WATERY-WHITENESS OF MARKET EGGS.

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SUMMARY.

1. It was found impossible to measure the viscosity of thick egg albumen by the methods employed. Thin albumen, however, was found to be just as viscous in watery-white eggs as in those of first quality.

2. The defect appears to be confined to the apparent thick albumen only.

3. Watery-white eggs kept almost as well as first quality over a 14-day period. The differences were not large enough to warrant the inclusion of watery-white eggs with second quality eggs, whose keeping quality was very poor.

4. No evidence of bacterial infection was found in watery-white eggs, and efforts to transfer the defect to normal eggs using the watery-white albumen as inoculum were unsuccessful.

INTRODUCTION.

An ideal egg is generally taken to be one having a clean shell, possessing desirable size and shape and, on breaking, exhibiting a firm round yolk well supported by a considerable amount of apparent thick albumen. Its appearance, odour and flavour must be attractive. Any abnormality must, of course, be expressed in terms of departure from this ideal. A watery-white egg exhibits a weakening of the albumen as a whole, but more particularly a lack of firmness of the apparent thick albumen. On candling, the defect seems to result not only in a more freely mobile yolk than usual, but frequently also in a movable air cell. Queensland Egg Board graders report that the defect is often associated with a large air cell, which is usually an indication of ''staling'' of an egg. On breaking a watery-white egg, the thick albumen instead of supporting the yolk tends to spread itself away from the yolk.

Queensland records concerning the incidence of the defect are unobtainable. Some graders report that in many instances a very high percentage of the eggs graded as second grade has been watery-white. There can be no doubt, however, that the trouble is of frequent occurrence, particularly during hot weather. The defect does not appear to be confined to aged eggs. One of us (P.R.) has noticed the defect in eggs immediately after they were laid. Anderson (1938) has also reported that some eggs are laid as watery-whites. The question is raised whether the defect is confined to a weakness of the envelope of thick albumen. It appears likely that a weakness or rupture of the thick envelope would cause an apparent watery condition.

This investigation was carried out during February, 1944. Primarily the answers to two questions were sought:

(1) Is the keeping quality of watery-white eggs so inferior to that of first quality that their grading as second quality is warranted on this defect alone?

(2) Is watery-whiteness of bacterial origin, being transferable from one egg to another?

GENERAL CONSIDERATIONS.

Candling as a Measure of Egg Quality.

There can be no doubt that candling is at present the only satisfactory method of grading eggs for a general market, but the very indirectness of the method itself places emphasis on the need for great care in the interpretation of candling observations. Hoover (1938) found a lack of correlation between candling grade and the interior quality of eggs, while in Australia Anderson (1936) has stated: "It is almost impossible to get two graders to grade alike. . . . . This is one of the principal difficulties confronting the egg trade. No form of mechanical testing for quality appears feasible at this juncture."

Albumen Quality.

Considerable interest has centred round the study of the albumen of eggs and factors which affect albumen quality. The percentage of thick albumen in eggs is a heritable characteristic, being a feature of the individual hen (Knox and Godfrey, 1938). The effect of inheritance with respect to albumen quality has also been studied by Wilhelm and Carver (1940 a and b) and Evans and Carver (1942). There is a distinct seasonal effect upon the percentage of thick albumen (Hunter *et al.*, 1936; Knox and Godfrey, 1938; and Wilhelm and Heiman, 1938). The amount of firm albumen has no bearing on its quality (Van Wagenen and Wilgus, 1935). Eggs rapidly lose albumen quality after they are laid. Besides temperature and humidity a time factor may be responsible for such deterioration (Wilhelm, 1939). Conrad and Scott (1939) have found that the wateriness of albumen produced by storage is not due to any enzymatic hydrolysis of the mucin present; in fact, if any decrease in the amount of mucin occurs it must be due simply to the effect of pH. The microscopic structure of the gel is unchanged, so that the change in properties must be due to a change in elasticity of the mucin fibres. The decrease in pH plays a very important part in this change. According to Wilhelm and Heiman (1938) albumen quality is unaffected by environmental temperature of the laying stock. Temperature of transport and storage, however, does affect albumen quality (Anderson, 1936; Wilhelm and Carver, 1940b; Evans and Carver, 1941; and Brant, 1943) and may increase the percentage of watery-whites (Anderson, 1936). Humidity of storage, according to Wilhelm and Carver (1940b), also affects albumen quality, but in contradiction of this Evans and Carver (1941) found that the relative humidity had little effect on the albumen index at a given temperature.

Tremulous Air Cells.

Hoover and Rogers (1939) have shown that both the candling process itself and several hours of transport cause a lowering in grade. It must be presumed that this lowering in grade results from the presence of tremulous air cells, since the evidence of other workers (Almquist *et al.,* 1934; Knox and Olsen, 1936; and Wilhelm, 1939) leads to the belief that rough handling will produce tremulous air cells but leave the albumen quality unaffected. Stidston (1939) stated: "The term 'watery-white' is often regarded as synonymous with the term 'tremulous air cell.' Watery-white does not necessarily mean that the egg has a small amount of thick white present. They are usually determined by observation of the air cell in candling and of its behaviour on rotating the egg."

All first quality eggs (6 dozen) used in the experimental work to be discussed were entirely free from tremulous air cells, but such air cells were present in both second quality and watery-white eggs. This rather suggests that all eggs showing air cells departing in any degree from the rigid condition are discarded from the first quality grade.

Yolk Shadow.

One other aspect of candling—namely, yolk shadow—is worthy of mention. A perusal of Appendix 2 will show that every first quality egg exhibited a pale yolk, while the yolk of every second quality egg was dark. It is reasoned that this yolk colour has a profound influence on the visibility of the yolk in candling. The work of other investigators (Parker *et al.,* 1926; Parker, 1927; Stewart *et al.,* 1932; Almquist, 1933; and Sharp, 1937) substantiates this claim. Van Wagenen and Wilgus (1935), however, found a significant correlation between yolk visibility in candling and observed albumen quality. As the yolk shadow appeared more visible and mobile in candling the score of the condition of the firm albumen was poorer. The following table from Almquist (1933) shows the relation of yolk colour to yolk shadow.

Colour of Yolk.	Light Yolk Shadow.	Distinct Yolk Shadow.
	%	%
Pale	76	24
Medium	53	47
Dark	23	77

The question can be raised here, Is there any correlation between the uniformly dark yolks of second quality eggs and their inferior keeping quality? It may be true, however, that most eggs having dark yolks are produced in country centres from birds with access to range. In addition the distance from market would create a slight age handicap when graded at the Egg Board's premises in Brisbane.

EXPERIMENTAL.

The Viscosity of Watery-white Eggs.

Before any investigational work was done it was thought advisable to obtain some measure of the viscosity of egg albumen in order that the extent of wateriness might be expressed numerically. This proved difficult. Eggs commercially graded into first quality and watery-whites were brought into the laboratory and attempts made to measure the albumen viscosity. Initially an attempt was made to determine the rate of flow of liquid paraffin through the albumen, but this was unsuccessful despite the range of mixtures of liquid paraffin and kerosene employed. Following this a Hoppler Viscosimeter was procured.

This instrument permits the measurement of the rate of fall of a standard ball through an inclined column of the medium. The absolute viscosity in centipoises can be calculated simply from the fall time, the constants of the instrument and the density of the medium.

Egg albumen was separated by means of a wire gauze into thick and thin portions, but owing to the ability of the thick albumen to retain some of the less dense portion within its mucilaginous ''envelope'' the separation was never complete. As a result of this it was impossible to obtain readings with the thick albumen, the ball travelling in a jerky instead of a smooth manner.

With both thick and thin albumen it was found that the period of fall decreased rapidly with each successive attempt to obtain a reading. This was apparently due to the denaturation of the albumen in passing through the narrow gap between the ball and the tube wall. Readings were obtained with thin albumen but only the first two agreed to any extent. At least three eggs had to be broken before sufficient albumen was obtained to fill the tube. The results of these viscosity measurements are given in Table 1, and the relative quantities of thick and thin albumen for each egg are recorded in Table 2.

Table 1.

VISCOSITY MEASUREMENTS OF FIRST QUALITY AND WATERY-WHITE EGGS.

Grade.	Measurements with Hoppler. Viscosimeter on thin Albumen only.	
	Time of Fall in Seconds using Ball No. 2.	Approximate Viscosity in Centipoises assuming the Density of Albumen = 1. (Initial reading only taken).
First Quality (Thin albumen only)	Reading 1 20·0	5·3
	,, 2 19·1	
	,, 3 18·9	
	,, 4 18·0	
Watery-whites (Thin albumen only)	Reading 1 20·0	5·3
	,, 2 19·0	
	,, 3 16·3	
	,, 4 15·2	

It will be seen that the period of fall decreased more rapidly in the case of watery-white eggs, but the significance of this is not clear. In other respects the figures show the thin albumen of the two grades to be similar, which suggests that the defect is confined to the thick albumen only. The same result is shown by the figures for the relative quantities of thick and thin albumen given in Table 2.

Table 2.

RELATIVE AMOUNTS OF THICK AND THIN ALBUMEN IN FIRST QUALITY AND WATERY-WHITE EGGS.

Grade.	Amount of Albumen per Egg in c.c.		
	Thick.	Thin.	Total.
First Quality	15	13	28
	12	14	26
	17	15	32
	18	12	30
Watery-whites	19	15	34
	11	13	24
	18	17	35

Because of the difficulties associated with its use, and the limited results obtained with it, the Hoppler Viscosimeter was deemed unsuitable for routine determinations of albumen viscosity. Further attempts at measuring this factor were abandoned.

Wilcke (1936) used the torsion pendulum to measure the viscosity of the contents of eggs without breaking the shell. His method measures the composite viscosity of all egg contents and not of any one component. His results lead to the conclusion that total egg viscosity could not be correlated with percentage volume or viscosity of the thin white nor with the volume of the thick white. Furthermore, the total egg viscosity is a characteristic of the individual hen and is not affected by feeding.

In the following work the appearance of the egg on candling and on breaking was used as the sole measure of its quality.

The Keeping Quality of Graded Eggs.

Twelve dozen graded eggs were obtained from the Queensland Egg Board. These eggs comprised four dozen first quality, four dozen watery-whites, and four dozen second quality exclusive of watery-whites. On arrival at the laboratory all eggs were candled, and one of each class was broken to observe the condition of the contents. An equal number of eggs from each class was stored at three temperatures—99°F., 75-80°F. and 50-55°F.—representing high temperature, summer room temperature and refrigerator temperature respectively. The temperature of the 99°F. incubator remained constant, and the temperature inside the refrigerator and the incubator at room temperature fluctuated within the above limits.

All eggs were candled and some were broken at regular intervals throughout the 14 days storage trial. Eggs were held with large end always upwards. Tables 3 and 4 give summaries of each lot of results; details of the examinations appear in Appendices 1 and 2.

Table 3.
SUMMARY OF CANDLING EXAMINATIONS.

Treatment.	Observations.
Refrigerator, 50–55° F. ..	All 3 grades of eggs kept equally well over 14 days
Room, 75–80° F.	Water-whites kept as well as 1st quality over 10 days, but 1 watery-white was bad after 14 days. Second quality deteriorated rapidly, all 2nd quality being unsaleable after 10 days
Incubator, 99° F.	Watery-whites kept equally as well as 1st quality. 2nd quality deteriorated rapidly. More cases of germ mortality occurred in watery-white eggs than in the other two groups.

Table 4.
SUMMARY OF BREAKING EXAMINATIONS*.

Treatment.	Observations.
Refrigerator, 50–55° F. ..	All eggs kept well up to 14 days, but 1st quality eggs were slightly better than watery-whites and watery-whites were better than 2nd quality
Room, 75–80° F.	Keeping quality of watery-whites was equal to that of 1st quality. 2nd quality were inferior after 7 days
Incubator, 99° F.	Watery-whites kept equally as well as 1st quality, but all eggs were unfit for retail sale after 7 days

* One egg from each group was broken and examined on each occasion.

It would appear from the results given in Tables 3 and 4 that, whilst second quality eggs are definitely inferior to first quality after storage at any temperature, this is hardly true in the case of watery-whites. In odd instances only did watery-whites deteriorate more rapidly than first quality and always the difference was slight. Anderson (1936) stated that eggs slightly affected with "watery-white" should not be graded out as of second quality.

Bacterial Examinations of Watery-white Eggs.

Suggestions have been put forward that the watery nature of the albumen may be of bacterial origin, either in the manner of a diseased condition of the laying stock or a bacterial infection of the egg. An examination of the relevant literature has shown that the bacterial content of eggs varies greatly and would appear to be dependent on a great many factors (Pennington *et al.*, 1914; and Haines and Moran, 1940). However, the general impression that can be gleaned is that a perfectly fresh egg produced by a healthy fowl under ideal conditions of cleanliness is usually sterile. Contamination after production may, however, be considerable, depending on the condition of the egg, particularly the shell, and on general conditions of environment. Haines and Moran (1940) found that bacterial infection of an egg through the shell is most likely to occur immediately after laying. In this state while the egg contents are cooling and contracting, resulting in the formation of the air cell, the inward suction is conducive to infection through the pores of the shell, particularly when the egg is dropped into moist and unclean nesting material. When the shell is cracked contamination is made still easier, such cracked eggs being most prone to internal moulding.

Whether or no the defect is the result of a diseased condition of the laying hens was not investigated. The bacterial condition of watery-white eggs was, however, examined.

The albumen from eggs graded as watery-white by the Queensland Egg Board was examined bacteriologically, and was found to be sterile to milk agar after aerobic incubation for 3 days at 37°C. An attempt was made to transfer watery-whiteness to sound fresh eggs, using "watery-white" albumen (0·1 ml.) as inoculum, but was unsuccessful. After 3 days at 37°C. the inoculated eggs were also sterile. It is concluded from these results that watery-whiteness is not the direct result of bacterial activity within the egg, despite the fact that albumen only was used as inoculum. It is considered highly improbable that bacteria confined entirely to the yolk would produce any thinning of the albumen and this the only change. The fact that the defect is known to occur in eggs immediately after laying adds strength to the belief that it is not bacterial in origin.

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APPENDIX 1.

DETAILS OF CANDLING OBSERVATIONS.

No. Days.	Temp. °F.	First Quality.	Second Quality excluding Watery-whites.	Watery-whites.
0	..	No. of eggs 48. All sound	No. of eggs 48, 36 clean, 12 soiled. Prominent yolks and large air cell—35 (7 soiled). Large air cell—10 (2 soiled). Soiled only—3 (3 soiled)	No. of eggs 48. Moveable air cell and apparently watery, 36. Fixed air cell (wateriness not readily discernible)—12
3	50–55	No change	No change	No change
	75–80	No change	1 egg showing deterioration	No change
	99	Yolks inclined to rise	1 egg definitely bad (discarded). Yolks more prominent in all cases	Yolks inclined to rise. (No greater change than 1st quality)
7	50–55	No change	No change	No change
	75–80	No change	2 more eggs showed yolks slightly more pronounced.	No change
	99	5 showing germ development (discarded) 3 of which alive; remaining 6 eggs sound	8 showing germ development (discarded); 7 alive; remaining 2 eggs sound	3 showing dead germ. All others equal to 1st quality
10	50–55	1 yolk rising	One yolk very high ..	One yolk very high
	75–80	Yolks elevated ..	Yolks very elevated. Have reached limit as a saleable egg	Yolks elevated
	99	2 discarded; 4 remaining showing some deterioration	Remaining 2 eggs discarded	All but 5 eggs discarded
14	50–55	1 yolk very high; all air cells slightly enlarged	One yolk very high; all air cells slightly enlarged	One yolk high; all air cells slightly enlarged
	75–80	All yolks very high ..	Deterioration very marked. 1 bad	All yolks very high. 1 bad
	99	All eggs discarded ..	..	All eggs discarded

APPENDIX 2.

Details of Breaking Observations.

One egg from each group was broken and examined on each occasion.

No. Days.	Temp. °F.	1st Quality			2nd Quality Excluding Watery-whites.			Watery-whites.		
		Yolk.	Albumen.	Colour.	Yolk.	Albumen.	Colour.	Yolk.	Albumen.	Colour.
0	..	High	Firm	Yellow	High	Slightly weak	Orange	High	Slightly weak	Yellow-orange
3	50–55	High	Firm	Yellow	Slightly inclined to flatness	Weak	Orange	Slightly inclined to flatness	Slightly weak	Yellow
	75–80	High	Slightly weak	Yellow	ditto	Weak	Orange	ditto	Weak	Yellow
	99	Flattened	Weak	Yellow	Flattened	Weak	Orange	Flattened	Weak	Yellow
7	50–55	High	Firm	Yellow	High	Firm	Orange	High	Firm	Yellow
	75–80	Slightly flat	Slightly weak	Yellow	Slightly flat	Slightly weak	Orange	Slightly flat	Slightly weak	Yellow
	99	Flat	Very weak	Yellow	Flat	Very weak	Orange	Flat	Very weak	Yellow
All eggs at high temperature had reached the stage of being unfit for retail sale.										
10	50–55	High	Firm	Yellow	High	Weak	Orange	High	Firm	Yellow
	75–80	Slightly flat	Fairly firm	Yellow	Flat	Weak	Orange	Flat	Very weak	Yellow
	99	Very flat	Very weak	Yellow	All	eggs bad		Very flat	Very weak	Yellow
14	50–55	High	Firm	Yellow	High	Weak	Orange	High	Weak	Yellow
	75–80	Flat	Weak	Yellow	Flat	Weak	Orange	Flat	Weak	Yellow
	99			All	eggs bad					

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