

Evaluation of Colostrum Quality - A Narrative Brief Overview

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To cite this article:

Mohamed Mansour El-Loly. Evaluation of Colostrum Quality - A Narrative Brief Overview. *International Journal of Immunology*. Vol. 10, No. 2, 2022, pp. 19-24. doi: 10.11648/j.iji.20221002.12

Received: June 14, 2022; **Accepted:** July 4, 2022; **Published:** July 18, 2022

Abstract: The objective of this narrative review is to synthesize studies relating to the estimation of colostrum quality on farms before feeding neonates. This is one of the best ways to ensure that the colostrum management program succeeds in transferring passive immunity to provide sufficient protection from pathogens and improve their health. It should be rapid, inexpensive, and easy to use. Colostrum is the first milk secreted by female mammals immediately after birth during the first few days, and its composition differs from that of the mature milk. It contains unique components rich in nutritional micro and macronutrients, and many bioactive substances like antimicrobial factors, growth factors, which all newborn mammals need to develop the digestive system, resist microbial infections, and boost immune systems to promote lifelong health and immunity, it is a divine immune gift from the Creator. Consequently, newborns should receive sufficient high-quality colostrum containing optimal immunoglobulins (Igs) level within the first few hours after birth to protect them from pathogens until the immune system develops. Therefore, the estimation of colostrum quality should be routinely checked on farms prior to feeding neonates. Colostrum quality assessment is based on the Igs level, where high-quality colostrum is defined as having an IgG value ≥ 50 mg/mL, and it can be evaluated using direct or indirect methods. It can also be improved when factors affecting the nutritional and immunological composition are considered.

Keywords: Colostrum Quality, Immunoglobulins, Specific Gravity, Visual Evaluation, Hydrometer/Colostrometer or Refractometer, RID, ELISA, IR

1. Introduction

Colostrum Igs provide basic lifelong immunity to neonates, due to their high nutritional value, biologically active components that they need to help their growth and development, prevent infection, enhance bone marrow stem cells, reduce body fat, increase lean muscle mass, and aid in gastrointestinal tract maturation [1, 2]. Regular colostrum quality control and better management practices should be necessary for dairy farms [3]. Colostrum is essential for the neonates' survival, but high-quality colostrum is not always available. To classify the colostrum quality as satisfactory, international recommendations set an IgG level of at least 50 g/L [4, 5]. Colostrum is a great immunologically important nutrient for mammalian newborns. They should be fed the first 2-6 h of birth at least minimum 3-4 liters of high-quality colostrum (IgG level ≥ 50 mg/mL) per calf to protect them from pathogens until its own immune system is developed [6-9].

There are two factors to consider that affect the colostrum quality, the first is the high level of Igs, the second is the total number of bacteria (must be less than 100,000 CFU/mL), pathogen load (must be free of *E. coli*, salmonella, etc.), where incorrect collection, heat treatments, or storage of colostrum can expose newborns to ingesting many pathogens. These increase the risk of diseases and decrease their ability to absorb antibodies [10]. Colostrum should be tested for quality to avoid feeding low or poor quality, whereas feeding newborn calves on poor quality colostrum increases morbidity and consequently higher mortality, it leads to failure of passive Igs transport, which has been associated with an increased risk of various diseases and death early in life. They also found that Brix refractometer is an acceptable tool for estimating colostrum quality and the transfer of passive immunity in buffalo calves [11].

A few farms routinely measure colostrum quality, and often use imprecise tests such as visual examination [12, 13].

To improve the management of colostrum in farms, quality control devices should be rapid, cheap, accurate, and easy to use [14]. Therefore, the estimation of colostrum quality in farms by measuring Igs content before feeding the calves is a useful tool to improve their health [15-17].

Many studies have been described to assess colostrum quality by measuring the Igs level through direct tests such as ELISA kits [18, 19], and mid- or near-infrared spectroscopy [20-22]. Other indirect tests have been developed by relating the content of Igs to specific gravity (SG) [14, 23], and refractive index [16, 24].

Colostrum quality is affected by several factors such as breed [25, 26], birth season [27], parity [23, 28], time between birth and colostrum collection time from birth to the first milking [29-31], the first colostrum yield [23, 32], the length of dry period [23, 33], hygiene procedures during the colostrum collection [34]. It can be improved through proper management of farm animal herds and hygiene practices [35]. There is a correlation between cow's nutrition in the dry period and colostrum quality [36]. The quality of colostrum can be improved when factors affecting its nutritional and immunological composition are taken into account [37].

2. Colostrum Quality Measuring Instruments

Colostrum quality should be tested to avoid poor or low-quality newborn feeding, using direct or indirect instruments for this regard.

2.1. Direct Instruments

Direct tools that measuring Igs such as visual evaluation, RID, ELISA and IR.

2.1.1. Visual Evaluation (Color and Viscosity)

Color and viscosity of colostrum give an initial impression of the colostrum quality, visual viscosity has been classified into three types, watery, liquidy and thick [38]. Visual assessment of colostrum is closely related to its quality, it is commonly depends on the appearance and clear viscosity although these techniques are inaccurate and highly subjective. Producers should not feed calves with watery or bloodstained colostrum [27]. Colostrum has a wide color spectrum and reflects its quality, which a paler or mature milk-like color correlates with lower colostrum quality about the total composition compared to a more yellowish and darker color [39]. Colostrum quality by visual evaluation (its color and consistency) has the lowest accuracy when used alone compared with currently available tools, and can be used for other purposes such as detecting undeliverable milk. It depends on the idea that darker colored and thicker colostrum will be more concentrated with higher Igs value; this colostrum can be used for many purposes. This assessment becomes more valuable when used with other indirect tests such as a colostrometer or refractometer [40]. The visual evaluation tool was used to track color changes

from colostrum to normal (marketable) milk to identify unsuitable for the dairy industry [41]. Additionally, the color measurement used to predict goat colostral IgG levels, and confirmed its high sensitivity and suitability, depending on the first and second milking samples and the perceptual changes in color distances [42]. The visual evaluation should not be trusted as an accurate way of colostrum quality.

2.1.2. Infrared (IR) Spectroscopy

Infrared spectroscopy is a fast and accurate method for evaluating the quality of colostrum, but is a laboratory method. A mid- or near-infrared spectrum was used to assess the colostrum quality and the IgG level was calculated via MATLAB software according to [20-22]. IR tool is small, rapid, low cost, requires minimal sample preparation, and is used in the farm, small laboratories or veterinary clinic [43-45]. More recently, the near-infrared spectroscopy has been suitable to evaluate the quality of colostrum recommended for human and animal use, because it is a cost effective, reliable, rapid, and easy to use [46].

2.1.3. Radial Immunodiffusion (RID) Assay

It is considered the golden reference, laboratory method, a direct, quantitative method for estimating actual Igs level in colostrum as described by [47], which is performed in the laboratory using standard protocols. Each sample (5 μ l) was placed into a well of plates, the diameters of the precipitated rings were read after 24 h of diffusion at room temperature in a humid atmosphere, then the actual values were estimated by comparing precipitation zone diameters from calibration curves plotted using serial dilutions of standard Igs fractions. Despite their accuracy, it is expensive and results take more than 24 h, so this test is not a practical method to assess the quality of colostrum daily.

2.1.4. Enzyme-Linked Immunosorbent Assay (ELISA)

An ELISA immunoassay kit has also been used for the same purpose as the RID assay [19, 48]. These techniques (RID, ELISA) are lab-dependent, costly, time consuming, and not suitable for working in farm conditions. However, both methods can be used to verify other indirect accuracy measurements [49].

2.2. Indirect Instruments

Indirect tools (hydrometer or colostrometer, refractometer) that measure Igs are most practical for rapidly assessing the colostrum quality at dairy farms, and should be reliable, accurate, cheap, and easy to use.

2.2.1. Hydrometer or Colostrometer

Hydrometer is also known as a colostrometer, which is a glass float immersed in a cylinder containing colostrum. There is a relationship between antibody level and SG, which can be estimated using a device, it is easy to use and the results are immediate. SG reading indicates an estimate of the colostral Igs level from the regression analysis equation. From this, the colostrometer tool was developed for practical field use. A hydrometer or colostrometer is a

very simple and low-cost instrument for providing an estimate colostrum quality at dairy farms. It is designed to float in the colostrum sample and measures SG and reading of poor, good and excellent colostrum quality, on the other hand, there is a colored chart to estimate the IgG level in the sample. When the IgG level in the colostrum is high, it will be denser and hence the SG reading will increase. Its readings are affected by temperature, foam, and the ratio of fat/total solids [50].

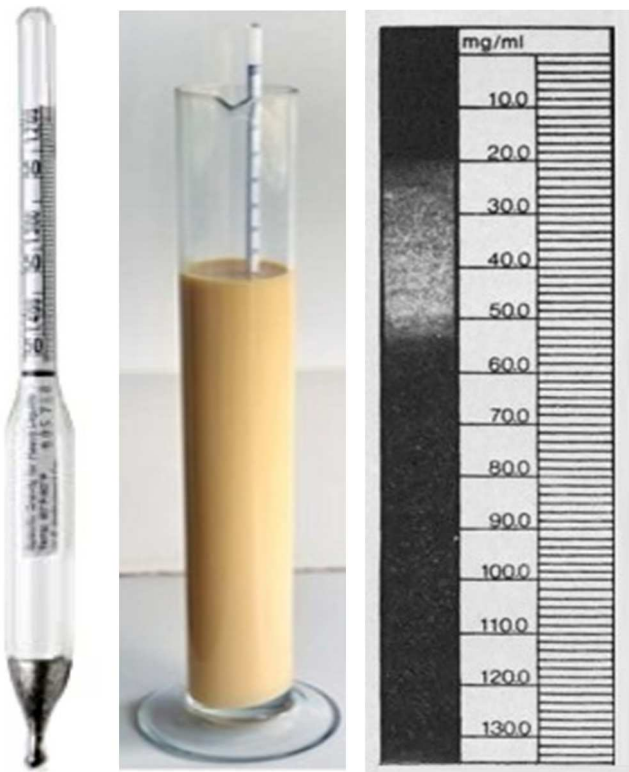


Figure 1. Colostrum quality measuring using a hydrometer.

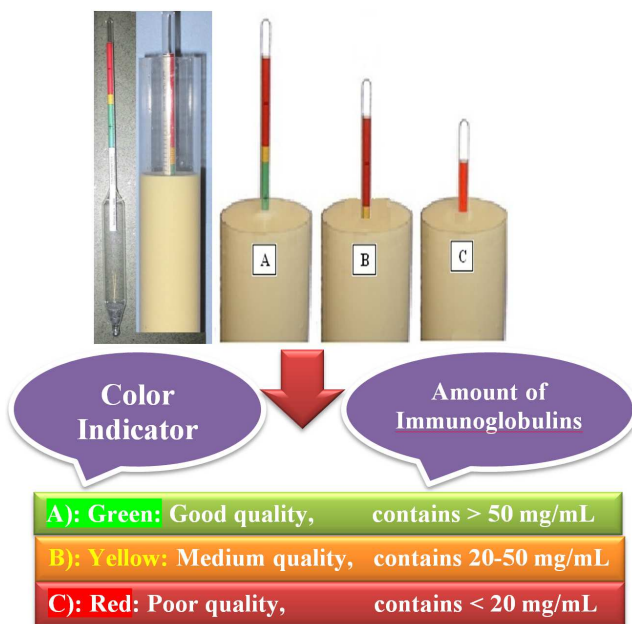


Figure 2. Colostrum quality measuring using a colostrimeter.

A colostrimeter is more effective than a visual assessment of colostrum, but it is sensitive to temperature and float glass easily breaks and becomes expensive to change. To best results, if colostrum is measured after collection, wait at least 10-20 min., in a narrow temperature range always at 20-22°C, and insure that there is minimal froth at the top of the sample. Calves should not be fed poor quality colostrum for the first 24 h of life, but they can be used as a valuable food on the second or third day. Poor colostrum is also mixed with good colostrum to feed the newborns that may reduce their mortality [51]. Colostrum IgG (mg/mL) assessed by a colostrimeter at an ideal temperature of 37°C (Pfizer Animal Health GmbH, Germany) [14, 52]. Furthermore, colostrimeter and refractometer are used to estimate the colostrum quality (IgG level) of German Holstein dairy cows [21, 53-58]. Figures 1 and 2 illustrate the descriptions of these tools.

2.2.2. Refractometer

A refractometer is a simple yet effective method for assessing the quality of colostrum, the device measures how much light is refracted from the path of light as it passes through the sample. While in colostrum, proteins cause the light to be refracted, and a high level of protein leads to increased refraction of light. It is commonly used in medicine to measure body fluid levels and in agriculture to measure the sugar level. It relies on the use of light to determine the liquid density, and has different measurement scales depending on its intended use. To measure colostrum quality with good accuracy, a refractometer calibrated in the Brix scale is used. Values are read as an IgG percentage [10, 56]. Similarly, Chigerwe et al. [55] used a hand-held digital refractometer DR201-95 (A. Krüss Optronic, Germany) to measure Brix% and refractive index. Brix refractometer of $\geq 20\%$ (50 mg/mL) IgG corresponds well compared to $\leq 20\%$ Brix (≤ 50 mg/mL) IgG corresponds to low-quality colostrum. Moreover, a Brix refractometer, either optical or digital provide great benefits as useful management tools to be included in the colostrum monitoring program on dairy farms to improve the health of newborns, they are accurate enough, require only a few drops, the results are almost instant and used at any temperature due to be unaffected by it as in a colostrimeter [56]. A Brix value of 22% is the appropriate limit to determine whether colostrum is of acceptable quality (colostrum $\geq 22\%$ should be measured), so any colostrum used for the first feeding should be $\geq 22\%$ Brix. It is equivalent to an IgG level of 50 g/L, which starts in the green region (good quality) on a colostrimeter scale, but the yellow area contains 20-50 g/L (medium quality), and the red area contains < 20 g/L (poor quality). A digital refractometer is more expensive but more convenient, easier to use and gives an accurate reading [59]. Figure 3 shows two types of refractometer, an optical device, which measures the amount of refracted light by placing a few drops of colostrum in the device's prism, and look at the light through eyeglass to determine where the line falls on the Brix scale. While in digital, also put a few drops of colostrum in the prism, a digital reading will appear on the Brix scale.

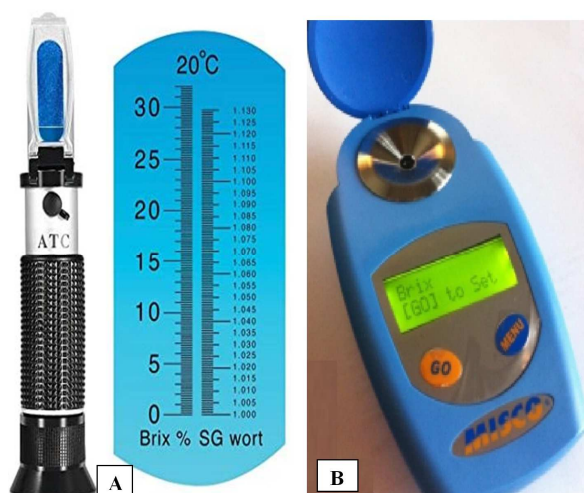


Figure 3. Both optical (A) and digital (B) Brix refractometers.

3. Conclusions

This review points out the importance of assessing colostrum quality on farms, where it should be routinely checked prior feeding newborns, and is a useful tool for improving their health through successful transmission of passive immunity and provide sufficient protection from pathogens. Assessment of colostrum quality depends on the level of Igs, and can be evaluated using several direct or indirect techniques. It can also be improved when factors affecting nutritional and immunological composition are taken into account. To classify the quality of colostrum as satisfactory, international recommendations specify an IgG level of at least 50 g/L.

Abbreviations

Igs: Immunoglobulins, IgG: Immunoglobulin G, ELISA: Enzyme-linked Immunosorbent Assay, IR: Infrared, RID: Radial Immunodiffusion, SG: Specific gravity.

Conflict of Interest

The author declares that he has no competing interests.

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