Obstacles in egg quality assessment

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The physical quality of an egg has long been an identified concern for consumers. Throughout the years, methods have been developed to assess egg quality in order to quantitate changes due to hen age, egg storage, genetic alterations, production practices, etc. Hand candling shell eggs to detect defects and assess quality has been found to be an economical means of screening. It requires some training and skill. The method can be highly subjective and variable from grader to grader. The Haugh unit (HU) has become one of the most accepted means of assessing egg quality. Companies are now marketing electronic devices to assist with HU determinations, but this equipment can be cost prohibitive. As the egg products industry has grown, so has the need for accurate methods to assess the quality and functionality of a wide array of products. Egg products are also used in a variety of products, such as frozen confections, bakery products and mixes, direct consumer products, etc. Customers often require certification of the safety and quality of ingredients entering a process. Many of the testing methods are highly subjective and variable. This can be due to the user and/or the laboratory. There have also been questions raised by researchers to the validity of some of the currently accepted egg quality determination methods. For this reason, more objective methods have begun to be developed for quality assessment of both shell eggs and egg products. This presentation will provide a critical review of available methods and technology as well as presenting research needs for egg quality assessment.

Key words: eggs; physical quality; functionality; quality determination

Introduction

The quality of eggs plays a major role in sales. Therefore, it is important for producers to have an understanding of the quality of the product they produce and the factors which affect that quality. Ultimately, “quality” is defined by the customer and their intended use for the product. Assessing egg quality has been a continual challenge for the egg industry. Many methods are subjective and make comparing results difficult. Objective methods often involve cost prohibitive equipment or supplies.

The natural variability of eggs also creates challenges in assessing egg quality. Determining the best physical orientation of the egg for each test should be addressed. There are many instances where multiple laboratories have conducting the same method, with the same equipment, but have placed the egg in different orientations, thus inhibiting the ability to directly compare the results. Furthermore, with eggs being variable on their own, it raises even more need for consistent testing methods between laboratories.
Ideal assessment methods would be cost effective, rapid, reproducible, and accurate. Hand candling and Haugh unit (HU; Haugh, 1937) are the most common methods for physical quality detection. Yolk index, albumen index, vitelline membrane strength, shell breaking strength and numerous other factors are often monitored for quality assurance. Functional quality is especially important for egg products. This review will focus on the advantages and disadvantages of the more common quality and functional assessment methods.

Physical quality

Hand candling has been utilized for an extended period of time as a non-destructive means to examine the overall quality of an egg. In 1949, Romanoff and Romanoff detailed the methods and principles of hand candling. Defects of the yolk, albumen and shell can be seen due to the back lighting of the egg by a concentrated light source. Furthermore, the size/depth of the air cell can also be determined. There are guidelines in place for egg grades based on candled egg quality in the U.S. (USDA, 2000). This is a very subjective method with the outcomes based solely on the perception of the grader. Bokhari et al. (1995) monitored the effectiveness of human graders in 12 processing facilities in the U.S. Line speeds were up to 240 cases/hr (86,400 eggs/hr). Graders working on the line to pull reject eggs. Of the reject eggs pulled, 17.3% were over-pull of acceptable eggs. Cage marks on the shell were responsible for 42.5% of the over-pull. The authors concluded that good employ training was imperative to reduce over-pull.

Raymond Haugh developed in the Haugh unit for quantifying egg quality in 1937. The equation takes into account the egg weight and height of the thick albumen and is weighted for a large size egg. U.S. standards for egg grades based on HU scores can be found in the USDA egg grading manual (USDA, 2000). One of the drawbacks of the HU is that the egg is destroyed during the assessment. HU measurements can be laborious depending on the equipment available. Newer electronic units have been developed and are available which decrease the amount of time necessary to examine a lot (100 eggs) of eggs. The electronic devices are costly and this can be prohibitive to some companies and researchers. Furthermore, the validity of the HU has been called into question due to the bias of the equation for large size eggs (Silversides, 1994; Silversides and Villeneuve, 1994). Currently, this is the most accepted method for egg quality assessment and the results are objective. One disadvantage of the HU is that the results are temperature sensitive. For this reason, tests should be conducted on eggs within a strict temperature range. The USDA guidelines specify a testing temperature of 7.2-15.6°C (45-60°F) (USDA, 2000).

Shell specific gravity and shell thickness have been utilized as a selection tool for breeders. Shell thickness can be directly measured with calipers. Through the years, it has been determined that shell thickness can be affected by the portion of the shell measured. For this reason, it is important to report the portion of the shell tested. Specific gravity is monitored by immersing eggs in tanks of salt water of set salinities to determine when the egg is suspended. Typical salinities utilized would range between 1.065 to 1.100. Stadelman (1995) makes note that specific gravity should only be conducted on fresh eggs since the formation and growth of the air cell can cause readings to be invalidated. Salinity tanks must also be monitored to ensure evaporation has not affected the set limits for each tank.

Methods for monitoring shell strength have become more precise as technology has advanced. Initially, shell compression strength was monitored through more subjective methods such as penetrometers, ball drops or weights placed on contact plates. More recently, Instron universal testing machines (Instron Ltd., Bucks, UK) and texture analyzers (Texture Technologies, Scarsdale, NY, USA) have been employed. With the advent of the more accurate computerized technologies, several of the previously accepted notions of shell strength have come into question. Jones and Musgrove (2005) found shell strength, as monitored by static compression, to be highly variable. Recent studies conducted in Europe have focused on determining dynamic shell strength (De Ketelaere et al., 2002; Lin et al., 2004). The authors report that dynamic shell strength is a more accurate determination of shell strength in
processing and distribution since they say eggs are exposed to more dynamic vs static insults through the distribution chain. In his review, Carter (1970) describes insults to the shell as multifaceted. When examining the effects of heat stress on egg quality, Lin et al. (2004) found a strong correlation between static and dynamic shell strength and they showed similar results for each treatment. Dynamic shell strength technology is relatively new and not widely marketed for laboratory use. With the newer static and dynamic strength detection methods come advantages and disadvantages. De Ketelaere et al. (2002) utilized different techniques to monitor shell strength and found that each method provided different information. These methods allow for a greater volume of more accurate information to be collected. The repeatability of the methods is high. Also, testing parameters are reported in publications allowing for readers to utilize the same settings for subsequent experiments. Conversely, new technology is often available at high costs and frequently in limited supply. There is also a greater amount of training involved with the more accurate assessment methods. The orientation of the egg during compression tests also varies between laboratories and can have an affect on the results.

Albumen quality has been monitored by a variety of methods, most of which are still frequently utilized. Albumen height is easily measured with a micrometer. When measuring albumen height, it is important to include how far from the yolk the thick albumen height was measured since there is a tapering effect as you approach the yolk or outer edge. Albumen weight is often calculated as the difference of egg weight minus yolk and dried shell weights. Researchers have also attempted to attain separate weights for the thick and thin albumen by cracking the egg onto a fine mesh screen and allowing the thin albumen to fall from the egg. The egg is then shifted back to a weighing dish and the yolk is removed. Skill is required when using this method to collect as much of the thick albumen as possible from the yolk in an attempt to obtain an accurate weight. The pH of the albumen has also been monitored as a means of assessing egg quality. The pH of the egg changes during storage, but also changes after the egg is cracked (Romanoff and Romanoff, 1949).

Yolk index has long been used as a measure of yolk quality. Yolk index is a calculation of the yolk width and height. In 1948, Funk determined that the measurement could accurately be conducted without separating the albumen from the yolk. Calipers are the only equipment required to conduct this measurement. Vitelline membrane strength and elasticity have been monitored for over three decades. Initially, vitelline membrane strength was detected by the vacuum created in capillary tubes (Fromm and Matrone, 1962). Static compression tests are currently utilized to detect membrane strength and elasticity. A variety of configurations have been reported including Allo-Kramer shear cells, puncture probes of varying diameters and extrusion cells. All configurations produce different results due to the size of the pressure zone. Lyon et al. (1972) have reported membrane strength to be greatest around the chalaza, so researchers make attempts to avoid the chalaza during testing. As was mentioned with the shell strength static compression test, the use of computerized static compression equipment allows for testing parameters to easily be transferred from lab to lab with the same equipment.

Yolk color is also an important quality factor. Two methods are generally used to examining yolk color: Roche color fan and L*, a*, b* color values. The color fan offers an affordable method for determining yolk color, but lack the precision of color analysis. Colorimeters are highly accurate but can be cost prohibitive. Both methods are acceptable in publications. Min et al. (2005) monitored yolk color with both a colorimeter and the Roche color fan. They found significant differences between treatments for colormetric readings and no differences in color fan scores.

**Functional quality**

Eggs serve many functional roles in foods. Therefore, it is not surprising that functionality tests have been developed. Initially, functional tests were relatively simple, such as whipping height for albumen or total solids for whole egg and its components. As the egg products industry began to expand, the functional tests became broader.
Whipping is frequently utilized for albumen functional analysis (Baniel et al., 1997). This can be conducted on several formats. Whipping heights are measured when a set volume of albumen is whipped for a set length of time and the height of the foam is measured. Whipping time is the amount of time it takes a set volume of albumen to reach a certain stage of foaming. This is a highly subjective measurement since the person conducting the test has to determine when the desired stage of foaming has been reached. Foam stability monitors how the foam breaks down during a set length of time. This is generally accomplished by placing a set volume of foam in a container and allowing it to set undisturbed for a certain amount of time, then measuring the fluid that has come out of the foam or monitor the volume displacement (Min et al., 2005). This method of analysis requires the foam to be placed into another container which means the foam is disturbed. The rate and amount the foam breaks down can be dependent on the way it is transferred to the measurement container which causes the method to be relatively subjective.

Angel food cake volume is a common method of testing albumen functionality. Sponge cake volume is often a test of whole egg functionality. Many of the published methods have to be altered due to the lack of availability of the original equipment. A set amount of batter is weighed into a baking pan and baked according to procedure. Cake volume is determined via rapeseed displacement. There is a great deal of variability in this analysis. The method requires the hand folding of the flour into the foam. Also, the sugar is added gradually during mixing. Both of these ingredients play a role in the potential volume of the cake. The manner at which they are added is purely under the control of the individual preparing the batter which can lead to great variability between people conducting the tests and between laboratories. Therefore, cake volume data cannot be directly compared. Trends in cake volume between treatments can be the best outcome. Shafer and colleagues (1998) reported significant differences in cake heights between their treatments, but no difference in cake volumes. This is an example of further variability in functionality testing based on cake volume performance.

Emulsion formation and stability are common methods for determining yolk functionality. Emulsion formation tests examine the strength of the emulsion immediately after it is has been prepared. Emulsion stability tests look at how the emulsion breaks down during a set period of time after preparation. The strength of the emulsion can be measured through compression or rheological testing. As mentioned during the discussion of shell strength and vitelline membrane strength testing, these methods can be simpler subjective measures or more complex object measurements. Once again, higher costs are associated with the more objective methods. As was noted in the previous paragraph about cake volume testing, emulsion formation also requires the gradual addition of oil as the emulsion is being formed which can cause variability between individuals performing the test. Emulsion stability can be measured by storing the product and conducting compression tests afterwards. Kiosseoglou and Sherman (1983) reported maximum viscoelastic properties were found quickly after mayonnaise preparation and flocculation occurred shortly thereafter. In a study conducted by Shafer et al. (1998), they found emulsion separation was not significant at 60 minutes, but was at 120 minutes. Differences in the methods of mayonnaise preparation could be responsible for the conflicting results. Examining the oil droplet size in the emulsion under a microscope has also been reported. Others have centrifuged the emulsion to determine the amount of oil that is forced from the emulsion.

Total solids of the whole egg, albumen and yolk play an important role in product functionality, especially in the field of egg products. Customers often require a certain degree of total solids in egg products to ensure the quality of the final product they will produce. Total solids can be determined quickly and easily. Curtis et al. (1986) published one such method. Common laboratory equipment is required, such as drying pans, dessicators, lab balance, transfer pipets and a drying oven. Results are also highly reproducible. Kuchida et al. (1999) also reported the development of an imagining method for detecting yolk:albumen ratio. Predicting it could be utilized in the processing line to divide eggs into functional categories for customer needs.

Many methods exist for determining the physical and functional quality of eggs and egg products. Often, these methods are subjective and variable. The objective methods can prove to be cost prohibitive for some but are accurate and reproducible. The egg industry and researchers need to work together to
determine the best methods for assessing physical and functional quality and develop new, affordable, objective technologies.

References


