products Institute, and the Department of Poultry Science, O.A.C. failed to show any definitely uniform yolk colour preference on the part of consumers. Women tended to favour a lighter yolk colour than did men. Both city women and men favoured a lighter coloured yolk than did their country counterparts. Many of both groups were decidedly opinionated with little sound reason for such opinions. Differences in race and background seemed largely to account for these.

A moderately dark yolk is not necessarily strong in flavour. Under present confined housing conditions, it usually indicates more alfalfa leaf meal and/or corn in the diet than is advisable for the production of eggs to meet present market yolk colour preference.

Strong and undesirable flavours are found mainly in eggs from unconfined flocks allowed to range in boggy barnyards and where birds are forced to scavenge by withholding or by light feeding of mash and grain. Resultant eggs may be reddish orange in yolk colour or even greenish if rape or such weeds as shepherd's purse or pennycress are consumed. Such conditions are now uncommon in Ontario and other specialized poultry areas in Canada.

Very light-coloured yolks may also be repulsive to some consumers but do not necessarily indicate lack of Vitamin A because this vitamin is now largely supplied in synthetic form without need for green feed.

#### (d) Shell Quality

Maintaining shell quality, always a major concern of the poultry industry, has become even more serious with present-day, small-sized, high production stock managed by forced production methods; these include the practice of keeping hens in production for longer periods of time. It is estimated that as high as 5 per cent of all eggs produced are lost either in production, or transport, or storage because of weak, thin shells.

Recent experiments (15) have shown that shell condition can be greatly improved by increasing the calcium content of the modern hen's diet. Instead of 2.25 per cent total calcium formerly recommended and considered adequate, these experiments indicate that a level of 3.75 per cent to as high as 5 per cent is more realistic under present conditions. This is especially true as the laying season advances and where the environmental temperature is above 70°F.

#### (e) Odours and Flavours

Eggs produced by healthy layers fed modern diets almost without exception are of good flavour and free from objectionable odours. However, eggs with "off" odours do occur, and eggs with a fishy flavour have been reported (16). Usually such eggs are the product of individual hens only. Meal made from certain types of fish, also cod liver oil fed *ad lib.*, may sometimes result in "off" flavours. A fairly widespread occurrence of "fishy" eggs in the Frazer valley of British Columbia in 1960 was traced to the feeding of a diet containing an excessive percentage of fish meal (16A). "Off" flavours may also occur when hens are forced to scavenge for much of their food and because of this consume certain waste materials, weeds, and garbage. Odour examination of broken-out eggs usually will detect musty, fishy, and other "off" flavours not detected by candling. This is a regular procedure when breaking out eggs for the production of frozen and dried eggs.

#### Management — as it affects egg quality

Good management includes close attention to every factor that will keep the laying flock quiet, contented, and healthy. It also includes the best possible care of the eggs produced until gathered and delivered to the egg room. Care should be taken that the layers have ready access at all times to clean, fresh water and the proper amount of oyster shell, because both affect egg quality.

Management as here understood may affect egg quality in several ways:

(a) Egg size can be influenced by date of hatching, March- to June-hatched stock having been reported to lay larger eggs than October- to December-hatched birds (17). Caged layers tend to lay larger eggs than those on litter (18). Pullets raised on a restricted diet, though slightly later in commencing to lay, tend to lay larger eggs during their first few months than those raised on full feed (19). A temporary shortage or lack of water will be reflected in decreased egg size for the following day or two.

#### **(b) Blood Spots**

Caged layers tend to produce eggs with a higher incidence of blood spots than those on litter or wire or slatted floors (20).

(c) Soiled, cracked, and broken eggs can be kept at a minimum: by avoiding overcrowding; by controlling ventilation so as to keep litter dry; by having clean well-bedded nests; by frequent gathering; and by careful handling in clean trays or baskets. Three or four gatherings per day are advisable with any type of nest. The writer has ample evidence that, even with roll-away nests, gathering only once or twice daily during summer weather or when pen temperatures are above 60°F. is insufficient, and results in considerable loss of egg-holding quality. The same is true of eggs from cage-housed layers.

#### **(d) Medications and seed treatments**

Because of their effect on egg quality, producers are well advised to be constantly on the alert in regard to dosage and use of such medications and seed treatments in the diets fed to their laying flocks.

Mention is here confined to only a few. For example, Sulfa drugs have been reported to interfere in some cases with proper shell formation. The coccidiostat Nicarbazin, if included in sufficient amount in the diet of laying stock, will result in the production of severely mottled yolks and even white-shelled eggs from "brown-shell" breeds. The severity of reaction is chiefly dependent upon the amount of the drug in the feed, but is also affected by strain. Mottling may not appear until after four or five days of storage. The presence of 125 p.p.m. in the feed may cause severe mottling, and as little as 50 p.p.m., some mottling. Discontinuance of such feed will result in production of normal eggs within about one week (21).

Diazinon (fly bait) accidentally included in the feed and arasan-treated grain have both been reported as causing thinning of albumen in the eggs produced. The presence of arasan may also produce soft- and irregular-shelled eggs and even eggs without shells. Phenothiazine in feed has been reported to produce mottled yolks in eggs (22).

#### **(e) Disease**

A number of poultry diseases have been reported as adversely affecting egg quality.

- (i) Newcastle disease has been found to increase the amount of thin white, and to cause serious interference with shell production. Thin, misshapen, and chalky shells may be produced and also shell-less eggs. Recovered birds tend to return rather quickly to normal production.

- (ii) Infectious bronchitis causes birds to lay eggs with watery albumen, and at times eggs containing soft, white, granular masses of material in the albumen. Many eggs are either shell-less or have misshapen, rough, and thin shells. Even mild attacks will adversely affect egg quality, and recovered birds often continue to lay faulty eggs for weeks and even months after apparent recovery.
- (iii) Layers affected by coryza (colds), C.R.D., and similar infections are likely also to produce eggs of subnormal quality, either of shell or contents, or both.

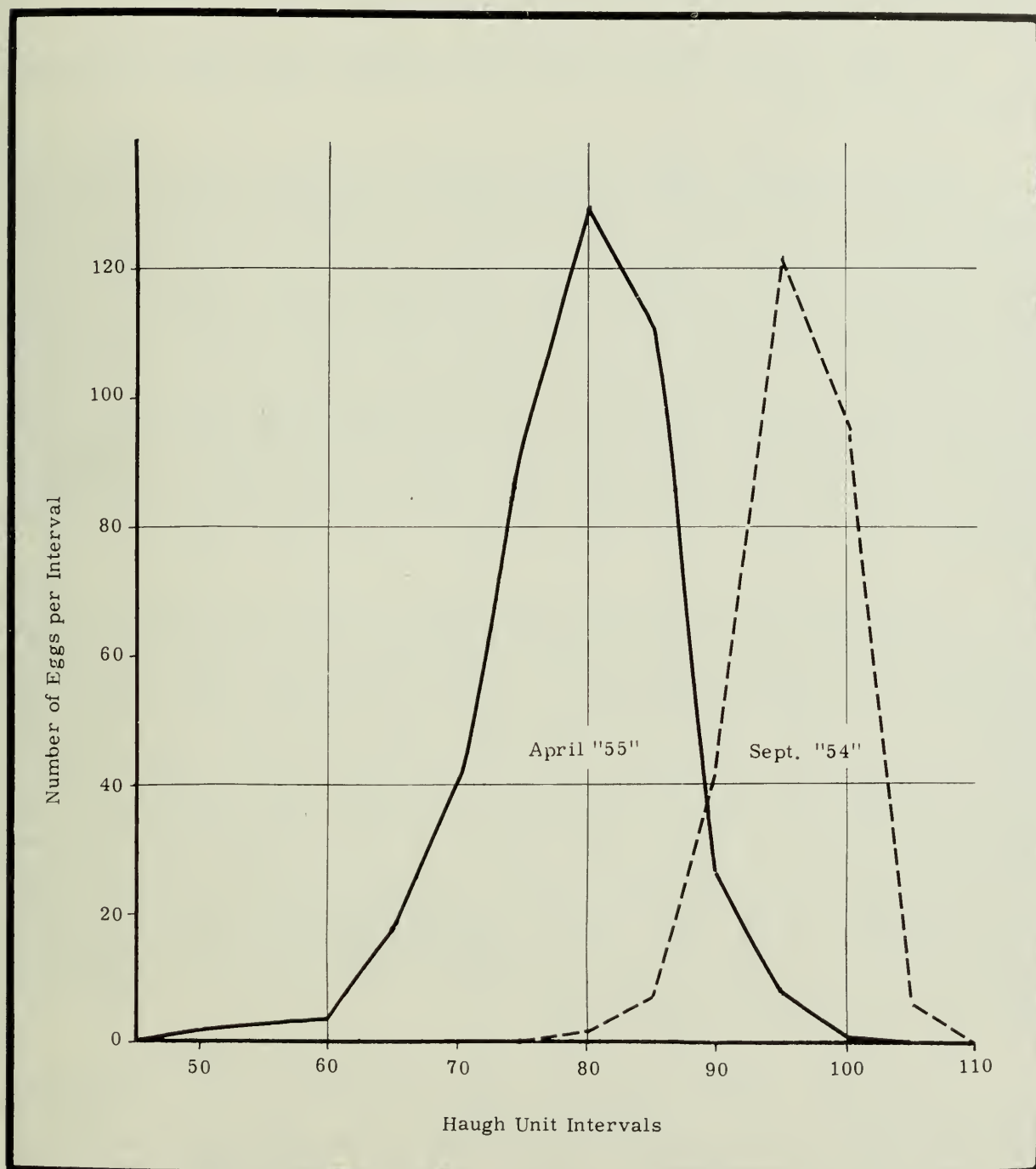


CHART 5. Showing the shift in egg quality from September to April in a group of White Leghorn pullets. With increased layer age, average quality declined about 15 Haugh Units and variation in quality increased greatly.

(iv) Ovarian abnormalities and infections also are a factor.

#### Age of Bird — as it affects egg quality

It is a well-known fact that the eggs laid by pullets during the first few months of production, though smaller in size than those later, are of the very highest quality. It is also generally known that this quality, as now recognized, tends to gradually decrease as the laying period is extended (Chart 5). Extensive experiments at this station have amply demonstrated this fact. Other researchers have reported similar results. Intensity of production is not necessarily a factor. However, strains of layers may differ somewhat, and health, time of year, and weather may be conditioning factors. Egg shell quality also usually suffers.

In table 13 this trend is shown as found in 1953 with 11 breeds, crosses, and strains.

Further studies, using present-day laying stock, were conducted at this station in 1959 and 1960, with the object of ascertaining the extent of quality decline with birds of several ages. Scientifically sampled and with three replications, this experiment involved three commercial egg farms with flocks of 6,000 to 15,000 layers. Two farms each carried flocks of three age groups, the third only two age groups. Three well-known strains were involved, a different one on each farm. To secure a more comprehensive picture of any quality changes resulting from age of layer, the factors of temperature and length of holding time were introduced. Haugh Unit value was the criterion of quality, and was determined by breaking out and measuring all eggs involved in the test. Some of the results are shown in Tables 14 and 15. Data from one farm and one strain only are included, because these quite well represent the results obtained from each of the others.

The combined data for each age group on the three farms is shown in Chart 6. Here, quite clearly, is illustrated the rate and extent of egg quality decline for each age of bird as conditioned by length of holding time and by holding temperature. It will be noted that the original egg quality (on the day laid) of the younger birds exceeded that of the two older ages by about 10 Haugh Units. The younger birds' eggs declined: more rapidly during the first three days; at a practically parallel rate up to the seventh day; then at a considerably slower rate than those of the older ages. Using 66 Haugh Unit quality as the dividing point between Grade A and Grade B quality, the eggs from both older groups are shown to have reached Grade B quality sooner, especially so if held at above 50°F. Also observed was the fact that the longer the laying period, the more variation in the quality of eggs produced. Furthermore, the average egg quality of the 11 months-in-lay stock declined very rapidly during the first few days at the higher temperature.

It is quite apparent that the longer the period of lay, the greater the necessity for speed in marketing and for use of the correct degree of refrigeration, from farm to consumer, if eggs from such stock are to reach the consumer in satisfactory condition. This is particularly important where eggs from hens of several ages and sources are to be marketed through a common controlled quality programme.

TABLE 13 — EGG PRODUCTION AND EGG QUALITY DECLINE BY STRAIN OVER A PERIOD OF 9 MONTHS  
(Average Haugh Unit Values)

Strain	14 Oct.	18 Nov.	16 Dec.	14 Jan.	10 Feb.	10 Mar.	10 Apr.	12 May	4 June	Percentage of Quality Decline Oct. to June	Percentage Production* (Hen-Day Basis)
NH x CR	92.0	88.9	86.6	85.5	84.3	85.0	80.6	81.3	76.0	17.4	57.2
WR	89.7	90.2	88.1	85.0	79.3	84.5	76.4	78.7	75.4	15.9	48.7
NH	94.1	91.2	90.0	90.8	85.0	87.1	82.2	81.0	74.9	20.3	48.3
RIR x LS	92.6	90.1	87.4	86.8	83.1	85.7	75.8	78.5	72.6	21.6	61.2
NH x BR	87.1	83.8	82.7	81.3	76.9	76.7	81.0	77.9	71.7	17.7	56.0
Inbred Cross	87.7	82.6	80.3	80.8	75.8	75.2	65.9	70.8	64.3	26.6	64.0
BR (Meat)	86.5	84.1	83.9	82.9	80.2	79.9	79.5	78.5	79.7	7.9	47.6
WL	87.8	81.4	82.1	81.6	78.4	79.9	72.9	72.5	72.6	17.3	48.4
RIR	95.6	91.7	89.3	87.5	83.5	86.7	82.7	85.0	82.7	13.9	61.9
NH x WW	89.2	87.0	85.4	83.4	80.2	78.4	73.7	79.8	72.0	19.3	51.2
BR (Egg)	88.0	83.2	82.4	82.6	80.6	77.1	77.4	78.9	78.0	11.3	54.7

\* 40-week laying period.

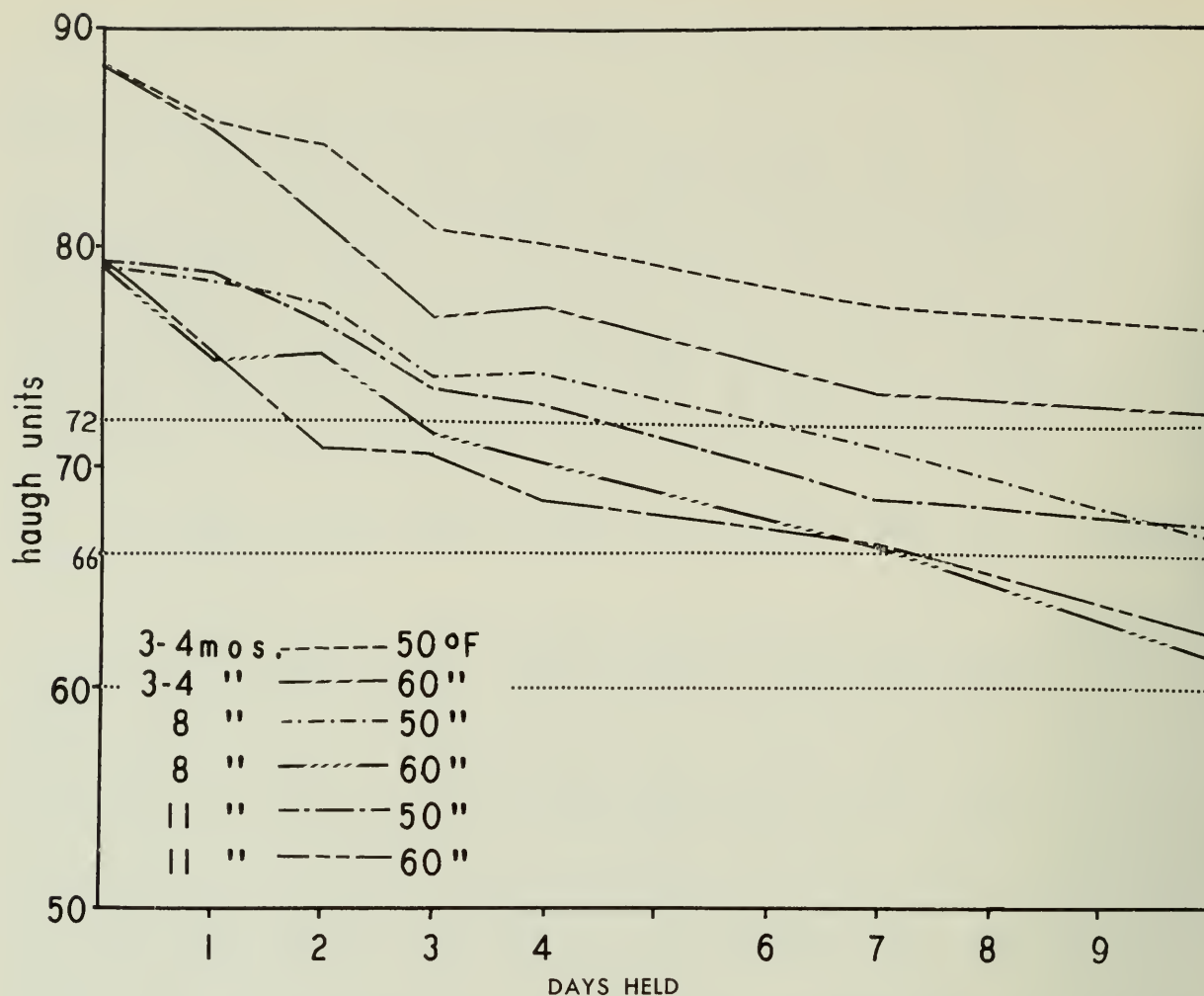


CHART 6. Effect on Albumen Quality of Age of Layer as Conditioned by Egg Holding Temperature and Time.  
Dept. of Poultry Science, O.A.C., Guelph, 1960.

TABLE 14 — EFFECT ON ALBUMEN QUALITY OF AGE OF LAYER AS CONDITIONED BY EGG-HOLDING TEMPERATURE AND TIME

Holding Temperature 50°F.				Holding Temperature 60°F.		
In lay	3-4 mos.	8 mos.	12 mos.	3-4 mos.	8 mos.	12 mos.
Days Held	H.U.*	H.U.	H.U.	H.U.	H.U.	H.U.
0	85.0	80.1	79.1	85.0	80.1	79.1
1	83.5	78.0	77.9	82.4	79.6	71.2
2	81.0	78.8	77.2	78.1	79.0	63.7
3	76.0	75.3	68.8	74.4	73.6	69.0
4	76.2	76.0	72.9	74.4	70.8	66.2
7	74.2	71.7	65.2	72.5	71.8	65.2
10	74.5	67.2	63.6	67.7	61.1	67.0
14	74.9	69.1	65.9	67.7	66.0	64.2

\* Average Haugh Unit Values.

Dept. of Poultry Science, O.A.C., Guelph, 1960.

TABLE 15 — EFFECT ON ALBUMEN QUALITY OF AGE OF LAYER AS  
CONDITIONED BY EGG-HOLDING TEMPERATURE AND TIME  
(Quality decline in percentage)

Holding Temperature 50°F.				Holding Temperature 60°F.		
In lay	3-4 mos.	8 mos.	12 mos.	3-4 mos.	8 mos.	12 mos.
Days Held	%	%	%	%	%	%
0	0	0	0	0	0	0
1	1.8	2.6	1.5	3.1	0.6	10.0
2	4.7	1.6	2.4	8.1	1.4	19.5
3	10.6	6.0	13.0	12.5	8.1	12.8
4	10.4	5.1	7.8	12.5	11.6	16.3
7	12.7	10.5	17.6	14.7	10.4	17.6
10	12.4	16.1	19.6	20.4	23.7	15.3
14	11.9	13.7	16.7	20.4	17.7	18.8

Dept. of Poultry Science, O.A.C., Guelph, 1960.

TABLE 16 — EFFECT OF FORCED MOULTING ON EGG QUALITY

Time	HAUGH UNIT VALUE				
	0 days	Held at 60°F. for			
		3 days	7 days	10 days	
3 mos. prior to moult	73.5	68.0	61.2	60.8	Nov. 2/59
2 mos. after moult*	83.7	73.6	72.2	67.7	Apr. 6/60
3 mos. after moult**	81.0	74.5	67.8	66.3	May 6/60
4 mos. after moult	80.2	71.1	68.1	64.8	June 6/60
5 mos. after moult	78.2	72.4	67.1	59.3	July 8/60
6 mos. after moult	75.0	69.0	66.2	59.7	Aug. 6/60
7 mos. after moult	76.4	66.6	65.1	59.8	Sept. 12/60
8 mos. after moult	73.6	66.9	61.4	62.2	Oct. 14/60

\* 40% Production.

\*\* 75% Production.

Dept. of Poultry Science, O.A.C., Guelph, 1960.

### **Forced moulting — as it affects egg quality**

With present strains, satisfactory production may continue for some months after egg quality and poorer grades become a problem. The time for this condition varies with strain and management, but usually becomes more or less acute after from 8 to 12 months of steady production. In some cases, egg quality from such flocks may be improved for a time by resting the birds by means of a forced moult. After they return to production, another satisfactory period of lay may follow. During 1959 and 1960, a study was conducted at this station to ascertain the possibilities concerning this practice. Monthly samples were collected from each of four commercial-size flocks of Leghorn-type hens—two flocks of each of two strains.

The samples were randomized into four lots, the first being broken out on the day laid while the three remaining lots were broken out in order after a 3-, 7-, and 10-day hold at 60°F. The egg quality of two of these flocks had been studied prior to moulting and the results of one, after 8 months of lay and representative of both, are shown in Tables 14 and 15. The results for the other, representative of the four moulted flocks included in this section of the study, are shown in Table 16.

### **Physiological disturbances — as they affect egg quality**

#### **(a) Abnormal eggs and rejects**

Notwithstanding the variety of conditions under which they are produced, the great majority of newly laid eggs are of excellent quality and attractive as food. There is, however, a small and varying percentage of eggs that are more or less objectionable due largely to abnormal physiological reactions during secretion and development of the various egg parts. Unfortunately, the basic cause of some of these reactions is not as yet fully known. As shown elsewhere, faulty nutrition and disease are factors, but no doubt other conditions also are involved. Many of the erroneous ideas commonly held are the result of this incomplete knowledge.

#### **(b) Blood spots**

Occasionally eggs are laid containing varying amounts of blood. Such eggs, because of their objectionable appearance, are classed as rejects when graded. Losses from this source vary from about 1½ to 10 per cent or more.

Blood spots result from the rupture of a small blood vessel in the follicle or sac within which the yolk or ovum develops while still attached to the ovary (Fig. 6). Some of the resultant haemorrhages occur between the follicle and yolk membrane (intra-follicularly); others occur in the upper part of the oviduct, where much of the egg albumen is secreted. Blood spots from the former are usually found on the yolk, and from the latter in the albumen. Most haemorrhages occur before the yolk is freed from its follicle, probably because the follicle did not rupture along the stigma, where there normally are few blood vessels, or the rupture extended beyond the stigma. The amount of blood released may be minute or comparatively large.

#### **(c) Bloody Eggs**

In such cases, the haemorrhage occurring in the oviduct has been relatively severe, and part or all of the blood has become diffused throughout the egg albumen.

## Cause of Blood Spots

Much attention has been given this problem as attested to by the many research papers published. Unfortunately there is still some question as to the basic cause or causes. There is every evidence that heredity is one factor, because some families or strains have been proven to be much more subject to the production of blood spots than others. Several investigators have definitely shown cage-housed layers to be more subject to blood spot production than floor-housed stock. Vitamin A has also been shown as a factor. The incidence of blood spots was increased when the ration contained less than 1,100 U.S.P. units of Vitamin A per pound of feed (23).

The fact that both blood and meat spot incidence varies from time to time within a flock fed the same feed indicates that other factors are also involved.

There appear to be more blood spots during periods of rapid egg production increase; also during rapid production decrease, following a period of very high production. More trouble occurs during the spring months, some in the fall, less at other times. Also, overstimulation of the reproductive system, congested ovaries (as in pullorum infection), and excessive or violent exertion, though questioned by many as being factors, have not been entirely ruled out. It is well to remember that the reproductive tract of the female may easily be ruptured when in production.

### (d) Meat Spots

Up until about 1950, the most commonly accepted theory concerning meat spots was that they consisted of blood in various stages of degeneration—blood-red colour changing progressively in the process to several shades of brown and finally to almost white (24). Later investigators demonstrated a high relationship between shell colour and meat-spot colour and also that meat and blood spots were separate entities (25). These recent investigations indicate that meat spots may be of more than one type, those found in white-shelled eggs being normally of degenerated blood. On the other hand, coloured spots in brown-shelled eggs appear to be of two kinds: (a) those having their origin in degenerated blood (a negligible percentage), and (b) those containing a considerable quantity of calcium and being fluorescent under ultraviolet light because of their porphyrin content. These investigations indicate that the majority of meat spots are not blood, and that their colour is not due to hemin content, but to protoporphyrin, which is the same pigment as that found in the shell of brown-shelled eggs. It was also found that 90 per cent of the meat spots of white-shelled eggs were white or nearly so in contrast with those of brown-shelled eggs, where 70 per cent were classified as intermediate to dark in colour (26).

Eggs with meat spots, unless abnormally large, are not classed as rejects, but are graded into Grade C. This is because the appearance of meat spots is less objectionable than that of blood spots and they can readily be removed when the eggs are broken out for use as food.

### (e) Inclusions

In addition to blood and typical meat spots, other abnormalities may occasionally be encountered in eggs. These include diseased and im-

mature ova, bits of sloughed off tissue (glandular tags) from the upper part of the oviduct (magnum), and, very rarely indeed, even an ascarid. Also, as already stated elsewhere, birds with or recovering from infectious bronchitis may occasionally lay eggs containing soft, white, granular masses of material in the albumen.

#### **(f) Multiple-yolked eggs**

Eggs containing more than one yolk occur more commonly with pullets, when commencing to lay and before a regular rhythm has been established, than with older birds. Two yolks are fairly common, but triple and even quadruple yolked eggs may occasionally occur. Most double-yolked eggs result from the "ripening" and ovulation of two yolks at the same time. In other cases, one or more yolks fail to be "picked up" or engulfed by the funnel or infundibulum (Fig. 6) of the oviduct until the stimulation afforded by a succeeding ovulation brings this about. Overstimulation, by a too rapid change from a grower to a laying ration at the onset of laying, may be a factor.

#### **(g) Soft Shelled and Shell-less Eggs**

While there is evidence that shell thickness is basically an inherited quality, age of layer, faulty nutrition, environmental temperature, along with certain drugs and respiratory diseases, are all contributing factors. Shells may be thin or soft, and in extreme cases entirely lacking. Most of the latter are laid while on the roost and at night.

Failure of the shell-secreting area of the oviduct to function properly, or too rapid passage of the egg mass through this area, are the immediate reasons. These malfunctions, in all probability, are caused by the foregoing factors.

#### **(h) Small Yolkless Eggs**

Examination of many such eggs has led to the conclusion that the stimulus produced by some foreign substance gaining entrance to the oviduct and passing along in the same manner as a normal yolk is the probable cause of such eggs. The passage of the particle will stimulate the albumen, shell membrane, and shell-secreting glandular areas of the oviduct to each secrete its particular product. Blood spots, bits of membrane, and small sloughed-off ova may usually be found in such eggs in place of a normal yolk.

#### **(i) An Egg Within an Egg**

This condition is relatively rare. A completely formed egg is forced back through the oviduct into the funnel region by reverse peristaltic action. As it again passes down the oviduct, albumen, shell membrane, and shell production is repeated. The result is an abnormally large egg which when opened, reveals a complete egg at its centre instead of a yolk.

### **Other Abnormalities — as they affect egg quality**

#### **(a) Glassy Eggs**

Such eggs have a very close-textured shell which resists normal evaporation and has a "peculiar" sound when "belled" against other eggs. Such eggs are the product of individual hens and no cause but heredity is known. They are normally suitable for marketing.

### **(b) Body Checks**

These are eggs in which the shell became checked or cracked while being formed. More calcium is added and the checks or cracks are then virtually sealed over. Such eggs are likely to break more easily during marketing because of their somewhat weakened shell condition. Though often missed in handling, the slight ridges or lines can readily be detected by candling and such eggs placed in the proper Grade C grade.

### **(c) Rough Shells**

Heavily ridged, round, flattened and other abnormally shaped eggs occasionally occur. Selective breeding and proper nutrition will usually reduce such shell problems to a minimum. However, respiratory diseases, medications, and other drugs may also be involved. Often, the condition is confined to individual hens that lay such eggs continuously. Flattened, thin-sided eggs may be caused by pressure of another organ against the side of the uterus while the shell is being formed.

### **(d) Mottled Yolks**

This condition may be found in fresh eggs, but is more common in eggs held for several days or longer. Many instances of yolk mottling have come to the writer's attention where producers have held eggs without adequate refrigeration during summer weather for upwards of a week before marketing. Mottling is apparently caused by egg albumen moving through the vitelline membrane into the yolk (27). The fact that mottling is frequently found in eggs held at high temperatures is probably due to the more rapid movement of water from the albumen to the yolk under these conditions. Adding animal fat to the diet of laying hens apparently has no effect on the incidence of mottling. Severe mottling may result from inclusion of the coccidiostat Nicarbazin in the diet. No doubt other factors also are involved.

### **(e) Mottled Shells**

This condition varies with individual birds and usually appears within one-half hour after the egg is laid. There appears to be a highly significant difference between strains, but no correlation between shell mottling and interior quality of the egg (28). Cases have come to the writer's attention where slow drying under refrigeration after washing resulted in mottled shells. More rapid drying eliminated the problem.

### **(f) Pink White and Salmon Yolks**

Pink albumen and salmon-coloured yolks in cold storage eggs, and occasionally in freshly laid eggs, result chiefly from oil left in cotton-seed products. Apparently the vitelline membranes become weakened in eggs from hens fed such products; there is passage of iron from the yolk into the white, where it reacts with conalbumen of the white to form a pink conalbumen compound. This compound when blended with normal yolk pigments produces the salmon-coloured yolks, and at times large, brown, thick, translucent curdled yolks, observed from feeding certain cotton-seed products (29). The active agent in these products is gossypol. Proper heat treatment during the production of such products will largely prevent such reaction.

XVIII WHAT CAUSES EGGS TO DETERIORATE IN QUALITY?

Eggs do not improve with age. The longer they are held, the poorer the quality. While quality decline is unavoidable, the rate of decline is dependent to a large degree on holding conditions. These include length of holding time, temperature, humidity, faulty sanitation, rough handling, and improper packing.

Length of Holding Time

The effect of the length of holding time is adequately illustrated in Tables 13, 14, and 16 and in Chart 6.

High Temperature

Temperature is one of the most important factors influencing egg quality. High laying-pen temperature (above 70°F.) has repeatedly been shown to affect hens' blood calcium content, resulting in an adverse effect on egg shell quality. Thus, the shell quality of many flocks tends to deteriorate with increasing spring and summer temperatures. However, it is now known that this adverse effect can be at least partially compensated for by an increase in the calcium content of the diet.

High holding temperatures speed quality deterioration and rapidly lower egg grade. The rate and extent of quality deterioration as affected by holding temperature is shown in Table 17 and graphically in Chart 7.

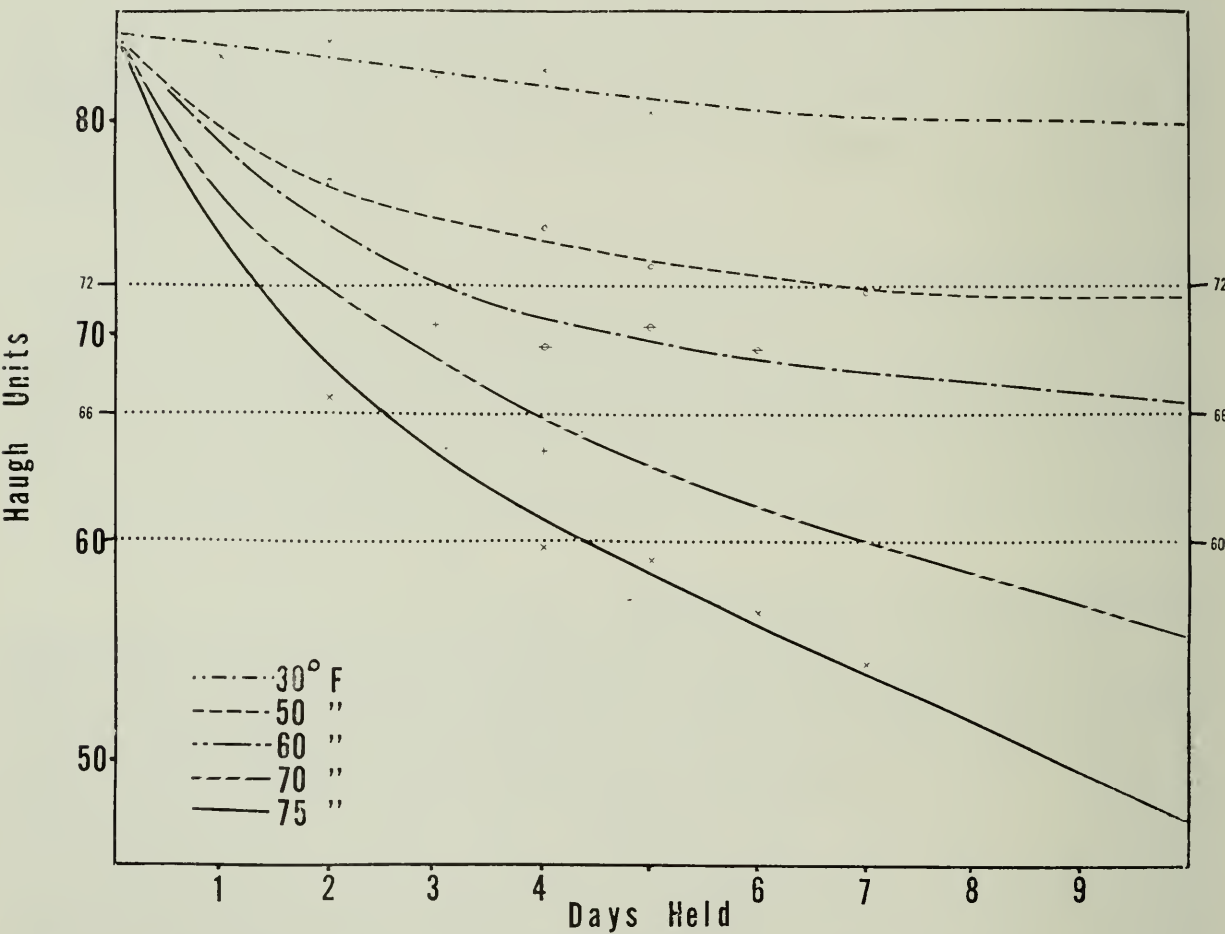


CHART 7. Effect on Albumen Quality as Conditioned by Holding Temperature and Time (Measured in Haugh Units). Dept. of Poultry Science, O.A.C., Guelph, 1960.

TABLE 17 — AVERAGE HAUGH UNIT VALUE AS CONDITIONED BY TEMPERATURE AND HOLDING TIME

Temp.	0 day	1 day	2 days	3 days	4 days	5 days	7 days	10 days
	H.U.	H.U.	H.U.	H.U.	H.U.	H.U.	H.U.	H.U.
30°	84.0	82.9	83.6	81.9	82.1	80.2	80.15	79.3
50°	84.0	78.9	76.9	75.6	74.8	73.1	71.9	71.6
60°	84.0	78.9	75.1	72.3	69.3	70.2	68.25	65.6
70°	84.0	75.9	71.8	70.3	64.3	63.5	60.3	55.2
75°	84.0	74.2	66.9	64.5	60.0	59.3	54.4	45.7

4 Replications at each temperature.

Dept. of Poultry Science, O.A.C., Guelph, 1960.

Under these conditions the quality loss in three days (twice per week marketing) at 30° to 75°F. was found to be 2.5, 10.1, 13.9, 16.2, and 23.2 per cent respectively, and in seven days (once per week marketing) 4.6, 14.4, 18.7, 28.2, and 35.3 per cent respectively. The need for proper holding temperature and for frequent marketing are quite apparent. It will also be noted that even at the recommended holding temperatures of 50° to 60°F., egg quality loss is quite rapid during the first 36 to 48 hours—then tends to slow down.

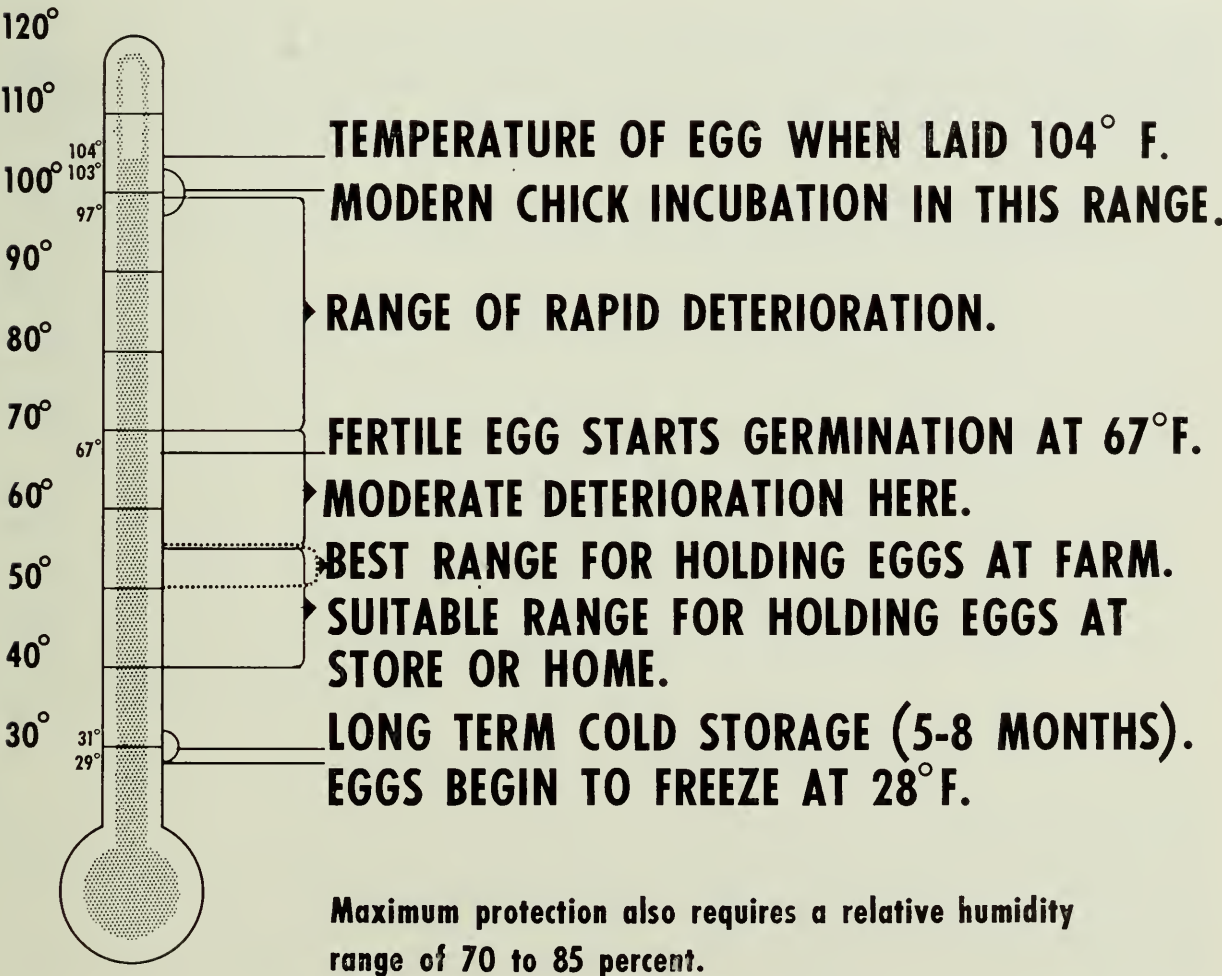


FIG. 35. Courtesy Canada Dept. of Agr., Ottawa, Ontario.

At the higher temperature of 70° to 75°F., quality loss continues at a rapid rate up to 10 days and even longer (other data). Similar results have been reported from other stations. The 30°F. temperature is used only for eggs held in long storage. Such eggs, upon removal from storage, must be "tempered" by moving to higher temperatures in stages over a period of two to three days to prevent them from reaching the dew point and "sweating" when exposed to normal handling temperatures. Care to prevent sweating upon removal during hot weather is advisable even when eggs are held at 50°F. Sweating is to be avoided as it encourages development of moulds and musty flavours.

Eggs are never better than when freshly laid. The longer they are stored, the less desirable they become, both in broken-out appearance and also often in flavour. High temperatures greatly accelerate deterioration, hence the emphasis on cooling. The author has frequently reduced top quality Grade A eggs to Grade B and even to Grade C quality in one week for classroom demonstration purposes, and retained others at Grade A quality, by storing for that time at room (70°-80°F.) and 50°F. temperatures respectively. Eggs held at room temperature show an enlarged germ spot, often some yolk mottling and, if fertile, even some embryonic development. Ten days to two weeks of hot weather almost invariably is reflected in lowered quality of the eggs reaching the market. This in turn results in increased consumer complaints.

### **Incorrect Humidity**

Both among producers and housewives, it is an all too commonly held opinion that eggs should be stored in a dry place. This idea is incorrect. Eggs so held, even if at the optimum temperature, quickly develop increased air cell size and also decrease in weight. Economically, therefore, it is important to prevent evaporation of moisture from eggs because:

- (a) It prevents loss of weight which would reduce many eggs from "large" classification to "medium" and from "medium" to "small". It prevents loss in grade, whether from true deterioration in interior egg quality or from the clues by which candlers do the grading (30). Air cell size, under ordinary conditions, is closely related to the actual amount of deterioration of interior quality. It is a direct measure of the amount of moisture evaporation that has accrued. Large air cells are evidence of age, high temperatures, and/or low relative humidity — the three factors most responsible for lowered egg quality (30). Under most Ontario conditions, the relative humidity in egg coolers should be held at from 70 to 80% R.H. Easily installed, small commercial humidifiers are now available for this purpose, both with and without automatic controls. Other means may also be used successfully, as recommended by any good refrigeration engineer.

### **Faulty Sanitation**

Much of the deterioration taking place in fresh, stored, and processed eggs results from the growth of bacteria and moulds. These organisms multiply rapidly once they gain entrance because eggs are a favourable medium for their growth. While most clean eggs are practically free of bacteria, soiled eggs are heavily contaminated. Washing with tap

water improves the appearance but tends to open the shell pores and so may afford greater ease of entrance. Shell membranes, albumen, and yolks may quickly become contaminated in spite of the germicidal effect of egg white on many of these micro-organisms due to the presence of lysozyme—deterioration of quality, and economic loss follow. Poor cleaning methods; unsanitary conditions in the holding room; damp and soiled egg trays, crates, and other equipment; and soiled hands are the common sources of contamination. Microbial multiplication occurs only in the presence of moisture and most rapidly under fairly high temperatures. One cannot over-emphasize either the need for sanitation in handling eggs or the need for rapid cooling because low temperatures greatly retard the growth of both bacteria and moulds. It has repeatedly been shown experimentally that eggs properly cared for show a minimum of contamination and little, if any, spoilage.

**Rough Handling**

Rough handling of eggs is harmful and ill-advised, no matter whether it occurs during the process of gathering, cleaning, candling, transportation, or at any other time. It results in much loss through breakage, and in lowered quality because of air cell and other structural damage. Such damage can only result in more rapid quality deterioration during the marketing process. Tremulous air cells and lowered grade are direct results.

**Improper Packing**

Careless packing involving many eggs being packed small end up rather than large end up is the cause of very considerable loss of egg quality during shipping or holding. Table 18, taken from a report of a Pennsylvania State University study, bears out this point.

TABLE 18 — \*PERCENTAGE OF EGGS PLACED IN EACH U.S. QUALITY GRADE, BY END UP AND EGG SIZE (based on interior grade only)

Large end up					Small end up			
Size of Eggs	Grade				Grade			
	%AA**	%A	%B	%C or lower	%AA	%A	%B	%C or lower
Large	67.8	23.9	5.8	2.5	17.3	6.0	73.2	3.5
Medium	73.6	21.2	3.5	1.7	19.8	6.2	71.8	2.2
Small	69.7	23.0	5.0	2.3	18.3	6.1	72.7	2.9

\* A total of 112,022 eggs was included in the analysis.  
Of these, 6,254, or 5.6 per cent, were packed small end up (31).

\*\* Comparable to Canadian Grade A1.

R. L. Baker, Penn. State University.

Eggs cooled in baskets should be properly packed in crates immediately after cooling. Eggs allowed to lie on their sides tend to have more prominent yolk shadows when candled because of the tendency of yolks to rise to the surface. Overly long, short, thick, and other abnormal eggs as well as rough- and thin-shelled eggs should be used on the farm or separately packed. Otherwise there is too much danger of breakage with consequent loss through soiling of surrounding eggs. Cartoned eggs are most attractive if spotlessly clean and uniform in shell colour and size.

In Figures 26a to 28b is shown a series of eggs that illustrate variations in egg quality as judged by broken-out appearance. Grade and Haugh Unit values are given for comparison. In spite of the general uniformity of egg quality obtained from flocks under a controlled management programme, eggs from some hens still vary from the average when laid, and may also vary rather widely in keeping quality when stored. However, the chief reasons for variations in broken-out appearance are the "post-lay" chemical and physical changes occurring within the eggs.

#### Physical and Chemical Reactions — as they affect egg quality

High quality eggs when laid usually contain a high percentage of thick white (26a). However, in the interval between egg laying and consumption a combination of chemical and physical reactions brings about certain changes. The air space, because of evaporation of egg contents, increases in size, resulting in lowered egg weight. The egg white gradually thins and decreases in quality and both white and yolk become increasingly alkaline. The yolk increases in size, the yolk membrane becomes weakened and more easily ruptured, and the yolk flattens when broken out (Fig. 28b).

When freshly laid, the egg contains approximately .5% of carbon dioxide ( $\text{CO}_2$ ). The thick white at this time often appears rather cloudy or opaque, particularly when cold, but soon becomes clear. Holding results in a gradual loss of  $\text{CO}_2$  and with it a loss of the original fresh flavour. The loss of  $\text{CO}_2$  also affects the hydrogen ion concentration or pH of the egg, resulting in the increased alkalinity. The freshly laid egg has a pH of about 7.6, while that of a held egg may rise with holding time to 9.5 or higher in low quality eggs.

The difference between firm and thin white may be considered to be chiefly due to a difference in mucin content, the thick white being a gel because of its high mucin content. Mucin content of thick white is about four times that of thin. The thick albumen is not a homogeneous gel but is composed of approximately 1 mm. wide bands of mucin fibres, sometimes visible in newly laid eggs. The cause of the thinning action has not as yet been fully explained, but is apparently the result of a chemical reduction of proteins (as evidenced by action of chemical reducing agents). Lysozyme is also apparently associated with the thinning procedure. There is evidence that lysozyme does not act as an enzyme in this change, but that there is a chemical interaction between proteins and mucin. Further study may serve to clarify the specific changes taking place. As the white thins, the increasing difference in concentration between yolk and white develops osmotic action, resulting in water from the thinning white being absorbed into the yolk through the semi-permeable yolk membrane, thus increasing the yolk volume. Because of this reaction along with some slight chemical interaction involving the membrane, the yolk membrane becomes stretched and weakened, the yolk flattens, and the membrane is easily ruptured when the pH rises to, or exceeds, 9.5 (Table 19).

Rapid cooling to 50°F. and holding at that temperature assists greatly in slowing down these reactions. It is because of this fact that so much emphasis is placed upon this point, as eggs held at this temperature will retain Grade A quality for up to two weeks or even longer.

TABLE 19 — THE EFFECT OF AGE OF EGG ON THE PROPORTIONS  
OF YOLK AND WHITE

Type of egg	Weight	White	Yolk	Shell	Loss (on separation)	In edible portion White	Yolk
	gm.	%	%	%	%	%	%
Two-day old	56.7	57.27	30.84	11.38	0.50	65.00	35.00
Commercial fresh	57.6	56.50	32.04	10.94	0.52	63.81	36.19
Storage eggs	55.5	52.53	35.17	11.39	0.91	59.90	40.10

U.S.D.A. Agr. Marketing Service.

## XX HOW CAN EGG QUALITY LOSS BE RETARDED?

### By Rapid Cooling

The four factors most responsible for maintenance or loss of egg quality during the period between laying and delivery are:

- Time between laying and gathering;
- Egg room temperature;
- Speed of cooling to the egg room temperature; and
- Egg room humidity.



FIG. 36. Egg cooling and holding room. Eggs are most commonly cooled in wire baskets or stacked in trays. Thorough cooling to cooler room temperature should precede packing into crates for marketing. Use of racks may be replaced by suspending wire baskets in tiers from hooks attached to horizontal metal pipes. Warm eggs should always be placed above the cooled ones.

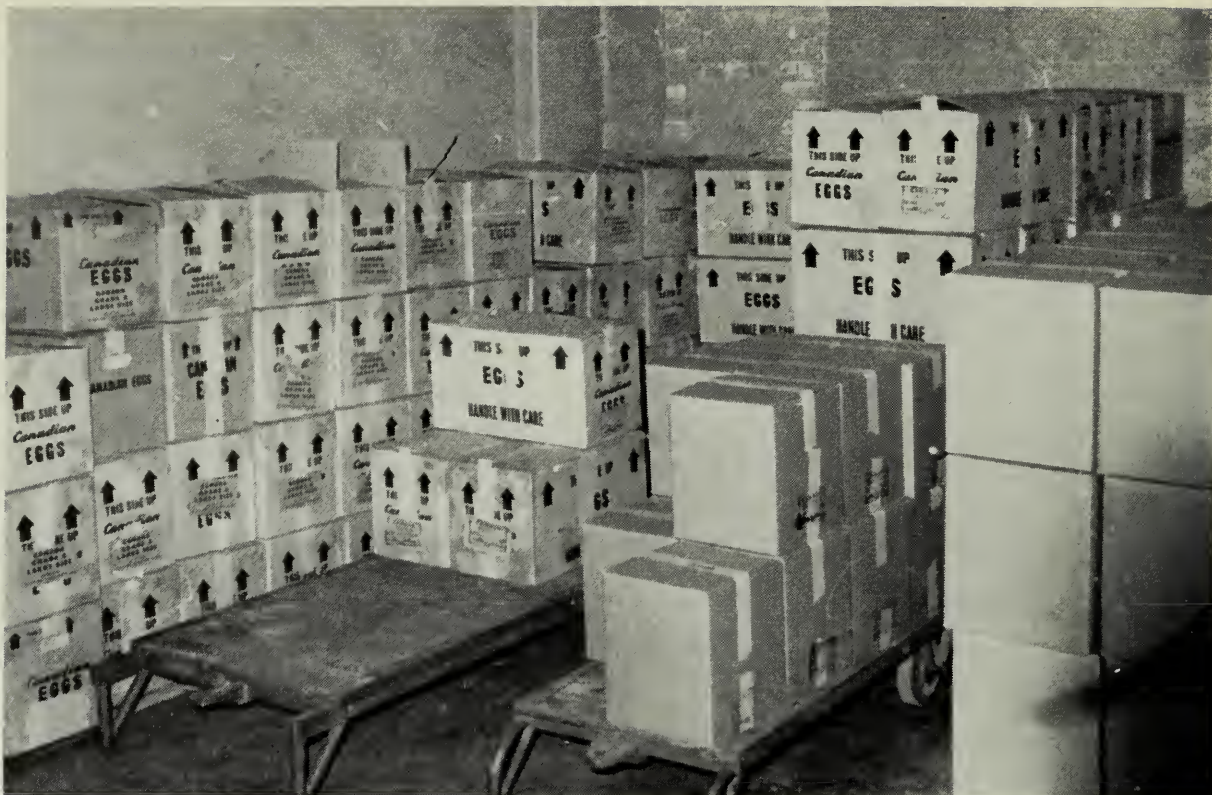


FIG. 37. Graded eggs held in grading station cooler, while awaiting shipment.

To enable consistent production and marketing of top-quality eggs to meet rapidly growing demands for such quality, operators of flocks of over 5,000 layers will increasingly find a mechanically refrigerated egg room an absolute necessity. With smaller flocks, the need for refrigeration is equally great but increasingly difficult economically as flock size decreases. Rapidly cooled eggs suffer less increase in yolk shadow and less moisture evaporation than more slowly cooled eggs, even if later conditions for both are the same.

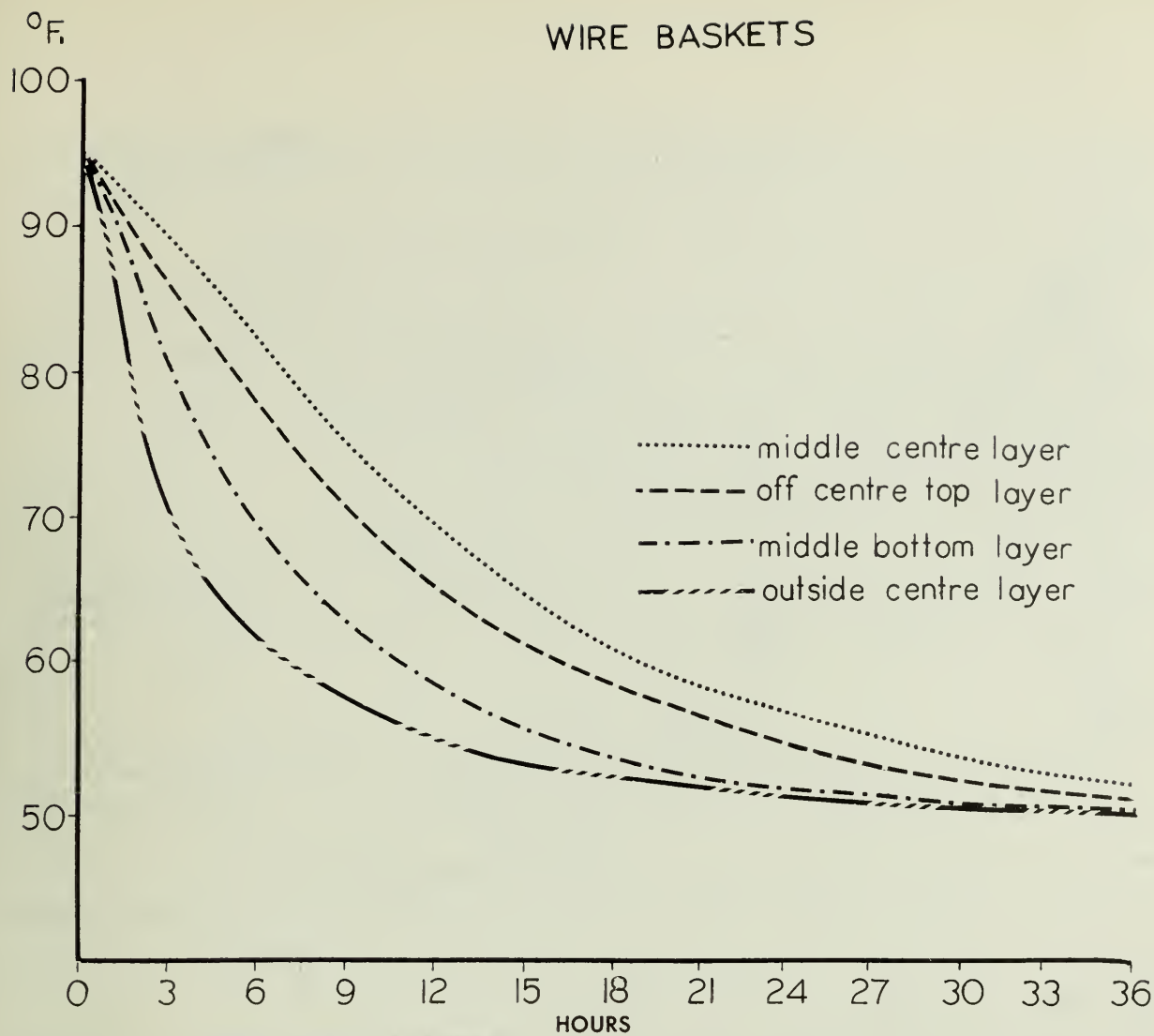
A plan for a walk-in cooler room is shown in Figure 38. Complete plans and specifications may be procured free of charge from the Department of Engineering Science at the O.A.C. upon request. Size of cool room will vary with requirements—such as size of flock and number of cases of eggs requiring storage at any one time.

### By Preventing “Sweating”

If eggs have been chilled below the dew point of the atmosphere, they will condense moisture or “sweat” when removed. Such eggs are more subject to bacterial spoilage, and are easily soiled by packing material and during handling before they have dried again.

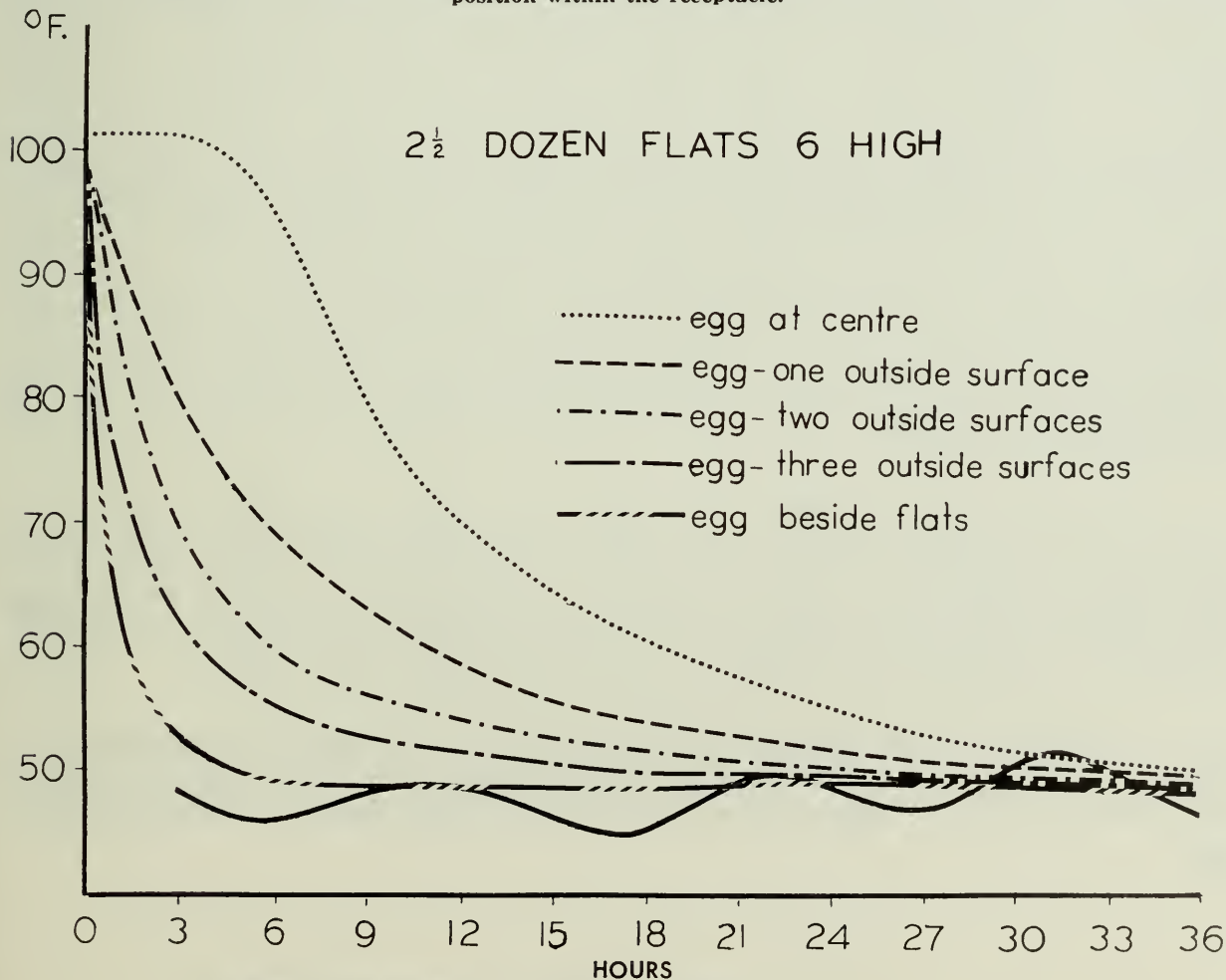
Sweating occurs only when eggs are colder than the dew point of the surrounding atmosphere, and the dew point is always below atmospheric temperature as long as the relative humidity is less than 100 per cent. The higher the humidity, the closer will be the dew point to atmospheric temperature (30). Care to prevent sweating is most necessary during periods of very warm, humid weather.

# WIRE BASKETS



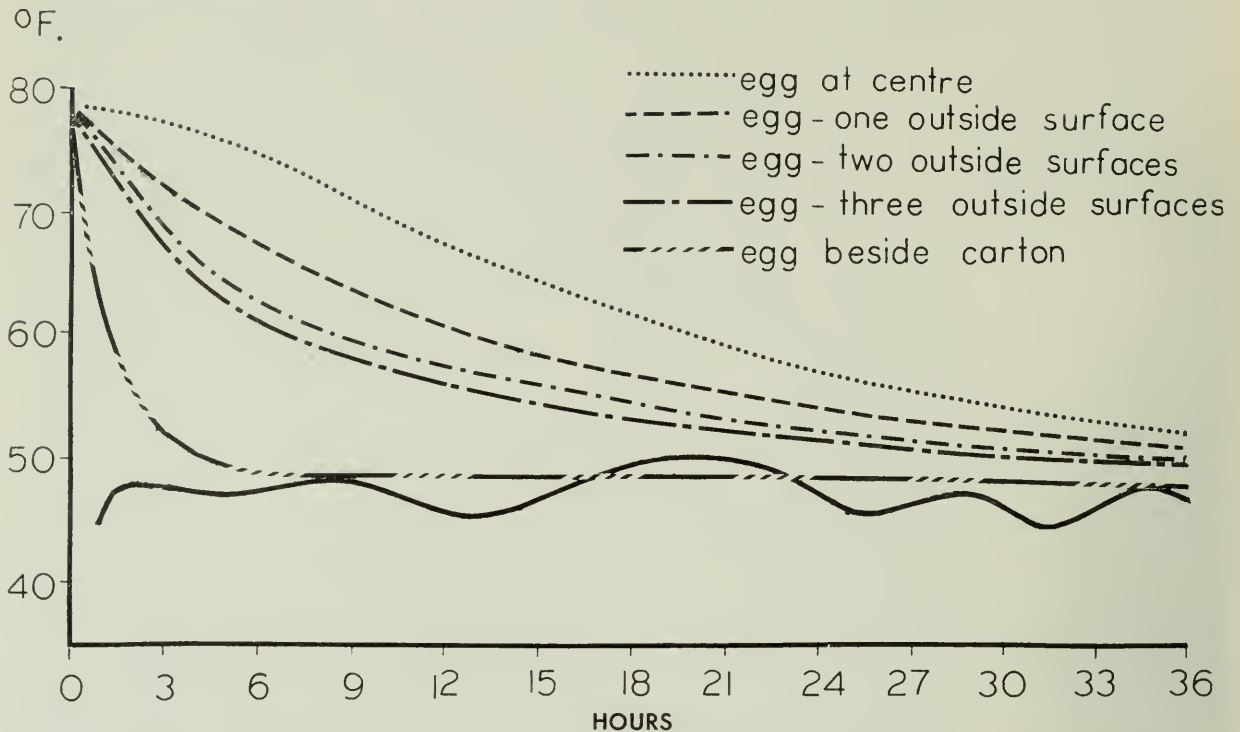
(a) Eggs cooled in wire basket.

CHART 8. Rate of cooling and time required to lower inside temperature of eggs from 80° and 100°F. to 50°F. when placed in a cooler held at 50°F. The rate of cooling varies with receptacle and with egg position within the receptacle.



(b) Eggs cooled in Keyes trays piled 6 tiers high.

## CORRUGATED CARDBOARD CASES



(c) Eggs trayed and cooled in a 15-dozen-size cardboard egg carton.

Courtesy—National Research Council and D. A. Fletcher, Canada Dept. of Agric.

### By Proper Cleaning

Practically all eggs have clean shells when laid. In spite of this fact, soiled eggs are one of the poultryman's major problems. No practical way has yet been found to entirely eliminate their occurrence. Whether nests be of single, community, or roll-away type and nesting material is the best known; whether floors of pens are of wire or slat construction or deep litter is employed—some eggs still become soiled. Even caging the layers does not eliminate the problem. In spite of all practical precautions, eggs may still be broken, nesting material soiled, and cage-floor wire dusty. Production of floor eggs adds to the problem. Furthermore, egg gathering and handling equipment are factors, as are also the soiled or wet hands of the operator. The result is that from 5 to upwards of 50 per cent of all eggs produced become soiled and more or less unattractive in appearance. *Only superior management will keep this problem at minimum level—5 to 10 per cent of the eggs laid.* In the following table 20 is the extent of the problem as experienced at the Poultry Science Department at the Ontario Agricultural College.

There is little question but that soiled eggs must be cleaned. Consumers are repelled by dirty eggs, but are attracted by clean eggs. It is the producer that must absorb the loss on dirty eggs, as only clean eggs are classed in the top grades which command the higher prices, slightly soiled ones being classed Grade B and badly soiled eggs Grade C.

There is general agreement, supported by much experimental evidence, that unwashed, clean eggs suffer less loss of quality during marketing than do cleaned eggs—particularly if the eggs must be stored for any





FIG. 39. Good reasons for cleaning eggs. Heavily soiled eggs are Grade C, slightly soiled eggs Grade B. All can become Grade A for shell condition if properly cleaned.



FIG. 40. An inexpensive non-heated, immersion-type egg washer. To give satisfaction, care is necessary to supply and retain water at the proper temperature.

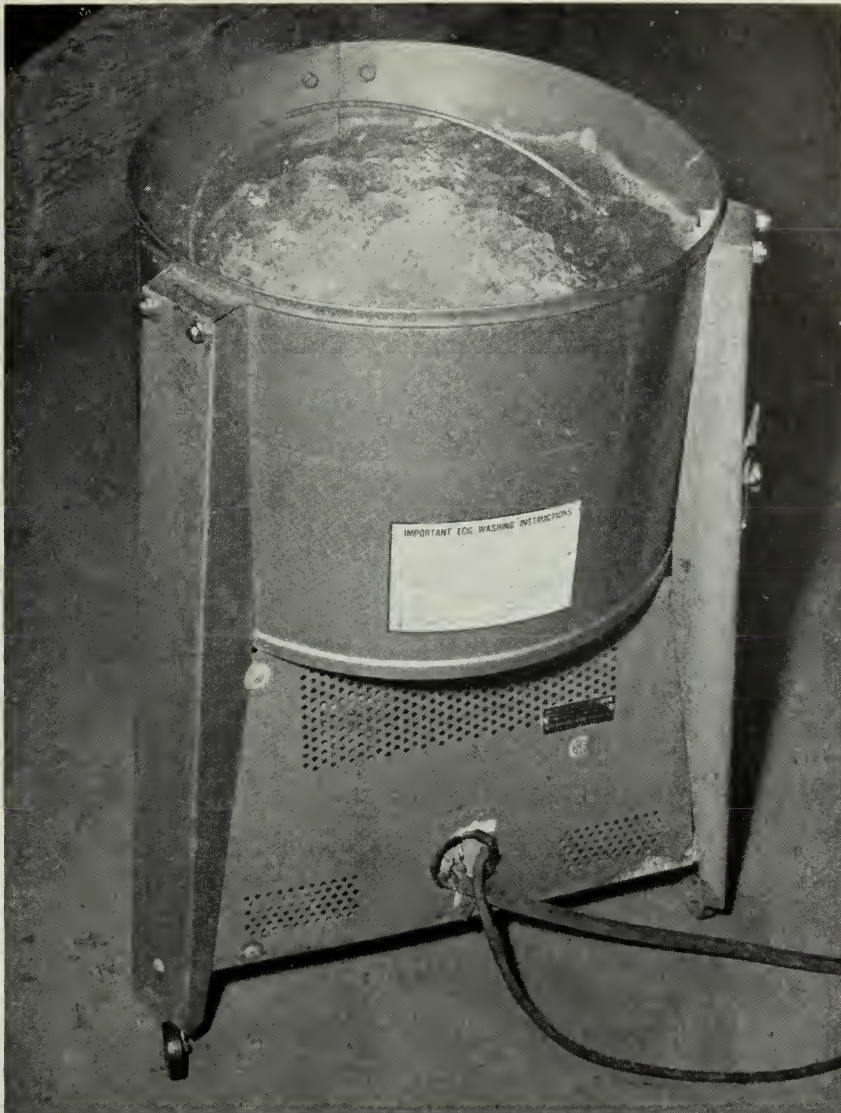


FIG. 41. A "bubbler" type of immersion egg washer with thermostatic water temperature control.

length of time. From the economic standpoint, however, poultrymen are forced to clean soiled eggs, and it is now pretty generally conceded that properly cleaned eggs will keep quite satisfactorily for all purposes, with the possible exception of long storage.

### How to Clean Eggs

Cleaning eggs is a nuisance. It is time-consuming and costly. Furthermore, it must be done properly or serious loss of quality may result with keeping quality lowered and consumer demand for eggs decreased.

Small soiled areas may be cleaned by buffing with a hand buffer faced with emery cloth or fine sandpaper—but this leaves shiny spots. Mechanical buffers and sand-blast machines are available for use with larger flocks, and steam sand-blast, pressure spray, and other large volume cleaners for use at central stations.

In Ontario, most producers find washing soiled eggs with water is easy and fast enough for their purpose. Cleaning with a damp cloth is too time-consuming to be economical except for small flocks. In consequence, most poultrymen use mechanical washers.

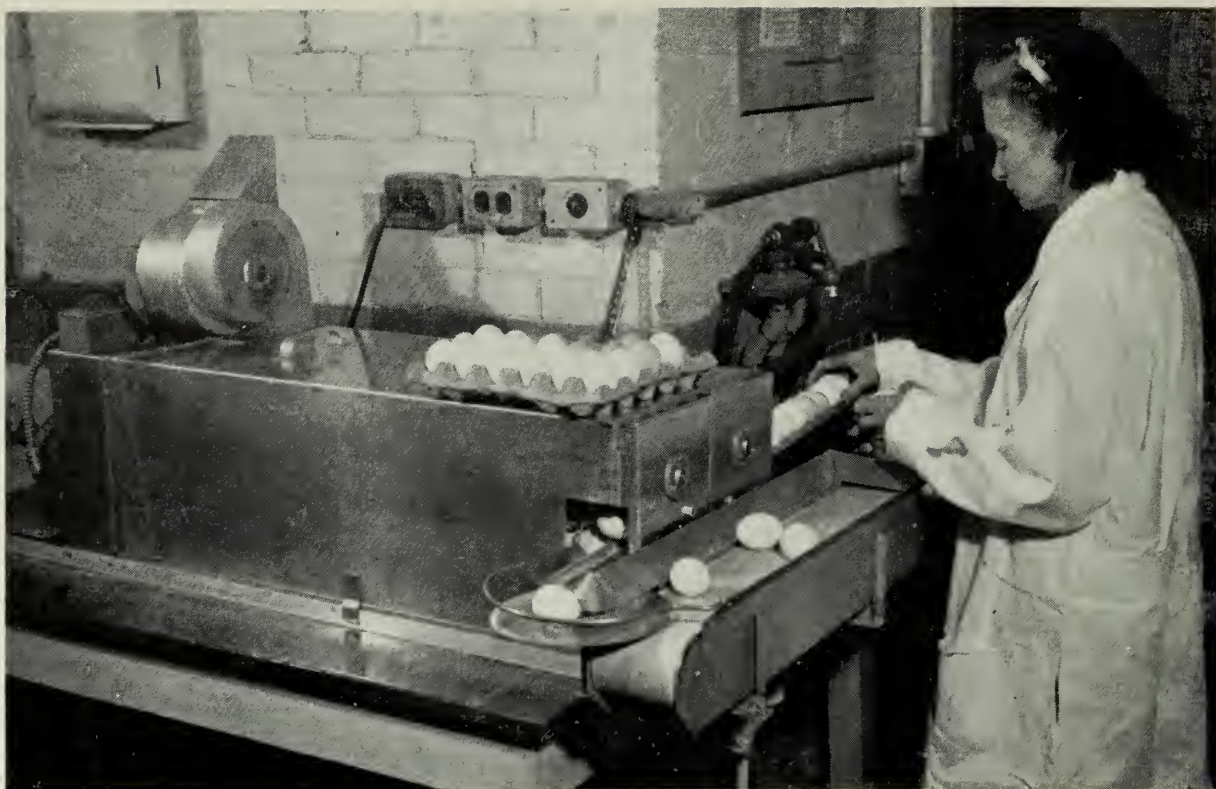


Fig. 42. A brush-type egg washer. The eggs are brush-cleaned while carried through a spray of hot water (165°F.), then transferred to the opposite side of the machine for brush-drying.

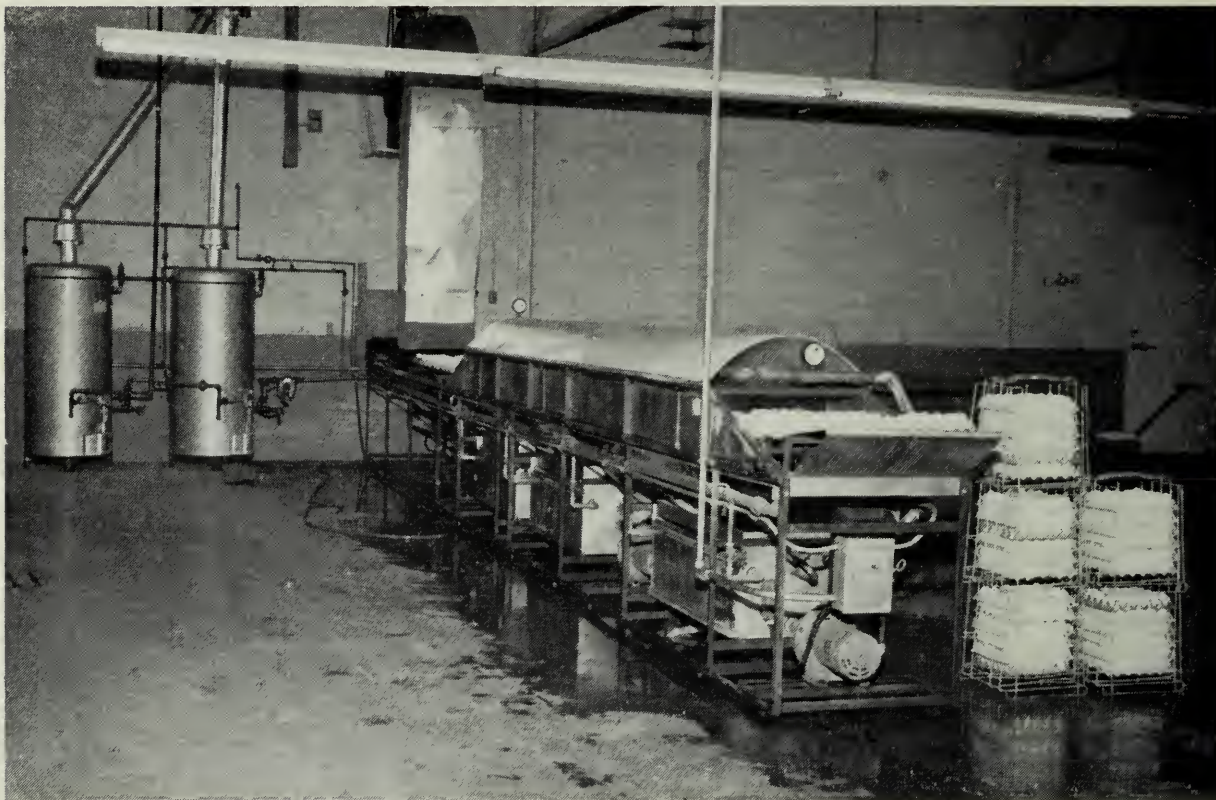


FIG. 43. A large "in grading station" belt-type egg washer. A spray of water at 105°F., under 18 pounds pressure, strikes the eggs while they are carried down its length. A "detergent-sanitizer" spray is followed by a rinse. The eggs are dried by a blast of warm air as they move into a cool room.

Mechanical washers are mostly of two types, either immersion or brush. Both types are satisfactory if properly constructed and correctly used. Both should have effective water-heating attachments and accurate temperature controls.

*It is best to wash only the soiled eggs.* These may be most easily separated from the clean ones during gathering—but may also be sorted out later. However, under certain conditions it may be more economical to wash all eggs rather than to take the time necessary to separate the soiled from the clean.

### When to Wash

Washing is most easily done immediately after gathering. It may be done after cooling the eggs overnight, though this may result in more cracks because of the temperature change when eggs are immersed. The longer eggs are held, the harder they are to wash—one of the problems with central-station washing.

### Rules for Washing

1. The room in which washing is done should be clean, and egg washers must be kept clean by *cleaning thoroughly after every day's use*.

2. In immersion-type machines, the water temperature *must be above that of the eggs to avoid contraction of egg contents*; such contraction creates a sufficient vacuum to help bacteria into the interior through the shell pores. The water temperature should also be high enough to check any build-up of bacterial growth in the wash water, but not so high as to cause coagulation of the egg “white”, preferably not under 110°F. and not over 125°F.

In brush-type machines, the water sprayed on the eggs may be as high as 165°F.

3. The time of immersion must be controlled according to water temperature—not over 4 minutes at 120° to 125°F., and not over 6 minutes at 110°F.

4. The water in immersion-type machines must be changed frequently—preferably after every six baskets of dirty eggs or eight to ten baskets of unsorted eggs. Eggs washed in dirty water may appear clean and yet be heavily contaminated with bacteria and mould spores, especially if covered with heavily contaminated foam (32).

5. Detergents and detergent-sanitizers are an aid. However, only those specially designed for use with eggs are safe and satisfactory.

6. All eggs must be thoroughly dried and cooled before being packed in crates for market because damp eggs and trays supply ideal conditions for mould and bacterial growth. Eggs washed as described will dry quickly, but use of a wind tunnel or an electric fan will further hasten drying (Fig. 44).

7. Eggs should be cooled before being packed, preferably to 50°F., and should be packed in clean trays, with large end up, and in cases previously cooled to the same temperature.

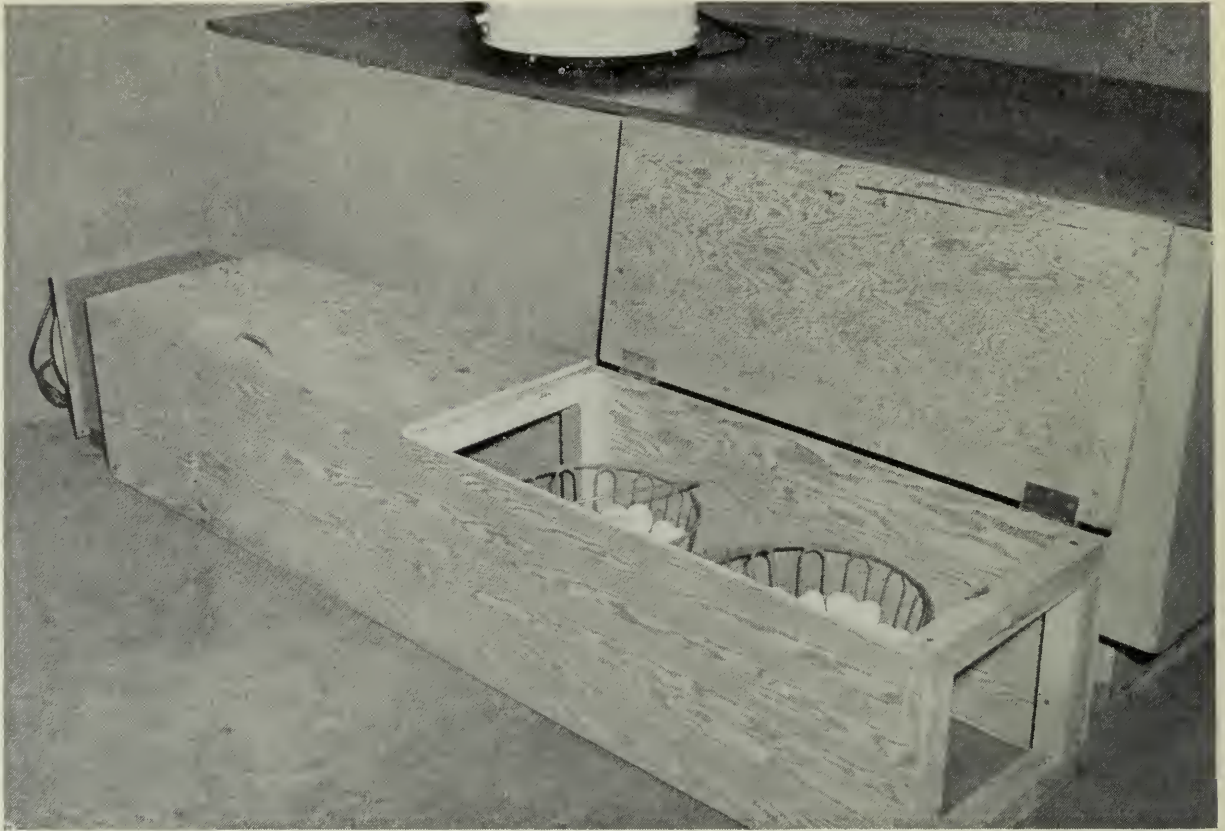


FIG. 44. An easily constructed drying tunnel for drying washed eggs. A fan at one end forces warmed air around and through the baskets of eggs.

8. Clean egg rooms are an important aid in the marketing of top-quality eggs. Eggs exposed to the contaminated air of a dirty egg room have been shown to become heavily contaminated with mould spores and bacteria (32).

### Special Cautions

1. Eggs must not be soaked, or washed in cold or dirty water. These practices are the most common causes of poor keeping quality, air cell mould, black rots, and of sour rots caused by *pseudomonas* contamination.

2. Too-hot water and/or too-prolonged washing may result in stringy coagulated albumen, as seen when candled and when broken out.

3. Produce clean eggs—but *if eggs must be washed, wash with care.*

### By Avoiding *Pseudomonas* Infection

It has been reported authoritatively that contamination of shell eggs with the essential trace nutrient, iron has a profound effect in increasing both the rate and extent of bacterial spoilage of eggs experimentally infected with certain *pseudomonas* organisms (*ovalis* and *fluorescence*).

The effect is probably due to the reversal of the protective action of the iron-binding protein conalbumen. It has been shown that this iron-binding egg white protein is the most important factor controlling the growth of these gram negative spoilage bacteria in egg white (33). Washing eggs in water having an abnormal iron content may, therefore, be a factor in the development of *pseudomonas*-contaminated eggs. Albumen

from such eggs has a sour odour and gives off a brilliant, light green colour under ultraviolet light (black light). Such eggs are known as sour rots and may be detected by use of an ultraviolet lamp in candling.

### **By Oil Treatment and Cold Storage**

Oil treating eggs with a white, odourless, paraffin base mineral oil can be of considerable value in retaining egg quality—both in the fresh egg trade and for eggs held in storage. By partially sealing the pores of the shell with oil, evaporation, with resultant egg weight loss, is reduced and cell size is kept small. Also, carbon dioxide escape is retarded; there is less increase in egg pH and, in consequence, less thinning of egg white. Oiling may be done at the farm after the eggs are cooled and before or while packing. The oil may be applied as a spray by means of an aerosol type or pressure hand sprayer, or as a dip. The latter method is less sanitary and may prove a source of contamination with dirty oil. Oil dipping is also more likely to leave an oily shell, less attractive to consumers. Sprayed eggs receive a lighter application confined mainly to the air-cell end. This degree of protection is unnoticed by most consumers.

Eggs may also be oil sprayed mechanically at the grading station (Fig. 23), though by this time more quality loss will have occurred. More frequent farm egg pick-up and use of modern spray equipment may make station spraying feasible and economical. O.A.C. tests indicate that, during the market period, oil-sprayed eggs may suffer less quality loss than untreated eggs by from 4 to 6 or more Haugh Units. The practice has fairly widespread use in the United States. Oiled eggs are often difficult to peel when hard-cooked.

Oil treatment for long-time storage of eggs of surplus production has been practised for some years. At times in the past, many thousands of cases were so treated and stored, the number dependent upon production, season, and Governmental policy. Currently, relatively few eggs are so stored and these only to private account. Eggs for this purpose are oil dipped or heavily sprayed by means of special equipment, then packed in new trays and cases to be stored at  $30 \pm 1$  degree Fahrenheit (eggs freeze at  $28.5^{\circ}\text{F.}$ ). Such storage practice is largely confined to eggs of Grade A quality. Eggs treated and stored in this way remain of high quality for upwards of six months (34). Storage rooms must be odourless, and must be maintained at very uniform temperature and a high degree of relative humidity (80 to 85 per cent R.H.). Special-type oils are required, specification for which will be found in the appendix.

### **By Storage in "Waterglass"**

Home storage of eggs is sometimes practised by immersing them in a mixture of water and sodium silicate, commonly known by the trade name of "Waterglass". Eggs so stored will keep fairly well for several months. The albumen tends to take on a pinkish cast in eggs stored for longer periods. Storage in this manner may be worthy of consideration where seasonal egg price and other special conditions warrant such action. In most areas, year-round production is such that fresh eggs are available at all times at reasonable prices. Waterglass is inexpensive and may be purchased at some grocery and general stores with full direction for use supplied on the wrapper.

### **By Overwrapping of Cartoned Eggs**

Overwrapping of cartoned eggs with a "Cellophane" cellulose film has been reported as another way of extending keeping quality of eggs—by retarding evaporation and also CO<sub>2</sub> loss.

## **XXI HOW TO RETAIN SUPERIOR EGG QUALITY**

Having outlined the conditions that affect egg quality and that normally result in superior quality, how can this quality be most completely retained to time of consumption?

### **By Frequent Gathering**

Three to four gatherings per day, as this results in less breakage, fewer dirty eggs, and more rapid cooling.

### **By Proper Cleaning**

To assure attractively clean eggs to the consumer and better grades for the producer. Eggs must be quickly dried after cleaning to best conserve quality.

### **By Rapid Cooling**

Extensive experience has convinced the author that it is next to impossible in summer, and difficult at other seasons, to market eggs of consistently superior quality through any "quality programme" without adequate refrigeration on the farm. Best results follow cleaning immediately after gathering, of all eggs requiring it, then cooling for 12 to 24 hours to at least 55°F. (better 50°F.) before packing in cases or cartons. It requires that length of time to bring warm eggs down to the recommended temperature. Lower temperatures than 50°F. are impractical for farm cooling rooms and may cause "sweating" when eggs are removed.

### **By Holding Under Controlled Humidity**

Relative humidity of holding room should not drop below 60 per cent R.H. nor rise above 85 per cent R.H.; 70 to 80 per cent is optimum, as this degree of humidity will sufficiently retard evaporation to keep air cells small, without danger from moulds.

### **By Careful Handling**

To avoid breakage and to prevent damage to the air cells as well as to the general interior egg structure, thus conserving quality and avoiding loss.

### **By Proper Packing**

It is important to pack all eggs large end uppermost, and to see that trays and flats fit the cases snugly. Improper packing results in poorer quality and lowered grades. It is also important to pack all eggs in pre-cooled containers only—cases held in the cooler overnight or at least for several hours until thoroughly cooled.

### **By Frequent Marketing**

Twice per week marketing or oftener is essential to shorten the period between production and consumption. Frequency will be conditioned



FIG. 45. A refrigerated egg truck.



FIG. 46. Cornell egg vendor. An excellent refrigerated egg sales cabinet for use in a poultry farm sales room or small retail store.

by size of flock, refrigeration on the farm, and method of marketing. Grading station pick-up trucks need to be insulated and probably refrigerated. Economy of pick-ups is conditioned by number of cases of eggs per call, the number of calls required per load, and the distance travelled. Thus the collection cost per case may vary widely.

### **By Moving Eggs Rapidly Through the Marketing Channels**

- (a) Rapid and efficient handling in grading stations with adequate refrigeration facilities and controlled humidity in storage room or rooms.
- (b) Speedy transportation by insulated or, preferably, refrigerated truck to retail or wholesale outlet.
- (c) Frequent delivery to retailers—at least twice and preferably three to five times per week.

### **By Up-to-Date Merchandising**

- (a) Adequate refrigerated holding space at retail outlets.
- (b) Sale of all eggs from properly refrigerated self-serve counters.
- (c) Having all eggs cartoned attractively and marked as to grade; also brand if so desired. Carton colours for the several grades and brands should be so designed as to avoid confusing the



FIG. 47. Cartoned eggs identified as to grade, attractively exposed for sale in a refrigerated, self-service, chain store egg counter. Many retailers market by brand in addition to grade.

customers. Attractive cartons containing clean eggs of uniform shell colour, uniform yolk colour, and dependably uniform high interior quality will undoubtedly result in increased sales and consumer satisfaction.

### By Proper Care of Eggs in the Home

This involves holding all eggs in the home refrigerator at 45 to 55°F. until required for use. For best results holding time should not be extended beyond one week.

It must be realized that eggs are a perishable product. Careless handling at any one point in the egg handling and marketing programme *will be reflected to a corresponding degree in lowered quality*—and to some extent by less enthusiastic consumer acceptance.

Strategically located producers with adequate year-round volume may find direct marketing by means of a temperature-controlled roadside egg vendor a profit possibility (Fig. 48).



FIG. 48. A roadside egg vendor in use by an egg producer.

Courtesy Conrad Poultry Farm, Michigan, U.S.A.

# A P P E N D I X

TABLE 1 — EGG PRODUCTION IN CANADA—1960

	Total Production*		Graded in Registered Grading Stations		Average** Production Per Layer
	By Province '000 Dozen	Percentage of Total	'000 Dozen	Percentage of Total Production	
B.C.	38,431	8.5	20,063	52.2	204.8
Alta.	45,456	10.1	14,666	32.3	179.2
Sask.	39,248	8.8	8,135	20.7	172.4
Man.	39,857	8.8	20,628	51.8	185.9
Ont.	193,762	43.0	112,066	57.8	205.8
Que.	58,641	13.0	20,104	34.3	192.2
N.B.	8,130	1.8	947	11.6	185.6
N.S.	21,439	4.7	8,989	41.9	204.9
P.E.I.	6,086	1.3	2,837	46.4	180.1
Total	451,050	100.0	208,435	46.2	195.2

\* Estimates.

Dominion Bureau of Statistics and Canada Department of Agriculture.

\*\* Estimates on Hen-Month Basis.

TABLE 2 — EGGS: RECEIPTS AT REGISTERED GRADING STATIONS  
BY PROVINCES — 1959

Percentage Distribution By Grade

	Ex. A Large	A Large	A Medium	A Small	Peewee	B Grade	C Grade	Cracks	Total Eggs Cases
B.C.	2.2	58.2	24.8	5.7	0.5	3.1	0.7	4.8	660,036
Alta.	4.8	44.9	21.7	4.2	0.2	19.4	2.1	2.7	563,471
Sask.	7.8	30.9	13.0	2.1	....	37.7	5.2	3.3	367,358
Man.	6.2	50.0	19.6	4.2	0.2	14.6	1.4	3.8	767,903
Ont.	12.7	49.9	21.6	5.5	0.6	4.5	1.4	3.8	3,816,699
Que.	17.2	45.1	21.1	6.4	0.5	4.9	1.4	3.4	740,382
N.B.	.0	53.0	21.0	7.1	1.3	11.6	2.6	3.4	31,814
N.S.	3.4	50.6	28.0	6.8	0.6	6.2	0.6	3.8	312,799
P.E.I.	.0	68.5	15.1	1.9	....	10.9	1.5	2.1	99,440
*Nfld.	6.8	51.1	25.5	8.5	0.3	3.5	0.8	3.5	10,006
Canada	10.1	49.1	21.4	5.2	0.5	8.4	1.6	3.7	7,369,908
**CANADA	8.9	49.9	21.3	5.3	0.5	9.1	1.8	3.2	

\*\* Years 1955-1959 inclusive.

Poultry Products Market Review, Canada Department of Agriculture.

\* Sept. 1 to Dec. 31 only.

TABLE 3 — EGGS BROKEN IN REGISTERED PLANTS FOR FREEZING  
Percentage Distribution by Year and Grade

	A Ex. Large	A Large	A Medium	A Small	Peewee	B Grade	C Grade	Cracks	Total Cases
1952	6.9	20.4	2.9	0.09	....	48.9	12.3	8.5	395,919
1953	4.2	15.1	0.3	0.02	....	64.4	10.6	5.3	376,334
1954	6.7	27.1	0.5	0.3	0.5	48.8	9.1	7.0	368,364
1955	9.1	26.5	0.5	0.03	0.1	49.8	8.0	6.0	406,102
1956	11.5	8.1	1.8	0.2	0.2	60.2	12.1	5.9	388,447
1957	8.1	20.7	2.1	0.3	0.2	53.3	10.3	5.0	641,388
1958	9.7	3.0	0.2	0.3	0.4	63.5	14.8	8.1	423,614
1959	21.4	25.3	1.8	0.3	0.2	33.4	9.6	8.0	709,305

Poultry Products Market Review, Canada Department of Agriculture.

TABLE 4 — FROZEN EGG PRODUCTION<sup>1</sup> AND DOMESTIC USE IN CANADA<sup>2</sup>  
'000 lbs.

Year	West*	East**	Total	Total Domestic Disappearance
1950	5,268	9,043	18,989	....
1951	7,276	3,644	10,920	13,753
1952	9,148	6,586	15,734	14,533
1953	11,467	3,703	15,170	16,316
1954	8,716	6,147	14,863	14,244
1955	10,204	6,147	16,351	20,523
1956	9,319	6,691	16,010	16,089
1957	17,341	8,292	25,633	17,555
1958	11,039	5,928	16,967	17,728
1959	14,523	14,167	28,690	20,302
1960	12,610	9,190	21,800	19,613

<sup>1</sup> Canada Department of Agriculture.

<sup>2</sup> Dominion Bureau of Statistics.

\* Manitoba and West.

\*\* Ontario and East.

TABLE 5 — OIL SPECIFICATIONS FOR STORAGE EGGS

Specific Gravity at 60°F.	—	0.835 to 0.860
Saybolt Viscosity at 100°F.	—	70 to 90
Flash Point ASTM	—	300°F. or over
Saybolt Colour	—	30 plus
Pour Point ASTM	—	preferably over 40

On a commercial basis 1 gallon of oil is required per 600 dozens of eggs  
(20 cases)

The number of cases per gallon depend upon:

The type of oil used  
Temperature  
Type of oiling equipment  
Internal egg temperature

Canada Department of Agriculture.

TABLE 6 — FREQUENCY DISTRIBUTION OF HAUGH UNIT SCORE  
(Based on 23 egg sample the first week, 11 eggs each succeeding week)  
Producer A2 — 800 birds — age 9 months (July)

Haugh Units	July			August					September				October				November			
	13	20	27	3	10	17	24	31	7	14	21	28	5	12	19	26	2	9	16	23
99+																				
96-98																				
93-95	1				1															
90-92	1			2	2		1	1	1		1						1			
87-89	2	1	3				1	1		2	1		1	1		1		1	1	1
84-86	1	1	1	1	2	2		1	1	1	1			2	2	1		1		
81-83	4	2	3	4		2	1	1	2	4	5	1	1		3	1	2		1	
78-80	3	1	1	1	4	2	2	2	2	1	1	2	4	2	2	3	1	3	1	4
75-77	8	4	1	1	1	3	3	2		1	1	2	1	1	1	3	2	4	2	2
72-74	1		2	1		1	1	1	1			3	3	2		2	2	1	2	1
69-71	2	2		1					1			2	1	2	3		2	1	3	1
66-68						1	2	2	2			1		1			1			1
63-65									1											1
60-62											1								1	
57-59																				
55-56																				
51-54																			1	
48-50										1										
45-47																				

Percentage of Grade A for 20 Weeks=93.34.  
Average Haugh Unit Score for 20 Weeks=77.80.  
Dept. of Poultry Science, O.A.C., Guelph, 1960.

TABLE 7 — FREQUENCY DISTRIBUTION OF HAUGH UNIT SCORE  
 (Based on 23 egg sample the first week, 11 eggs each succeeding week)  
 Producer A8 — 4,500 birds — age 16 months (July)

Haugh Units	July			August							September				October				November			
	13	20	27	3	10	17	24	31	7	14	21	28	5	12	19	26	2	9	16	23		
99+																						
96-98																						
93-95																						
90-92																						
87-89																						
84-86																						
81-83			1				1			1							1		1	1		
78-80		1						1		1						1	1		1	1		
75-77																						
72-74	1	1	1			1		1	1		1				1	1	2		3			
69-71		1	1	1			1	1	5	2		1	2	1		3		2	1	1		
66-68	4				2	2	1	1	2		1	5	1		2	1	1	1	1	1		
63-65	1	2	2		2	2	1	1	2	2	1	2		1	1	1	2	3	1	1		
60-62	4	2	1	3	1	1	1	2	1	1	1	2	3	2	2		2	2	2	2		
57-59	5			3	1	1				2	1	1		2	2	1	1	2		1		
55-56	1	1		1		1	1	1		1	1				2					1		
51-54	3		1	1	1	2	2				2					1	1	1		1		
48-50	1		3		2	1	1				2		2	3		1						
45-47		1	1	1	1		2	1												1		
42-44		1			1											1						
39-41								1														
36-38	1																	1				
33-35																						
30-32	1							1														

Percentage of Grade A for 20 Weeks=85.6.  
 Av. Haugh Unit Score for 20 Weeks= 61.4.  
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FIG. 49. "A dish fit for a king."

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