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Validation of the G-grãos prototype for soybean, sorghum, corn, and bean classification: experience report

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Abstract

This article describes the results of the analysis of the perception of potential users of the prototype of the Android application G-Grãos, developed for the classification of soybean, sorghum, corn, and bean, with the objective of promoting assertive and real-time decision-making. This study is characterized by technological innovation regarding its proposal of grain classification, offering the possibility of determining the classification report for each grain. The app meets the normative instructions of the legislation referring to bean (12/2008 with amendments by IN MAPA 56/2009 and 48/2011), corn (60/2011 with amendments by IN MAPA 18/2012), soybean (11/2007 with amendments by IN MAPA 37/2007 and 15/2004), and sorghum (Ordinance 268/1984), established by the Ministry of Agriculture, Livestock, and Food Supply (MAPA). The app was built using the Java Language, Spring Boot API technologies, along with Hibernate, as well as the Model-View-Controller design pattern. As a result, the acceptance survey indicates that the developed application obtained a positive and relevant acceptance in the form of qualifications such as praise, criticism, and suggestions by the target audience. In addition, the prototype built also obtained the ability to classify soybean, sorghum, corn, and bean according to the normative instructions established by the current legislation.

Keywords: application; grains; acceptance survey; grain classification.

Practical application: Supports real-time decision-making in grain production and trade.

1 INTRODUCTION

The plant classification process is mandatory, as instituted by the Ministry of Agriculture, Livestock, and Food Supply (MAPA), to assess the extrinsic and intrinsic characteristics of the product, being considered a parameter to safeguard the quality of the marketed product and adequate pricing. Thus, the grain analysis and classification stage is a mechanism that allows rural producers to know the specificities of their product (SENAR, 2017). According to Oliveira et al. (2021a), classification at the time of commercialization comprises a stage of product characterization, based on specific and comparative analyses of the analyzed sample with the official standards in force.

Ribeiro (2015) clarifies that the inspection of the quality of food and agricultural products is expensive, as it is usually done manually, which requires intensive use of labor. In addition, there may be divergences regarding the adoption of evaluation criteria during the harvest period, given the high volume of grains sold, affecting the price of the evaluated product.

According to Massruhá et al. (2020), Information and Communication Technologies (ICT) established a new form of interaction between customers and companies, given the access to computers and cell phones, Wi-Fi technology, and other digital platforms. The authors report that the main technologies used by farmers are aimed at assisting in production in general, more specifically in the planning and management of farm activities and in the acquisition and sale of inputs and products.

In this context, innovations in the agricultural sector, represented by mobile applications, constitute an alternative for the digital transformation process in rural areas, given the different possibilities of applications (Oliveira et al., 2021b). Complementarily, Mahapatra (2020) clarifies that the use of mobile technologies as an instrument of intervention in agricultural activities has become popular, and the inclusion of smartphones increases the multidimensional positive impact, as it enables services that go beyond simple voice or text messages.

Based on this, the proposal of the present study describes the methodology of the prototype built with the capacity for classification of soybean, sorghum, corn, and bean according to the normative instructions established by the current legislation and validates the application developed from the analysis of the perception of the public of interest, making this study analogous

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to an "acceptance test." Pinheiro et al. (2015) state that the quality of the software can be ensured by verification and validation activities, whose objective is to show that the system conforms to its specification and that it meets the customer's expectations.

1.1 Relevance of the Work

This work is relevant because it demonstrates the development and validation of an innovative technological tool (G-Grãos app) capable of classifying grains (soybean, sorghum, corn, and bean) according to Brazilian legislation. The study contributes to agricultural production by offering a fast, reliable, and user-friendly solution for decision-making in real time, reducing subjectivity in grain classification and supporting quality assurance across the production chain.

2 MATERIALS AND METHODS

The application was developed for Android devices, considering the predominant use of this system in Brazil, as indicated by the Google report (2020 *apud* Cardoso, 2020), according to which 9 out of 10 Brazilians use Android cell phones. The Java programming language and the Spring Boot API technologies were used, together with Hibernate, whose function was to centralize all requests, storing them in the form of data inserted into/by the application. The application was developed according to the Model-View-Controller design pattern, in order to facilitate the exchange of information between the user interface and the database, providing fast and dynamic responses. The attributes/functionalities inserted in the center of the process of building the user interface were identified during the requirements survey phase, through interviews with rural producers in Iporá, GO, Brazil, and with the owner of a grain storage unit located in the same region.

As for the functions, it is the producer who inserts the data into the available tool, which processes them and generates the grain classification report, enabling the producer to contrast the results obtained by the application and the technical reports of the receiving unit.

Table 1 depicts the functional requirements of the developed application.

The functional requirement "Calculate Grain Class, Group, and Type" was developed using the normative instructions Bean 12/2008 (with amendments by IN MAPA 56/2009 and 48/2011), Corn 60/2011 (with amendments by IN MAPA 18/2012), Soybean 11/2007 (with amendments by IN MAPA 37/2007 and 15/2004), and ordinance Sorghum 268/1984. To arrive at the results presented on the classification report screen, the following formulas were used (Equations 1-11):

Equation 1: Calculate excess percentage of damaged grains (%)

$$\%=\frac{(\text{percentage found }(\%)\text{-maximum tolerable percentage})*100}{(100\text{-maximum tolerable percentage})} \tag{1}$$

Equation 2: Calculate discount for damaged grains (kg)

$$\text{kg}=\frac{(\text{load }(\text{kg})*\text{excess percentage}(\%))}{100} \tag{2}$$

Equation 3: Calculate the excess percentage of greenish grains (%), only for soybean

$$\%=\frac{(\text{percentage found }(\%)\text{-maximum tolerable percentage})*100}{(100\text{-maximum tolerable percentage})} \tag{3}$$

Equation 4: Calculate the discount for greenish grains (kg), only for soybeans

$$\text{kg}=\frac{(\text{load }(\text{kg})*\text{excess percentage}(\%))}{100} \tag{4}$$

Equation 5: Calculate excess percentage of cracked, broken, and crushed grains (%)

$$\%=\frac{(\text{percentage found }(\%)\text{-maximum tolerable percentage})*100}{(100\text{-maximum tolerable percentage})} \tag{5}$$

Equation 6: Calculate discount for cracked, broken, and crushed grains (kg)

$$\text{kg}=\frac{(\text{load }(\text{kg})*\text{excess percentage}(\%))}{100} \tag{6}$$

Equation 7: Calculate excess percentage of impurities (%)

$$\%=\frac{(\text{percentage found }(\%)\text{-maximum tolerable percentage})*100}{(100\text{-maximum tolerable percentage})} \tag{7}$$

Table 1. App functional requirements G-Grãos.

Functionalities	Description
Maintain producer	The app allows producers to register with the app and change their data.
Maintain sample	It consists of registering, changing, searching, and deleting samples that contain the data (date of collection, weight, requester, truck license plate, and person responsible for the collection).
Maintain classification	It refers to the registration, search, and alteration of a certain classification belonging to an already registered sample.
Calculate discounts	Functionality responsible for calculating the discount on loads with mild or serious defects.
Calculate grain class, group, and type	According to the determining attributes of each grain, the app calculates its class, group, and type.

Equation 8: Calculate discount for impurities (kg)

$$kg = \frac{(load\ (kg) * excess\ percentage(\%))}{100} \quad (8)$$

Equation 9: Calculate clean product

$$kg = Load\ (kg) - impurities\ discount\ (kg) \quad (9)$$

Equation 10: Calculate excess percentage of moisture (%)

$$\% = \frac{(Percentage\ found\ (\%) - maximum\ tolerable\ percentage) * 100}{(100 - maximum\ tolerable\ percentage)} \quad (10)$$

Equation 11: Calculate discount for moisture (kg)

$$kg = \frac{(Clean\ product\ (kg) * excess\ percentage(\%))}{100} \quad (11)$$

Table 2 represents an example of the application of the above equations to calculate the grain classification discount.

Data about the perception of potential users of the application were collected by recording an explanatory video with a duration of 1 min 31 s showing a sequence of screens and functionalities, using the Shotcut tool. The instructional video was sent to the respondents via WhatsApp, along with the link to access the online questionnaire with the respective questions: "What is the perception in relation to the use of this application?" and "What are the suggested improvements for it to be effectively adopted by the producer?" It is worth pointing out that the research followed this format because the application is not yet hosted on a platform that allows the tool to be downloaded.

Thus, research with a qualitative-quantitative approach and descriptive objective was carried out to identify the perception of the public of interest in relation to the operations delivered by the system. The sample is composed of 16 participants: professionals from a grain storage unit located in Iporá, GO, Brazil (a grain classifier, a manager, and the owner/rural producer); and professors and researchers in the area of Agricultural Sciences from the Instituto Federal de Educação, Ciência e Tecnologia de Goiás (IF Goiano)—Iporá and Rio Verde campuses—and from the Universidade Estadual de Goiás, with specialization in storage of agricultural products (research inclusion criterion). The data were analyzed in Excel using descriptive statistics, with the objective of condensing the information to describe the behavior of the variables that make up the general sample in three perspectives: praise, criticism, and suggestions.

Table 2. Discount application example.

Categories	Result (%)	Limit	Discount	Load (kg)	Discount (kg)
Impurities	2.5	1	1.5	45,000	675
Total	—	—	—	—	675
Moisture	16.6	14	2.6	44,325	1,152.45
Damaged	11	8	3	—	1,329.75
Final total	—	—	—	41,842.8	2,482.2

3 RESULTS AND DISCUSSION

According to Yankah et al. (2022, p. 2), "mobile devices are electronic devices that can be used to store, access, create, and modify data and information anywhere and anytime." The smartphone app is one of the platforms from which a farmer can get all the solutions and information in just one touch, revolutionizing the way of conducting agricultural business.

Thus, the creation of a classification application for soybean, sorghum, corn, and bean is in line with these new demands of the sector, and the present proposal was developed considering the requirements proposed in the project, with the visual design built according to the user-centered design approach. According to Huynh et al. (2021, p. 690), "effective design emphasizes the exploration of the user's perspective and experience. The term 'user' refers to any person for whom the product or service is designed."

According to the sequence of screens shown in Figure 1, after the initial screen, the functional prototype for registration and classification of bean, soybean, sorghum, and corn is presented. As visualized, the tool has a simple interface in order to facilitate the user experience without, however, compromising issues associated with functionalities, which can be differentiated through colors.

Figure 2 shows the functional prototype of the classification report for soybean and corn, respectively. Equations 1 to 11 yielded the results presented in the classification report screen, which summarizes the result of the classification process, in this case according to the official standards established by MAPA, since the classification of grains can be divided into "official" (according to current standards) and "commercial" (adjusted according to the needs of each company) (SENAR, 2017).

The answers obtained were analyzed from three perspectives: praise, criticism, and suggestions. Perception analysis about the application showed that 80% of the respondents made compliments and pointed out some suggestions, 12.50% had only criticisms about the application, and 7.50% had only suggestions. Figure 3 details the perception of potential users about the tool, as well as the positive aspects identified by the respondents.

As presented above, the participants' impressions are in line with the scope of the proposal. Among the mentions made about the tool, the following comments stand out: easy operation and different functionalities; in line with market demands; reliability due to the possibility of comparison between reports (produced in pdf and XLS formats; self-explanatory interface and simultaneous classification.

According to Kenny and Regan (2021), the tendency for individuals to adopt certain technology at home or at work signals technological readiness, which varies according to individual behavior. However, the positive intention to adopt the technology stems from the perception of the benefits of using

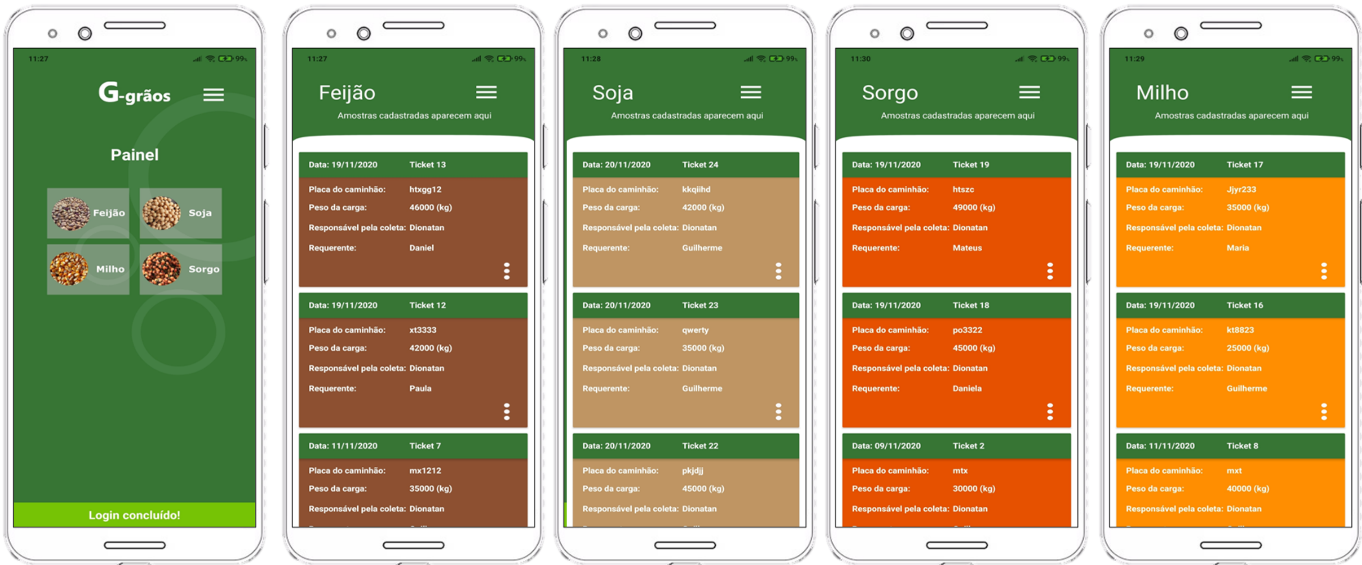

Figure 1. Functional prototypes of the G-Grãos app.

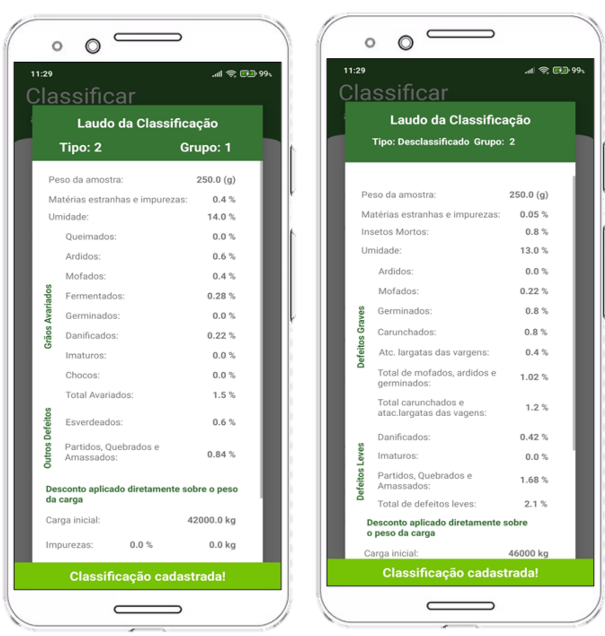

Figure 2. Functional prototypes of the report containing the group and type of soybean and corn grains.

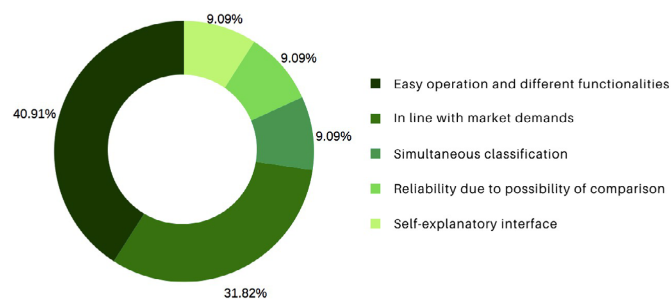

Figure 3. Aspects indicated by respondents about the application.

it. Omar et al. (2021) clarify that consumers' intention toward innovative technology is associated with an optimistic attitude and its positive impact, while discomfort toward innovative technology negatively impacts consumers' intention to adopt it. In the case of this study, the results were perceived by the research participants as positive.

Regarding the criticisms, some reports were identified as important regarding the difficulty of the interviewees to adapt to the current standards, as it is more common to use the commercial classification, whose criteria are defined by the receiving company. Participant A said, "Most producers in Rio Verde and the region only measure moisture and do not use all the classification items presented in the application; this is currently the trend." The participants also mentioned the need to better present the classification reports to include the specification of the classification tables of the four grains (soybean, corn, sorghum, and bean).

Another point raised is associated with the reliability of the answers generated by the classification process. In this context, the following actions emerge as solutions to be listed for the previously mentioned criticisms: creating a screen in the application with the information of the formulas used for each calculation; creating a calculator that accepts manual calculations, but also has pre-defined calculation functions, such as those currently used by the application and accepted by current legislation, as mentioned above. In addition, if the calculations are modified outside the established parameters when the report is produced, the following message is issued by the App: "generated values not standardized in accordance with current legislation."

The item "suggestions" indicates the updates that can be made, and the following factors are highlighted, as shown in Figure 4:

- text support to the user with the evolution of screens in the classification process;
- sending the report via WhatsApp or e-mail for printing;

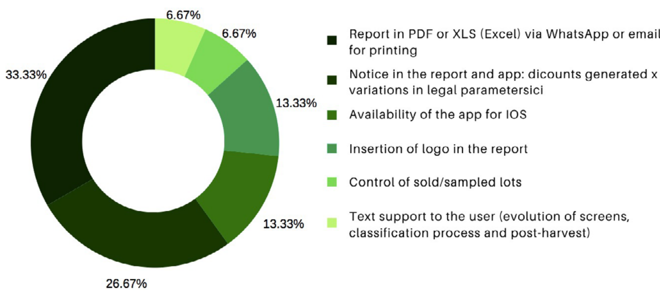

Figure 4. Suggestions of the respondents.

- notice in the report and in the system of the discounts generated when considering the official classification as a parameter
- control history of sold/sampled lots;
- availability of the application for IOS;
- insertion of a logo in the report.

Participants also suggested inserting explanatory notes about each stage of the classification process to provide the user with a greater understanding about each phase.

In the literature, there are some applications of software for grain classification, such as: Everz and Vaz (2021) developed an app for monitoring and managing the soybean classification process, from the registration of the sample to the display of reports; Barbosa et al. (2020) developed a *Chatbot* for the classification of soybean grains and calculations of discounts on the grain load, making it possible to compare the data from the classification carried out by the Chatbot with those of the storage units; Everz and Vaz (2021) developed a system for grain classification using corn, soybean, and wheat, creating a system to generate a classification report with the objective of creating an automated process for grain classification, aiming to increase quality and yield in the area.

In general terms, the analysis of the perception of potential users, as proposed, presented results that will support adjustments in the tool. At the same time, it was found that the software is adequate and can be used by users, considering the functions and tasks it must perform and for which it was developed, as well as its usability. Thus, as Albiero (2017, p. 23) explains, "Software testing in a mobile environment, in itself, is a challenge for modern software engineering. The varied number of devices available on the market, the fragmentation of operating systems, and the different types of applications make it more complex".

From this perspective, at the same time that the testing of a tool proves to be challenging because it contemplates different nuances, the proper use of information from these technological tools can avoid different losses. As highlighted by Parente et al. (2020, p. 129), "Applications, software programs, and systems play a fundamental role in this context, as through them it is possible to disseminate a large amount of information to many people." These authors also add that implementation and testing are decisive in analyzing the alignment between what was proposed in the project and the operation applied. In this context, the G-Grãos application presents satisfactory results, as it allows the user to have real-time information about the quality of the product that is being marketed.

4 CONCLUSIONS

The application developed is an innovative tool in terms of efficient, reliable, robust, and accurate results for the classification of soybean, sorghum, corn, and bean grains, according to the normative instructions of MAPA. In this perception analysis, it was possible to identify the potential of the prototype and, at the same time, verify the achievement of a significant acceptance for the target audience, providing the opportunity to build an adequate tool for official and practical classifiers.

In addition, the study points to the possibility of validating the proposal by instructional video, emerging as a new way to evaluate the generated tool. Therefore, the development of the video proved to be an effective methodology for presenting the functionalities of the prototype, so that the target audience understood the steps and gave their opinion about the intention of use.

For future studies, there is the possibility of including all the suggestions in the current prototype in order to build a new version of the application that will obtain more acceptance from users. Thus, when making it available for production and promotion of the app in the main app stores, it will be possible to reach a larger audience of classifiers.

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