Visión Electrónica Vol. 19 No. 2 (2025) • Julio-Diciembre • ISSN 1909-9746

UNIVERSIDAD DISTRITAL FRANCISCO JOSÉ DE CALDAS

Visión Electrónica
https://doi.org/10.14483/issn.2248-4728

VISIÓN ELECTRÓNICA

A RESEARCH VISION

Development of a color classification algorithm in processed milk using RGB image analysis with computer vision

Desarrollo de un algoritmo de clasificación de coloración en leche procesada: análisis de imágenes RGB usando visión computacional

Jose Ivan Avila Arias[1], Daniel Felipe Capera León[2], Maria Paula Guevara Tovar[3], Nayive Nieves Pimiento[4]

INFORMACIÓN DEL ARTÍCULO

Historia del artículo:
Enviado: 23/05/2025
Recibido: 01/07/2025
Aceptado: 17/11/2025

Keywords:
Programming algorithm
Quality
HSV
OpenCV
Perception
Python
RGB
Streaming
Computer vision

Palabras clave:
Algoritmo de programación
Calidad
HSV
OpenCV
Percepción
Python
RGB
Streaming
Visión por computador

ABSTRACT

This document presents the design and testing of an optical sensor based on computer vision to detect the ideal color quality of processed milk through the reflection of a white incident light source, with the aim of being used in industrial dairy production quality visual testing, the system is designed with the use of a digital camera acting as a photodetector and a Python programming algorithm using the OpenCv library, which allows the detection and identification of color and its translation from Red, Green, Blue (RGB) to Hue Saturation Value (HSV). To minimize human intervention in the process, the system detected the coloration of previously evaluated and recognized samples of good quality and took these color values to calculate a non-rejection range, then evaluated an individual sample and classified it as ideal or non-ideal color quality, and finally recorded the results obtained from the tests.

RESUMEN

En este documento se presenta el diseño y pruebas de un sensor óptico basado en la visión computacional para detectar la coloración de calidad ideal de la leche procesada por medio de la reflexión de una fuente de luz blanca incidente, con la finalidad de ser utilizado en las pruebas de calidad visual de una cadena de producción industrial lechera. El sistema está diseñado con el uso de una cámara digital la cual actúa como fotodetector y un algoritmo de programación en

1. Industrial Engineering student, Universidad Distrital Francisco José de Caldas, Faculty of Engineering. E-mail: jiavilaa@udistrital.edu.co. ORCID: https://orcid.org/0009-0009-4223-508X

2. Industrial Engineering student, Universidad Distrital Francisco José de Caldas, Faculty of Engineering. E-mail: dfcaperal@udistrital.edu.co. ORCID: https://orcid.org/0009-0000-7801-7695

3. Industrial Engineering student, Universidad Distrital Francisco José de Caldas, Faculty of Engineering. E-mail: mpguevarat@udistrital.edu.co. ORCID: https://orcid.org/0009-0005-4557-3421

4. Mechanical Engineer, Universidad Pontificia Bolivariana; Master in Environmental Sciences, Universidad Jorge Tadeo Lozano; PhD student in Natural Resources Engineering, Universidad de Oviedo; Full Professor, Universidad Distrital Francisco José de Caldas – Industrial Engineering. E-mail: nnievesp@udistrital.edu.co. ORCID: https://orcid.org/0000-0003-2914-4836

Cite this article as: J. I. Avila-Arias, D. F. Capera-León, M. P. Guevara-Tovar, N. Nieves-Pimiento, "Development of a color classification algorithm in processed milk using RGB image analysis with computer vision", Visión Electrónica, vol. 19, no. 2, 2025.

lenguaje Python que utiliza la librería OpenCv la cual permite la detección e identificación del color y su traducción tipológica de Red, Green, Blue (RGB) a Hue Saturation Value (HSV). Para minimizar la intervención humana en el proceso, el sistema detectó la coloración de muestras previamente evaluadas y reconocidas como muestras de buena calidad y tomó estos valores de color con el fin de calcular un rango de no rechazo y posteriormente evaluar una muestra individual y clasificarla como una coloración de calidad ideal o no, para finalizar, se registraron los resultados obtenidos de las pruebas.

1. Introduction

The dairy industry has one of the oldest manufacturing origins, "dating back to around 4,000 BC and has evolved to the present day"[1].c and has evolved up to the present day"[1] facing obstacles such as the preservation of freshness or flavor variability which were overcome by means of different technological advances such as pasteurization, "which was implemented in the Colombian dairy industry in the 19th century"[2], this process consists of destroying through the use of heat, This process consists of destroying all pathogenic flora and a large part of the banal flora that may be present in the milk, ensuring a minimum alteration of the physical structure, the chemical balance provided by the process allows preserving the vitamins and freshness of the milk throughout the supply chain, which provides security to the final consumer.

Currently, the dairy industry continues working and coupling technologies to the dairy production processes, mainly in the area of quality which, in Colombia, is defined by the International Farm Comparison Network (IFCN) that standardizes the quality of milk in the following parameters: "milk solids in (3.3 % for protein and 4.0 % fat), microbiological quality given by colony forming units or its acronym CFU in (<100 000 CFU/ml) and somatic cell count (SCC) in (<400 000/ml)"[3].

The count of protein and fat parameters for the departments specialized in the dairy industry in Colombia such as .Antioquia, Cundinamarca, Boyacá and Nariño.are "3.3 % protein and 3.7 % fat.as maximum percentages [4] , which indicates a long way to go to guarantee the quality defined by the CFU.

The assurance of the parameters of protein, fat and microbiological quality is given through the analysis of tests that are performed on samples of processed milk, in these tests are the so-called organoleptic tests that çonsist of qualifying the odor, color and flavor of the milk sample"[5]. which are performed by a taster. These subjective tests are essential to ensure that the milk meets quality standards before consumption.

The direct relationship that has the taster, which is a human resource triggers a high production cost, since minimizing deviations from these qualifications requires hiring a high number of tasting personnel in these tests, this occurs due to the impression of the senses such as visual perception, which can be altered by external factors such as the contrast of light or internal as the mood of who performs the color test [6]. Due to these problems, integrated sensor systems are currently being developed to allow the characterization of organoleptic measurements in different sectors such as medicine [7].

Milk is a liquid compound with a whitish, subtly yellowish color and opaque tone, these color properties are due to the amount of fat globules that cause the effect of the dispersion of incident light, milk has photosynthetic pigments which are called carotenes and vitamins such as B2 that provide the subtle yellowish tone, processed milk changes its color slightly depending on what kind of processes it was subjected to; Pasteurization increases the white tone due to the high temperatures used and the sterilization process that guarantees safety provides a subtle brown tone, other processes such as skimming of milk provides a slightly blue color and decreases its opacity [8].

Computational sensorics and artificial vision or also called computer vision have proven to be the best alternatives to those processes that require standardization, reducing the subjectivity of the measurements. RGB (red, green and blue) sensors allow distinguishing colors by extracting information through the reflection of the visible electromagnetic spectrum or light, using three coupled sensors that separate the light and decompose it by frequencies, extracting the red, green and blue components. To determine which colors are captured, color models are used [9], these allow the numerical representation of these colors. The way in which the machine language understands the information provided by the sensor is through a conversion between the color components captured by the RGB sensor and those understood by the Python Open CV library which are HSV (saturation and brightness) [10]. Standardizing organoleptic tests is essential for the Colombian dairy industry, since its recognition in foreign markets depends on compliance with the quality standards defined by the IFCN [11].

The standardization was performed using a photographic sensor and the use of the Opencv library that allows reading

images and the Phython programming language, videos as well as storing and analyzing them in the HSV color scale, to perform the RGB to HSV conversions the algorithm that transforms the values to a range allowed by the OpenCv library was used, this tool detected the ideal range for the white color and delivered a mask or filter with the introduced color range which is ideal for milk [12].
In this study an algorithm was developed in Python using the open CV library, this algorithm detected the color of a series of "30"samples of lactose-free milk alqueria, which has certified quality, After detecting the color of the milk the algorithm executed a translation of the color in a numerical color scale "BGRzielding the data for each of the tones "BG.ªnd -"which have a minimum value of "0.ªnd a maximum of "255", with these data a statistical study was performed to determine the Z interval of a mean for each color value "B G R". The algorithm was provided with the results of the study, with this data the tool was able to analyze another batch of samples and determine if the color quality was ideal according to whether its color range was positioned in the rejection or non-rejection zone.

2. Algorithm Development.

The development was divided into three sequential sections, the first was the development of the program in Python language, which detected the color of milk without deviating to other colors, the second was the color data collection from the certified samples and the color characterization, finally, tests of the programming algorithm were performed fed with data provided after a statistical analysis that allowed to obtain a color range where the sample is not rejected.

2.1. Program development.

The programming algorithm is designed so that each frame can read the white color, then translate it to HSV and once this is done, display the color values in BGR scale.

2.1.1. Capture video.

The first step is to obtain a high quality video, for this a photo sensitive sensor or digital camera Logitech C920e was used. To initialize the camera we use çv2.VideoCapture(0)"where the "Zero.ºf the function is used to indicate the port where the sensor or camera is connected, in this way with the command ".read"the program reads the first frame of the camera and verifies that it has started correctly, after this a "Whileçycle is used to continue capturing and reading each of the frames of the video.

2.1.2. Define and convert color range.

To convert the color range, the function çv2.COLOR_BGR2HSV"was used to convert values from RGB to HSV so that the opencv library can understand and operate this color code, so that the programming algorithm only focuses on the color of interest, a wide range of white has been introduced, in this way it will only detect the color of interest and all those that the milk can acquire.

2.1.3. Outline the color area.

One of the fundamental aspects to run the tests with the certainty that it was analyzed correctly was to see what the algorithm analyzed in real time, for this a mask and a contour to this mask was made by using two functions:
çv2.inRange( )"which allows to create a mask of the previously typed color vector and çv2.findContours"which makes a contour to this mask, for more clarity in the tests it was decided to use a circle around the contour using the function çv2.circle()".

2.1.4. Read and display color values.

Once the area was outlined, we proceeded to print the values converted into RGB using the function "print().ºnly if the frame or frame shown was the one indicated to take the sample, printing by console the numerical values in RGB of the enclosed area, so we could know the color value that the programming algorithm is seeing by taking the samples and registering the color values.

2.2. Materials and Methods Sampling.

Milk color can vary due to different conditions such as the amount of fat, treatment temperature or environmental factors during storage. For this study, high quality lactose-free milk was selected that complied with all regulatory parameters for product preservation and consumption.
To obtain the data, 30 tests were performed on four samples, with an interval of 2 seconds between each shot. The resulting values are expressed in the form B-G-R RGB color", due to the Open CV library of the program.
The lactose-free milk had the following nutritional information:

Figure 1: Nutritional information for lactose-free milk brand Alquería [1].

	Por 100mL	Por porción
Calorías (kcla)	**47**	**93**
Grasa Total	1,6 g	3,2 g
Grasa Saturada	**0,9 g**	**1,9 g**
Grasa Trans	**0 mg**	**0 mg**
Carbohidrato Total	5,0 g	10 g
Fibra Dietaría	0 g	0 g
Azúcares totales	5,0 g	10 g
Azúcares añadidos	**0 g**	**0 g**
Proteína	3,1 g	6,2 g
Sodio	**60 mg**	**120 mg**

Source: Productos Naturales De La Sabana S.A.S. Nutritional Information Table (2022).

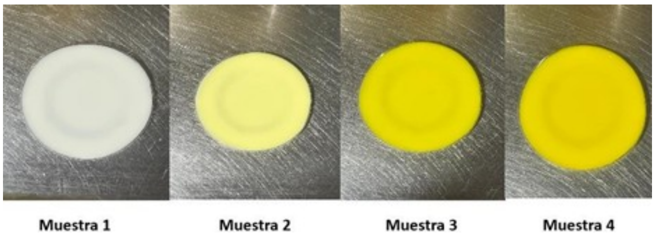
The tests were performed to determine acceptable ranges for the color of quality milk by taking values of the milk in the RGB system and gradually altering its color.
A Logitech camera with 720 pixels was used for the samples; and a white LED light with a diameter of 0.08 m and 3 W of light power.
The distance between the camera lens and the milk sample was 0.445 m, the LED light was located at 30° and 0.570 m away from the sample.
Figure 2 shows the set-up for the tests.

Figure 2: Assembly carried out for taking the tests.

Source: Own

The procedure was carried out with four different samples: of high quality natural lactose-free milk, the first sample of pure milk, to the second one a drop of yellow dye was added, to the third one two drops of yellow dye and the fourth one three drops of yellow dye; each sample was of 20 ml and each drop of dye constituted 0.05 ml, they were placed on a transparent sheet on a dark surface, to focus the white and yellow tonalities.

Figure 3: Samples used.

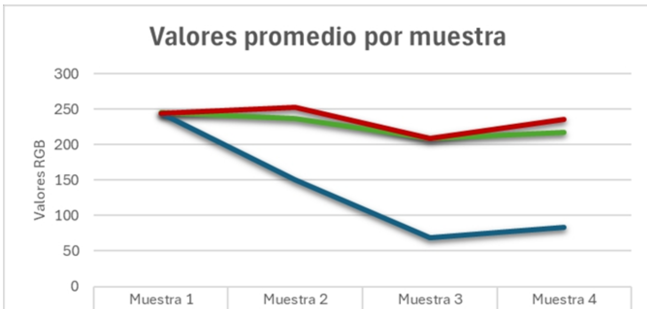


Source: Own

3. Results

Figure 4 shows the average data tabulated for each of the samples for each color value corresponding to "B G R"; software was used to show the theoretical color based on the average RGB values obtained; this tool made it possible to determine differences between each sample, the real color (color of the milk perceived by the human eye), the nominal color (color captured by the camera lens) subsequently converted into RGB data by the program, and the theoretical color (color resulting from the RGB components).

Figure 4: Average values per sample



	Muestra 1	Muestra 2	Muestra 3	Muestra 4
B	244,1333333	150,6333333	69,3	83,3
G	245,4666667	236,4666667	208,5666667	216,9666667
R	244,3333333	252,7333333	208,7333333	235,6333333

Source: Own

The average values of each R-G-B component are observed for each sample. The resulting values are similar to the colors perceived by the observer, having some variations due to light reflection on the sample, and the limited resolution of the camera.
The maximum value for each component of the RGB system is 255, as shown in Table 1. If each component is at its maximum value, pure white will be obtained as the theoretical color.

Table 1: RGB values for pure white color

Component	Value
R	255
G	255
B	255

Source: own elaboration

Based on this, we can determine that: for sample 1, all components are in a range greater than 240, indicating that the color captured by the camera is close to the theoretical color of the milk (opaque white [12]); for sample 2, component B, corresponding to blue, is the one that shows the lowest value, since the decrease in this value allows approaching a bright yellow color. Sample number 3 and number 4 present similar values, but the perceived variations are due to the V component (Value in HSV system), which refers to the brightness of the color; however, the H component (Hue in HSV system) does not show a significant change, indicating that the tone is yellow, but the light is reflected in a different way for each sample.
Figure 5 compiles the variance data for each RGB component of each of the samples. Green is the color with the lowest variance in all cases; given the conditions under which the analysis was performed, it is the shade that is most accurately captured, unlike the other components (blue and red).
The highest variation was found in sample number 1, indicating that it is more difficult to recognize shades close to pure white, however, the shades vary between a white color with light blue tones and an opaque white, being these colors characteristic of a milk in good condition, therefore, it is not considered an error in the development of a milk in good condition of the tool. The variances of the following samples present a differentiability that does not pose a risk in the acceptance or rejection of the color within the program, because in all the samples a "yellow"shade is evident in different percentages.

Figure 5: Variance values by sample.

Source: Own

After analyzing each sample and obtaining the ranges of the characteristic values of the milk in RGB components, acceptance or rejection tests were performed; the one-mean T-interval test was used to find an acceptance range based on the sample taken from the quality milk, the following equation was used:

$$\bar{X} \pm t\frac{s}{\sqrt{n}} \tag{1}$$

This results in the following ranges for each sample data

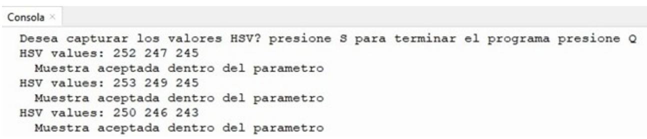
Table 2: Color ranges in RGB for ideal quality

Range	B	G	R
Max	255	255	255
Min	241	244	241

Source: own elaboration

Therefore, the programming algorithm was fed with the color parameters obtained from the statistical study, to recognize the samples and identify if the RGB color value observed is within the acceptance range and therefore equivalent to a milk sample whose visual quality test is appropriate and within the ideal range.

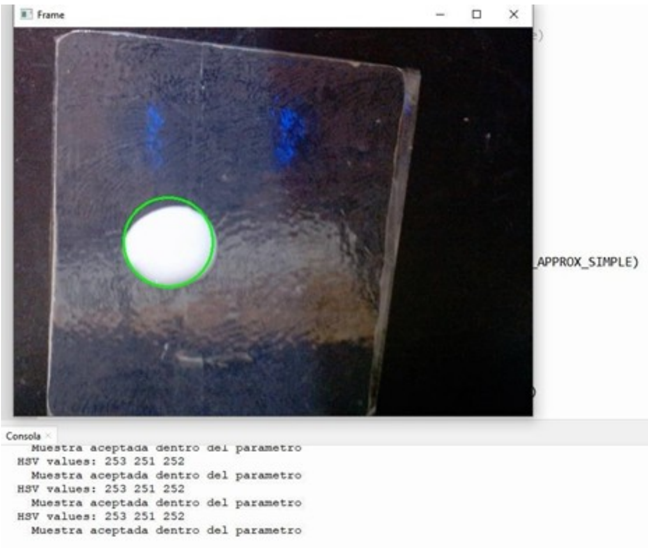
Figure 6: Results per console of the samples.



Source: Own

Finally, the algorithm obtained the ability to detect those ideal milk samples that are within the previously found parameter, the algorithm requests capture through the input of the "S"key which was assigned in order to capture only the desired data.

Figure 7: Video stream milk sample results



Source: Own

4. Conclusions

The research carried out allows concluding that the samples require a colored background that acts as a contrast medium; in the case of milk samples, a background with absence of reflection of the incident light is required. Likewise, the light intensity directly affects the "saturation"value of the samples and the incident angle of the light can affect the sampling due to the total reflection of the white light beam, therefore, it is necessary to use light diffusers for sampling.
The algorithm has shown to be able to capture the value of milk colors without the intervention of an observer, thus, visual perception ceases to be a problem in sampling due to the application of artificial vision; in these cases the robustness of the system may allow extending the applications of this research to the implementation of studies.
The use of statistical analysis within the algorithm, providing it with greater capabilities that could have an impact on the control of the production of the processed milk.

References

[1] J. J. Dillon, *Seven Decades of Milk-A History of New York's Dairy Industry*. Read Books Ltd, 2019.

[2] Y. Castilla-Pinedo, L. Alvis-Estrada, and N. Alvis-Guzmán, "Exposure to organochlorines by ingestion of pasteurized milk marketed in Cartagena, Colombia," *Journal of Public Health*, vol. 12, pp. 14-26, 2020.

[3] E. Valbuena, G. Castro, K. Lima, W. Acosta, W. Bríñez, and A. Tovar, "Microbiological quality of the main pasteurized milk brands distributed in the city of Maracaibo, Venezuela," *Revista Científica*, vol. 14, no. 1, 2019.

[4] J. E. Carulla and E. Ortega, "Dairy production systems in Colombia: challenges and opportunities," *Archivos latinoamericanos de producción animal*, vol. 24, no. 2, pp. 83-87, 2016.

[5] H. M. Rodríguez-Magadán, T. Salinas-Rios, M. Aquino-Cleto, I. Y. Ortiz-Muñoz, M. I. Pérez-León, G. Jiménez-López, and J. Hernández-Bautista, "Yield and organoleptic characteristics of fresh cheese made from alcohol-positive milk," *Agro Productividad*, vol. 12, 2019.

[6] G. Rojas and E. Jeannet, *Neurobiology of visual perception*. Editorial Universidad del Rosario, 2021.

[7] V. R. Valencia, N. L. Larrea, J. G. Salazar, and J. M. Valencia, "Prototype of a wireless sensor network for recreational water quality monitoring," *Revista Ibérica de Sistemas e Tecnologias de Informação*, no. E32, pp. 359-372, 2020.

[8] A. Revilla, *Milk technology: processing, manufacturing and analysis*, 1982.

[9] J. D. Filoteo-Razo et al., "RGB sensor to detect color changes in fruit skin," *Acta Universitaria*, vol. 26, no. 1, pp. 24-29, 2020.

[10] L. Ningsih and P. Cholidhazia, "Classification Of Tomato Maturity Levels Based On RGB And HSV Colors Using KNN Algorithm," *RIGGS: Journal of Artificial Intelligence and Digital Business*, vol. 1, no. 1, pp. 25-30, 2022.

[11] M. D. Demasi and L. Vidal, "Use of the OpenCV library for segmentation and classification of weather radar images," 2022.

[12] R. J. Acosta Morales, "Vehicle license plate recognition applying digital image processing in Python-OpenCV," Doctoral dissertation, 2020.

[13] A. Revilla, *Tecnología de la Leche-Processing, manufacturing and analysis*, 1982. [Online]. Available: https://www.academia.edu/36652945/TECNOLOGIA_DE_LA_LECHE_REVILLA

[14] E. E. Arévalo-Vázquez et al., "Implementation of object recognition by color and shape in a mobile robot," *Research in Computing Science*, vol. 91, no. 1, pp. 21-31, 2015. doi: 10.13053/rcs-91-1-2

[15] V. Z. Bryan Manuel, "Evaluation of the quality and safety of milk in the dairy collection center san isidro del canton sucre," [Research Project], 2021. https://repositorio.espam.edu.ec/bitstream/42000/1886/1/TIC_MV12D.pdf

[16] I. L. Chagua Aduviri, M. A. Quispe-Barra, and O. A. Ortega Achata, "Design and construction of a prototype quinoa color sorting machine using IR sensors," *Revista De Investigaciones Altoandinas*, vol. 24, no. 1, pp. 45-52, 2022. doi: 10.18271/ria.2022.272

[17] R. Contrero, "Milk quality: A challenge in Ecuador," *La Granja: Journal of Science from the Vida*, 2008. https://lagranja.ups.edu.ec/index.php/granja/article/view/7.2008.05

[18] S. Dussán-Sarria, A. M. Garzón-García, and R. E. Melo-Sevilla, "Development and evaluation of a prototype for color measurement in fresh vegetables," *Technological Information*, vol. 31, no. 1, pp. 253-260, 2020. doi: 10.4067/s0718-07642020000100253

[19] C. A. Padrón Pereira et al., "Determination of color in epicarp of tomatoes with computer vision system during ripening," *Agronomía Costarricense*, 2012. doi: 10.15517/rac.v36i1.9969

[20] S. Rege, R. Memane, M. Phatak, and P. Agarwal, "2d geometric shape and color recognition using digital image processing," *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*, 2013. https://www.matlabi.ir/wp-content/uploads/bank_papers/gpaper/g517-www.Matlabi.ir.pdf

[21] D. S. Shreya, "Digital image processing and recognition using python," *International Journal of Engineering Applied Sciences and Technology*, 2021. doi: 10.33564/ijeast.2021.v05i10.046

[22] M. A. Tafur Garzón, "Food safety and international trade," *Colombian Journal From Ciencias Pecuarias*, 2009. https://revistas.udea.edu.co/index.php/rccp/article/view/324460/20781634

[23] A. L. Valdivia Avila, Y. Rubio Fontanills, and A. Beruvides Rodríguez, "Hygienic-sanitary quality of milk, a priority for producers," *Salud Animal*. http://scielo.sld.cu/pdf/rpa/v33n2/2224-7920-rpa-33-02-1.pdf

[24] T. Vargas, "Milk quality: Vision of the dairy industry," INLACA Foundation. http://avpa.ula.ve/docuPDFs/xcongreso/P297_CalidadLeche.pdf

[25] N. Zuluaga, "Food sensory analysis as a tool for the characterization and quality control of dairy derivatives," [Thesis Abstract], 2017. https://repositorio.unal.edu.co/handle/unal/62784

[26] L. Zumbado Gutiérrez and J. J. Romero Zuñiga, "Concepts on safety in primary milk production," *Revista Ciencias Veterinarias*, vol. 33, no. 2, p. 51, 2016. doi: 10.15359/rcv.33-2.1

[27] J. Zurita and L. Perez, "Design and implementation of an automatic machine to classify objects according to their color detected by a color sensor," 2024. https://repositorio.espe.edu.ec/bitstream/21000/7343/1/AC-ESPEL-ENI-0313.pdf

Image or Figure Sources:

[1] Productos Naturales De La Sabana S.A.S. Nutritional Information Table (2022). https://alqueria.com.co/productos/leche/4-leche-deslactosada