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+Leite: A Multiplatform Mobile Application To Determine Dairy Herd Performance Based On The Body Condition Score And Days From Milk Data

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Abstract: *Intense control over production records is extremely important, however, it is uncommon for most producers, particularly those who operate on family farms, to perform appropriate zootechnical control. Herd management software is relatively complex and requires extensive data collection. In addition, they are not very user-friendly and therefore do not meet the requirements of most milk production systems in Brazil. Thus, the objective of this study was to develop an multiplatform mobile application (APP) capabled of diagnosing the zootechnical efficiency of the dairy farm in a simple and friendly way, with minimal data collection. To use the APP, "+Leite", is necessary to input the body condition score (BCS), on a scale from 1–5, where 1 is thin and 5 is obese, and indicate the calving date or if the cow is in a dry period. Based on this information, the APP calculates the BCS Index (BCSI) according to the lactation phase and the reproductive efficiency index (REI), which indicates the proportion of animals in each production phase. Finally, from the arithmetic mean between the BCSI and the REI, the APP calculates the herd's zootechnical efficiency index (HPI). The BCSI, REI, and HPI of the herd were classified on an efficiency scale ranging from 0–1 (0 being poor and 1 being excellent). The APP provides recommendations for animals that should gain or lose weight, based on the ideal BCS recommendation for each production phase. In addition, HPI issues reports on which female cattle should be pregnant and which ones should be dry. With these records and reports, +Leite helps the producer to make decisions regarding the nutritional and reproductive management of the herd to maximize the productivity of the dairy farm.*

Key Word*: Body Condition Score; Herd Performance Index; Reproductive Performance Index; Dairy cows.*

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I. Introduction

Monitoring of zootechnical indices is a key element in improving the productive efficiency of dairy herds. For the producer to adapt to the new production models, the current technical recommendation suggests implementing intense control over the zootechnical records of the herd. However, despite the importance of proper zootechnical control of the herd, this practice is a routine only in highly technical dairy farms[1]. This is owing to the fact that productivity management and evaluation systems are relatively complex, requires purchase of technological equipment, and requires intensive data collection and control, which directly impacts the financial resources of the producer. Smallholders, particularly those in developing countries, are highly disadvantaged when it comes to skills involving modern and sustainable agricultural practices[2].

Therefore, the development of management and herd evaluation tools that are practical, simple, and friendly for processing, interpreting, and transforming data into information is necessary to assist producers, technicians, and extension agents evaluate the productive indexes of the dairy farm, without the need for financial investment. In this regard, the herd performance index was suggested as an tool productive herd diagnosis, that can meet the needs of most milk production systems in Brazil. The HPI only considers body condition score (BCS) and lactation phase data[3].

The BCS has been extensively studied since the 1970s and has already been widely described in the literature, providing support for decision-making in dairy herd production and nutrition management[4]. Body condition score index (BCSI) is a new method to deal with BCS data, considering the lactation phase and the recommendation for each of these phases. However, BCS assessment is not routinely performed on most dairy farms in Brazil.

Another important index variable is the date of delivery. With this record, it is possible to extract the reproductive efficiency index (RPI), which indicates the distribution of births throughout the year of a given

property that aims to produce milk throughout the year. Based on this indicator, it is possible to make recommendations for reproductive management and verify whether there is a concentration of animals at any stage of lactation.

Using the two indicators (BCSI and RPI) we can calculate the HPI of the property, which indicates the level of use of the productive potential of the property. Thus, considering the routine of the producer, a mobile application for dairy farm diagnosis was proposed as a simple, friendly, and intuitive solution. Thus, it is possible to estimate how much of the productive potential of cows is being exploited. In addition, it serves as another index for evaluating the zootechnical evolution of the herd.

The remainder of this paper is organized as follows. Section 2, Materials and Methods, explains BCSI, RPI, HPI and other calculated indices and the techniques used to develop the application. Section 3, Results and Discussion, presents +Leite, a mobile application developed for iOS and Android platforms, demonstrating its main functions. Section 4 presents the Conclusions.

II. Material And Methods

Body Condition Score Index (BCSI)

Each cow's BCS is evaluated on a scale of 1 (very thin, emaciated) to 5 (very fat, obese) in increments of 0.25 BCS units[5]. For the evaluation of the BCSI, it is necessary to enter the BCS data for all cows, whether they are lactating or dry. The BCS is a subjective way of assessing the ratio of body fat to non-fat components in the body of a living animal. Generally, BCS assessment is performed subjectively by a trained technician who considers the thoracic and vertebral region of the spinal column (chin, loin, and rump), ribs, spinous processes (loin), tuber sacrale (hip or hook bones), tuber ischii (pin bones), anterior coccygeal vertebrae (tail head), and thigh region[6]. This assessment can be performed visually or tactilely.

After identifying the BCS of the cows, it is necessary to identify the lactation phase. To properly identify the lactation phase, one must know the date of the cow's last calving or indicate whether the cow is dry. For this methodology, the lactation phases were divided into three phases: up to 100 days in lactation, more than 100 days in lactation, and dry cows. For each lactation phase, a recommended BCS range is presented; the cow can be considered to have a BCS below, within, or above the recommended range. The appropriate BCS intervals used in this study are in accordance with the recommended BCS for cows to reach high fertility cycles, in which cows express maximum productivity and fertility with intervals of up to 13 months between calvings.

Further, it is necessary to determine how many units of BCS are missing for cows to reach the recommended BCS, aiming to differentiate the animals, highlighting those with greater productive potential. The BCS adequacy level (BCAL) was obtained from this process[3]. BCSI was then calculated by averaging the sum of the proportions of cows with adequate BCS and BCAL.

The BCSI is then classified on a scale ranging from 0–100%, allowing the identification of actions to be taken for each identified level. Another important fact to highlight is that for each lactation phase, actions to maintain productivity will be different. Hence, the BCSI must be calculated for each lactation phase to perform management adjustments according to the lactation phase.

Reproductive Performance Index (RPI)

Reproductive performance is one of the factors that affect the productivity and profitability of a herd. There are many obstacles to optimizing it, such as the loss from conception to delivery. Considering milk-producing herds, reproductive efficiency must be observed more carefully because to produce milk efficiently year-round, reproductive management must be efficient and well distributed throughout the year; this will ensure that deliveries do not occur in a concentrated manner and there is no loss of income and productivity.

To calculate reproductive efficiency, it is first necessary to calculate the days in lactation (DIL) of each cow from the date of the last calving or to determine whether the cow is dry. When dividing the lactation phases, the ideal proportion of cows for each phase was calculated, considering the total number of cows.

Determining the optimal number of cows per lactation phase makes it possible to calculate the RPI during the lactation phase. The calculation was performed by taking the ratio between the number of cows in the phase and the ideal number of cows in that phase. To calculate the RPI for the property, the ratio of the sum of the ideal number of cows in all phases to the total number of cows in the herd must be calculated.

Herd Performance Index (HPI) and Other Calculated Indexes

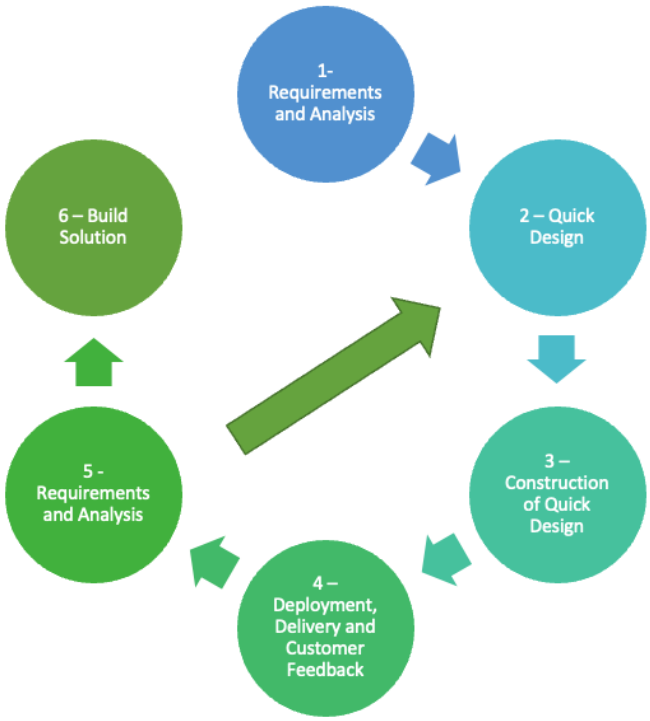
The HPI, which indicates the level of utilization of the farm's production potential, was calculated by averaging the RPI and BCSI. Thus, the HPI is an index that, if followed periodically, can inform the producer what the productive evolution of his herd is, as well as carry out the management suggested by the APP to increase productivity.

The proposed solution also calculated the milk production per cow per day (L/cow/day) of the herd. In addition, if the producer enters the area available for milk production, the APP also calculates the dairy cows per hectare rate (lactating cows/ha) and milk production per hectare rate (L/ha).

Application +Leite

For the development of the APP +Leite, prototyping development methodology was used; it is a valid technique that can be perfectly employed if the system to be developed has the characteristics of having dynamic queries, interacting strongly with people, or having an algorithm or combinatory processing that needs to be developed in an evolutionary way. The creation of a prototype is a job that must be done interactively following the cycle shown in Figure 1.

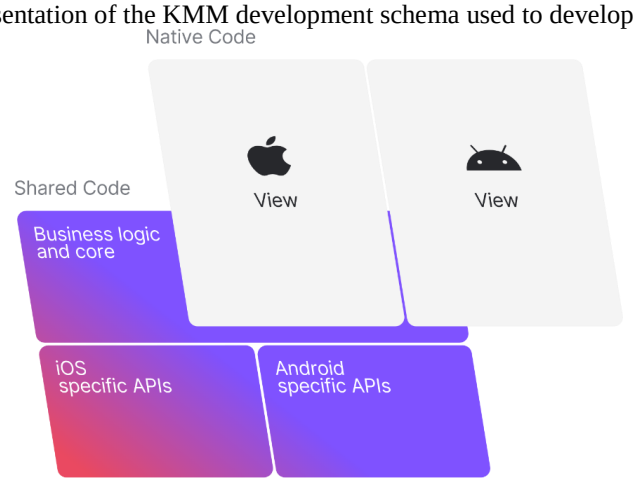
Figure 1: Life cycle of the prototyping process used to develop the APP +Leite.[7]



Similar to all software development approaches, prototyping begins with requirement gathering. During this phase, customers and developers constantly interact, facilitating the gathering of system requirements and functionality. A "quick design" is then developed, focusing on the aspects defined by the user. Rapid design leads to building a prototype that is evaluated by the customer/user and used to refine the requirements. Prototyping is an efficient software-engineering paradigm. The prototype will be built to serve as a basis for defining the requirements. Finally, the prototype will then be discarded, at least in part, and a real software will be designed, taking quality and maintainability into consideration7.

The integrated development interfaces Android Studio and Xcode are used, and these tools support the development process. As the focus of the project is to develop an application to be made available for the Android and iOS platforms, the Kotlin programming language was chosen to support the Kotlin Multiplatform Mobile (KMM), which provides a software development Kit for iOS and Android application development, it can share the application layers that determine the business rules, while allowing access to Application Programmin Interface (API) that is unique to iOS or Android8. Another benefit that KMM has is that the layouts are programmed natively, Figure 2 shows the development scheme proposed by KMM. Therefore, the Swift programming language was used to develop the interface in the iOS application. An SQLite database system was used.

Figure 2: Representation of the KMM development schema used to develop the APP +Leite.[8]



III. Result

The use of the +Leite app has proven to be a simple and efficient tool for conducting productive diagnoses in dairy farms. The app was developed with the aim of facilitating data entry and automating the control of zootechnical diagnoses. It can be used on tablets and smartphones with Android and iOS operating systems, and it is available in English and Portuguese. The app can be downloaded from the Google Play Store (https://play.google.com/store/apps/details?id=com.embrapa.maisleite) and the Apple App Store (https://apps.apple.com/br/app/leite/id1625170399).

The Body Condition Score (BCS) is an essential tool for nutritional and reproductive management in dairy herds. For each lactation phase, there is a recommended range of Body Condition Scores (BCS) for cows. The ideal BCS allows for high fertility and maximum productivity, with intervals of up to 13 months between calving. The BCS ranges are shown in Table 1.

Table 1: The appropriate BCS intervals used in this study are in accordance with the recommended BCS for cows to achieve high fertility cycles according to the references presented.

Lactation phase	Recommended	Notes
Until 100 days in milk	2.5 a 3.0	[8,9]
More than 100 days in milk	2.75 a 3.25	[10]
Dry cows	3.0 a 3.5	[9]

This is due to the time required to monitor the entire herd and the manual work of recording cow information throughout different production phases. In Figure 3, examples of cows that were evaluated for BCS values from 1–5 are shown.

The +Leite app solves this problem by allowing the user to analyze the property immediately after entering herd data. The indices generated by the app are intuitive and self-explanatory, ranging from 0 to 100%. Herds with higher indices are considered to have better productive and reproductive performance. Figure 4 presents the relationship between BCSI and its classification.

Figure 3: Examples of body condition score of dairy cows.

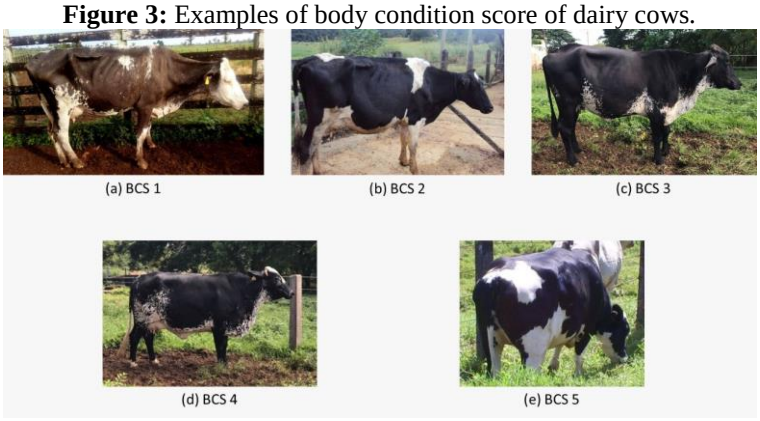
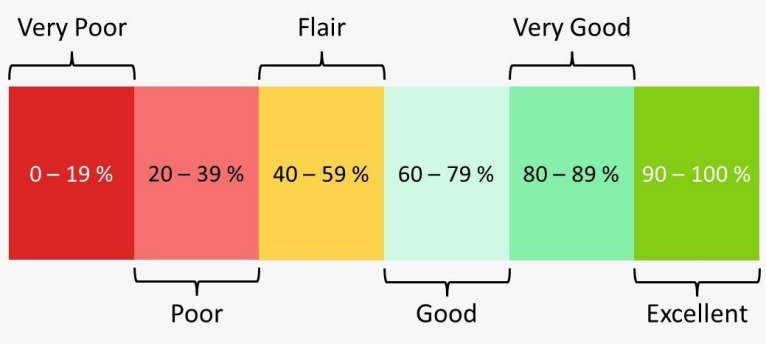


Figure 4: The BCSI, RPI and HPI are classified within a scale that goes from 0 to 100%, allowing the identification of actions to be taken for each identified level.



Tracking the reproductive performance of the herd and determining the ideal number of cows per lactation phase allows calculating the Lactation Index (IDR) during the lactation phase. Figure 5 presents the values used to determine the ideal proportion of cows in each lactation phase.

Figure 5: Distribution of the optimal proportion of cows per lactation phase in a full cycle herd with year round milk production.

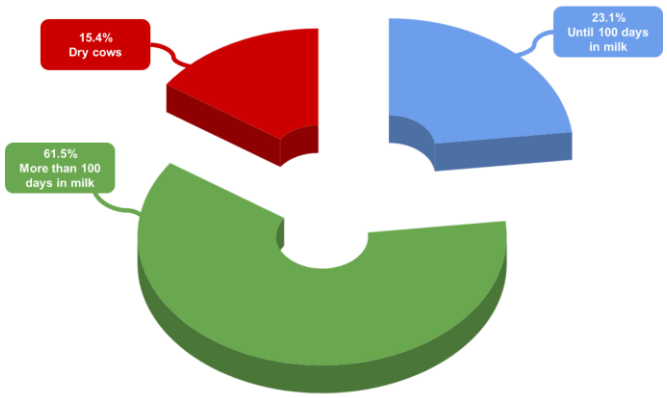
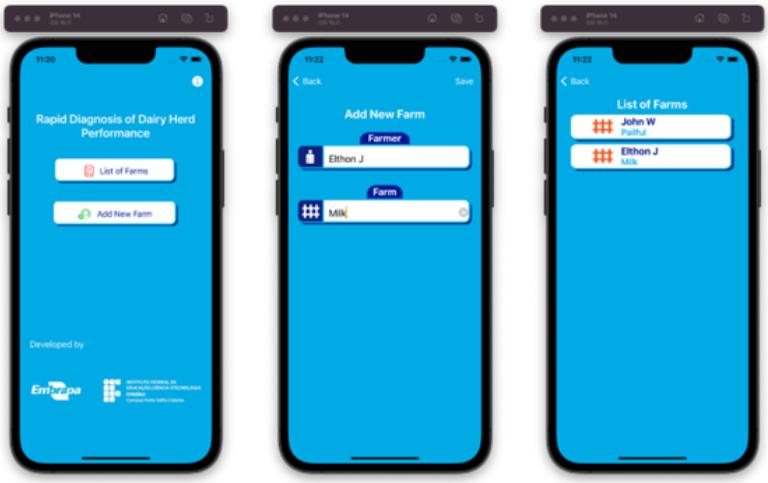


Figure 6A shows the app's home screen, where the user can register a new property or access already registered properties. Registering a new property is simple, requiring only the owner's name and property identification (Figure 6B). The list of properties is intuitive and easy to navigate (Figure 6C).

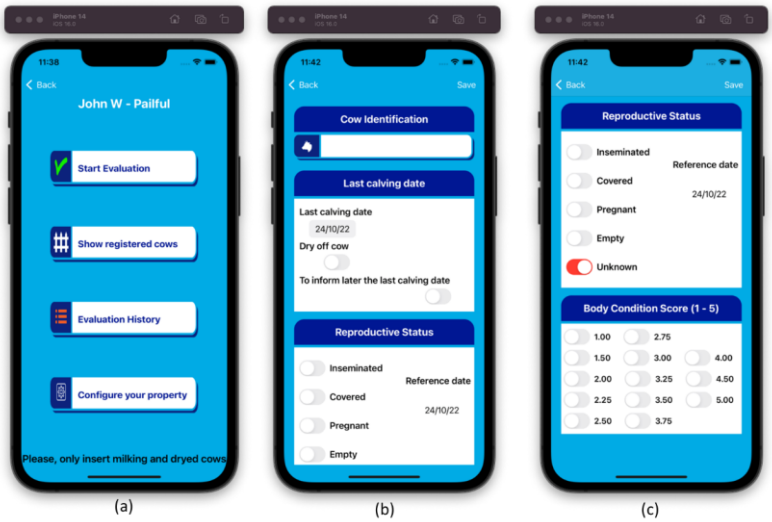
Figure 6*:* (a) Shows the image of the initial screen that allows the user to register a new property or access properties that are already registered in the application. (b) The registration of a new property requires only the owner's name and property identification. (c) List of properties is intuitive and easy to navigate.



(a) Home (b) Add New Farm (c) List of Farms

Figure 7A presents the property control page, displaying the main functions of the app. The user can start a new assessment, view registered cows, access assessment history, and configure the property by defining the farm area and the area used for milk production. Figure 7B illustrates the process of registering a new cow. It is necessary to identify the cow and choose whether the cow has calved recently or is dry. Lactation phase information can be entered later. The cow's reproductive status can also be recorded, indicating whether it is naturally mated, artificially inseminated, pregnant, empty, or unknown. Additionally, it is possible to determine the BCS by selecting one of the available options (Figure 7C).

Figure 7: (a) Shows the property control page. It displays the main functions of the application, allowing the user to: Start a new evaluation; Display the registered cows; Access the evaluation history and Configure the property. (b) and (c) fields to register a new cow.



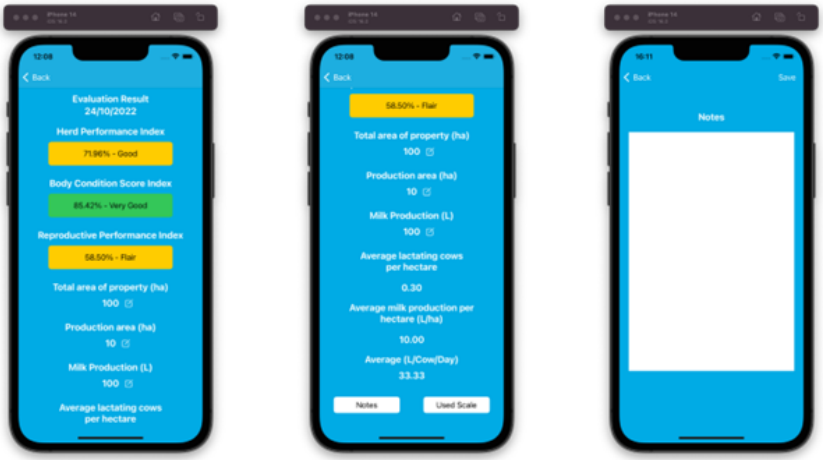
After registering the cow, a list with identification information, BCS, current reproductive status, and lactation phase is available (Figure 8A). Cow information can be edited at any time before completing the assessment. At the end of the assessment, the user can enter the daily milk production, allowing for the calculation of productivity indices per cow or per hectare (Figure 8B).

Figure 8: (a) List with cow identification information, BCS, current reproductive status and lactation phase is available. (b) Ask if the user wants to inform the daily milk yield.

Each assessment generates a copy of the evaluated cows, allowing the user to modify the data in future assessments. The assessment results are presented in Figure 9A, indicating the assessment date and generating the Reproductive Performance Index (RPI), BCS Index, and Reproductive Efficiency Index (REI). The app also provides information about the daily milk production per cow/day and per hectare, as well as data on the farm

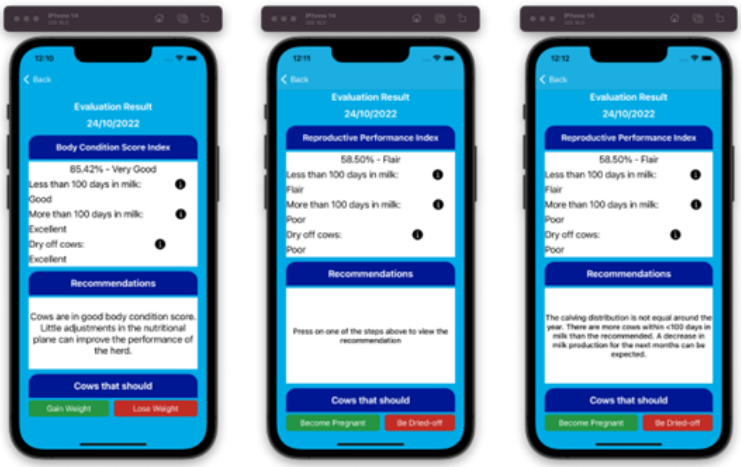
area, area used for milk production, and number of lactating cows per hectare (Figure 9B). The user can make notes about the assessment (Figure 9C).

Figure 9: (a) result of the evaluation is presented informing the date of the evaluation and generating the HPI, BCSI and RPI. (b) Daily milk production, per cow/day, per hectare, besides the area of the farm, the area used for milk production, and the number of lactating cows/ha. (c) To make notes about the evaluation.



The BCS Index and REI have detailed analyses for each lactation phase. The BCS Index allows the user to visualize the herd's condition in relation to the appropriate BCS for each lactation phase. The app also provides recommendations for feeding management aimed at improving the BCS Index of the herd. The user has access to an estimate of how much each animal needs to gain or lose to reach the recommended BCS according to the production phase (Figure 10A). In the REI, in addition to the overall result of the herd (Figure 10B), the user receives recommendations on actions that can be taken to improve reproductive efficiency during the lactation phase. The app also generates information about which cows should be pregnant or dry (Figure 10C).

Figure 10: (a) Result of BCSI the herd, the situation of the herd by lactation phase. (b) RPI result with the recommendations on actions that can be taken to improve reproductive efficiency by lactation phase. (c) Information about which cows should be pregnant or be dry is also generated by the APP.



IV. Discussion

The use of the +Leite application has proven to be a viable and efficient solution for conducting productive diagnoses in dairy farms. The simplicity and user-friendly nature of the application allow producers to perform assessments quickly and conveniently, without the need for extensive manual note-taking. Additionally, the availability of the application on mobile devices with Android and iOS systems, as well as in different languages, enhances its accessibility.

Evaluating BCS (Body Condition Score) is an important practice for nutritional and reproductive management in dairy herds, but its routine implementation is still limited on Brazilian dairy farms. The +Leite app addresses this challenge by providing producers with an effective tool to monitor the BCS of their herds. The indices generated by the application enable producers to easily assess the productive and reproductive performance of their cows, facilitating the identification of areas that need improvement.

The application interface has been intuitively designed, with simple and easy-to-navigate screens. Registering a new property and inputting cow data are quick and straightforward processes. The ability to edit cow information at any time before completing the assessment offers flexibility to the user.

The reports generated by the application provide a comprehensive view of the performance of the dairy property. IDR (Reproductive Index), IECC (Energy-Corrected Milk Index), and IER (Efficiency Index) are indices that provide information about the reproductive and productive performance of the herd, allowing the user to evaluate the herd's status in different lactation phases. These indices are presented clearly and comprehensibly, facilitating result interpretation.

The application also provides feeding management recommendations aimed at improving herd performance. The recommendations are specific to each lactation phase and take into account the ideal BCS for each moment. This assists producers in making nutrition-related decisions for the herd.

The functionality to record daily milk production enables the calculation of productivity indices per cow and per hectare. This provides a more comprehensive view of the property's performance in terms of milk production. The user can also make notes about the assessment, allowing the inclusion of additional relevant information for property management.

The ability of the application to save previous assessments and allow comparisons over time is a significant advantage. This enables the producer to track the progress of the property and verify if the measures taken are resulting in improvements in productive and reproductive performance.

While the +Leite app offers several advantages and conveniences, it is important to emphasize that its use depends on the correct and accurate input of data by the user. The accuracy and reliability of the results are directly related to the quality of the information provided. Therefore, it is essential for the producer to pay attention to the correct input of data to ensure more precise results.

In summary, the +Leite app is a promising tool for productive diagnosis in dairy farms. Its simplicity, efficiency, and ability to generate relevant results and recommendations make it a valuable option for producers looking to improve the performance of their herds. The application offers a practical and accessible way to conduct assessments and monitor the progress of the property over time.

V. Conclusion

Production diagnosis and herd monitoring tools that are practical, simple, and user-friendly for processing, interpreting, and transforming data into information are extremely important, particularly for producers who do not use herd management software. In addition, digital tools, such as APP +Leite, allow access to simple indices to be generated and interpreted. The ease of operation and focus of the APP on improving the productive efficiency of dairy farms can directly impact herd productivity and the owner's quality of life.

This study presents a mobile application that implements the premises mentioned above, with the main focus on delivering to the user the ease of identifying how the potential of his property is being exploited. To the best of our knowledge, this is the first time that such a simple method has been developed for dairy herds. Thus, it is expected that the developed technology will help producers improve the profitability of milk production. It is anticipated that new indexes and monitoring alerts will be implemented in future versions of the APP +Leite, as well as evolutionize the way information generated by the APP is visualized.

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