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Improving the management of poultry production: Mobile application development and validation

Melhorando o manejo na produção avícola: Desenvolvimento e validação de um aplicativo para celular

Mejora de la gestión de producción avícola: Desarrollo y validación de una aplicación móvil

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Abstract

The broiler production chain is productive, and chicken meat has achieved high export rates to several countries in the world. This study aimed to develop a mobile application that helps the producer to audit the issues of good production practices. The application was developed for Android and programmed in Java. For its development, questions were used, with different weights according to their importance for production. These questions were removed from the items that make up the manuals of good practices used in Brazil. A test was carried out with users to determine the possibility of using the application in the field. After answering all the questions, the user gets a score ranging from 5 to 1 (excellent to bad). It also indicates which questions they did agree with good practices. The test with users showed that the application was easy to understand and enabled users to make decisions that would improve broiler production.

Keywords: App; Broiler production; Good practices of production; Loss reduction; Quality control; Technology.

Resumo

A cadeia produtiva de frangos de corte é produtiva e a carne de frango tem alcançado altos índices de exportação para vários países do mundo. Este estudo teve como objetivo desenvolver um aplicativo para celular que auxilia o produtor a se auditar nas questões de boas práticas de produção. O aplicativo foi desenvolvido para Android e programada em Java. Para seu desenvolvimento foram utilizadas questões, com pesos diferenciados em função de sua importância para a produção. Estas questões foram baseadas nos itens que compõem os manuais de boas práticas utilizadas no Brasil. Foi realizado um teste com os usuários para determinar a possibilidade de uso do aplicativo no campo. Após responder todas as perguntas, o usuário obtém uma nota que varia de 5 a 1 (excelente a ruim) e são indicadas quais as questões que não tiveram em conformidade com as boas práticas. O teste com os usuários mostrou que o aplicativo foi de fácil compreensão e possibilitou os usuários a tomar decisões que melhorariam a produção de frangos.

Palavras-chave: Aplicativo; Produção avícola; Boas práticas de produção; Redução de perdas; Controle de qualidade; Tecnologia.

Resumen

La cadena de producción de pollos de engorde es productiva y la carne de pollo ha alcanzado altas tasas de exportación a varios países del mundo. Este estudio tuvo como objetivo

desarrollar una aplicación móvil que ayude al productor a auditar los temas de buenas prácticas de producción. La aplicación móvil fue desarrollada para Android y programada en Java. Para su desarrollo se utilizaron preguntas, con diferentes pesos según su importancia para la producción. Estas preguntas fueron basadas en los elementos que integran los manuales de buenas prácticas de producción que se utilizan en Brasil. Se realizó una prueba con los usuarios para determinar la posibilidad de utilizar la aplicación en el campo. Después de contestar todas las preguntas, el usuario obtiene una puntuación que oscila entre 5 y 1 (excelente a malo) y se le indica qué preguntas no tuvo de acuerdo con las buenas prácticas de producción. La prueba con los usuarios mostró que la aplicación móvil era fácil de entender y les permite tomar decisiones para mejorar la producción de pollos.

Palabras clave: Aplicación; Producción de pollos de engorde; Buenas prácticas de producción; Reducción de pérdidas; Control de calidad; Tecnología.

1. Introduction

Brazilian broiler production chain has competitive advantages due to the fast production cycle, the possibility of a verticalized organizational structure, and a low-cost protein, which attracts consumers from different social classes (Reck & Schultz, 2016). This chain is characterized by modern systems of planning, organization, coordination, management techniques, and mainly by incorporating production management and diagnosis technologies (Espíndola, 2012; ABPA, 2019).

Most studies focused on Brazilian poultry production centered on nutrition, birds' health issues, environmental controls, and animal welfare (Garcia et al., 2010; Menezes et al., 2010; Martins et al., 2013; Carvalho et al., 2014; Lima et al., 2014; Sans et al., 2014; Souza et al., 2015), lacking studies in technology for diagnosing the good practices in the production process. The application Good Agricultural Practices (GAP) in Brazil has been following several documents through the documents emitted by of the ministries of Health (MS) and Agriculture, Livestock and Supply (Brazil, 1993; MAPA, 2014). Besides that, the Brazilian Agricultural Research Corporation (Embrapa) and other institutions such as the Brazilian Association of Animal Protein (ABPA) also provide their versions of a manual of good practices adopted by broiler farmers (Avila et al., 2007; ABPA, 2019).

High agricultural productivity depends on technology, which is positively associated with the development of a region (Eberhardt & Vollrath, 2016). Cutting-edge technology, including information technology, precision agriculture, remote sensing, robotics, cloud

computing, Internet of Things (IoT), and big data analysis, can improve agricultural and livestock production, product quality, and development besides improving the environmental benefits (Chen et al., 2017; Hashem et al., 2015; Kamilaris et al., 2017; Weber & Weber, 2010). However, the adoption of innovative technology in the agricultural sector has been slow compared to other industries, which can affect productivity and inadequate application of equipment, technology not focused on the problem, lack of basic infrastructure, and many others (Carter et al. , 2016; Baerdemaeker, 2013; Verma & Sinha, 2018).

Poultry farmers might obtain information to provide favorable conditions that contribute to making decisions in the production process in real-time to maximize the productivity of the animals, allowing the expression of their genetic potential. Similarly, an appropriate working environment is desirable to preserve the health of workers and ensure maximum performance and quality of activities (Alencar et al., 2009; Carvalho et al., 2015). Animal welfare is another consumer demand that has been imposed by importer's market and worldwide adopted to minimize health issues and avoid hunger, thirst, or the lack of natural expression (Bessei, 2006; Federici et al., 2016). In a production system, chickens must be protected and in comfort, have freedom of movement with space for exercise, have access to water and food of sufficient quality and quantity, and have free access to feeders and drinkers (Silva et al., 2009). The use of good practices during broilers' growth include compliance of welfare norms in all weeks of production; however, the technical follow-up is not always easy to meet since there are numerous items to check, resulting in a tedious and time-consuming task.

The objective of the present study was to develop an application for Android mobile devices, with the development of an application (Frango's) for compliance with good practices of broiler production. We aimed to help farmers comply with the good practices of essential norms in a less complicated way.

2. Material and Methods

The purpose of the research was to develop a mobile App using the questions related to the known good practices of production and examining if the broiler flock rearing complies with the good practices of management. We used the published norms employed by farms in a written form (Brasil, 1993; Avila et al., 2007; Souza et al., 2015; Federici et al., 2016) to build up the App. Questions were also addressed to identify possible critical points or hazards associated with losses in broilers farms (Menezes at al., 2010).

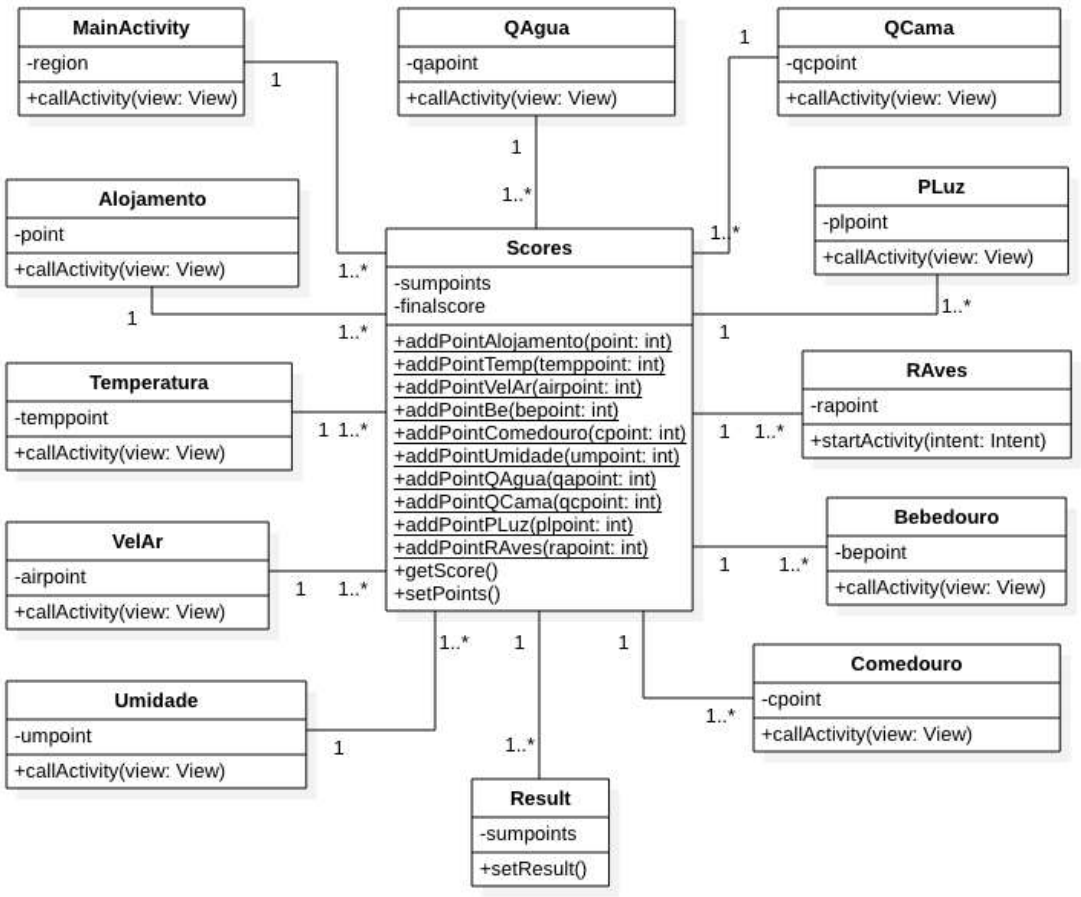
The present study is an 'action research' (Pereira et al., 2018) applied in a joint perspective with data-driven analysis to improve good practices implementation at the broiler farmer level. The validation of the mobile application was done using a user acceptance test survey with the App users, including technicians and farm managers.

2.1. App development

Frango's App was developed to be used in Android operational system version 6.0 or superior (Google, 2018). We used the IDE Android Studio 3.2.1, and the programming language Java oriented to object to develop the application.

The variables or classes included in the application are shown in Figure 1. The associations between the application classes were based on the most critical factors in the farm production process.

Figure 1. Class diagram of the App Frango's.



Source: The authors

The calculation of the final score (scores) resulting from the diagnosis of a broiler production good practices by the App is obtained by assigning weights to each class/variable or questions. The different categories of questions are based on factors of importance, according to the production phase (week). Thus, scores are calculated according to the chosen region and the production phase, according to Eq. 1.

$$S_n = 0.7q_1 + 0.7q_2 + 0.4q_3 + 0.6q_4 + 0.7q_5 + 0.3q_6 + 0.3q_7 + 0.7q_8 + 0.2q_9 + 0.1q_{10} \quad \text{Eq. 1}$$

where S_n = diagnostic score of good practices in n weeks of production and q =questions asked to a farmer.

The weights attributed to each question were proportional to the importance of the question and are presented in Table 1. S_1 refers to the score given in the first week of growth (varying from 1 to 5), and q (varying from 1-10) reports to the questions addressed to the farmer related to the management questions. The given weights varied each week as the good practices changes when the broilers grow-out. The final score, which is the final diagnostic of the compliance with the good practices, is then calculated as shown in Eq. 1.

Table 1. Weight factors of questions 1 to 10 for calculating scores.

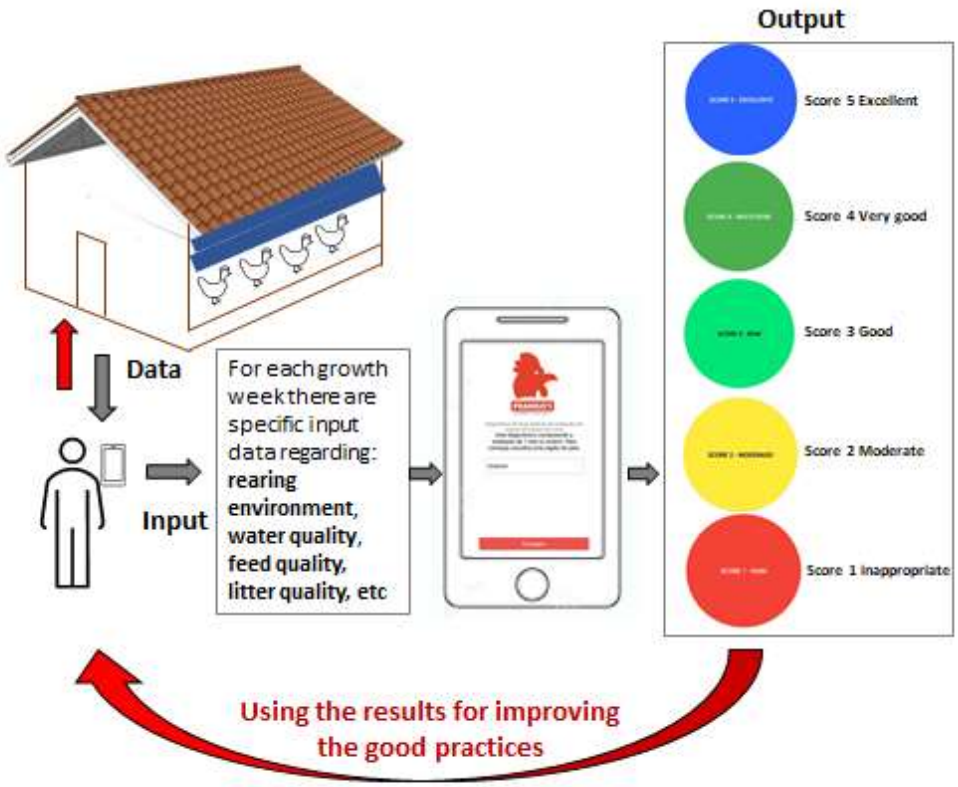
	q_1	q_2	q_3	q_4	q_5	q_6	q_7	q_8	q_9	q_{10}
S_1	0.7	0.7	0.4	0.6	0.7	0.3	0.3	0.7	0.2	0.1
S_2	0.6	0.6	0.4	0.6	0.7	0.3	0.3	0.6	0.2	0.1
S_3	-	0.6	0.5	0.6	0.7	0.4	0.3	0.5	0.2	0.2
S_4	-	0.6	0.6	0.7	0.7	0.5	0.5	0.6	0.2	0.2
S_5	-	0.7	0.6	0.8	0.7	0.6	0.6	0.7	0.2	0.3

S = score. q = question asked. Source: The authors

The interaction diagram between the user and the App functions like this: (1) the user selects the region the farm is located; (2) the user enters the answers to the questions corresponding to the phase of the production process in which the flock is located; (3) after answering all the questions, the user receives an output answer with scores of good production practices. The flow-chart of the App input and use is shown in Figure 2. The input answers were related to the questions mostly associated with the rearing environment, water and feed

quantity and quality, litter quality, number of dead broilers in the flock, and the management to remove those dead birds from the house. Although the questions remain almost the same, the weight changes as they are associated with the broiler needs at each age for each week of growth. The output consists of the overall, ranging from 'excellent' to 'inappropriate'. The output gives feedback to the user to improve the future score, as the user receives information on the scores, pointing out how far the real values are from the ideal scenario.

Figure 2. Flow-chart of the App with the input data and the output results as input for decision-making.



Source: The authors

The questions related to parameters considered for the elaboration of the questions about good production practices were about rearing environment (the temperature and relative humidity), the airspeed, the amount and quality of water flow from drinking places, the regulation and flow of feeders, the litter quality, the quality of the water, the compliance with the light program, and the verification or collection of dead birds (carcasses on the litter).

2.2. User Acceptance Testing Process

A user acceptance test case was applied to define the output or expected result of the Frango's mobile application. Ten user acceptance testers from the broiler meat chain (producers, health auditors, technicians, and quality managers) were investigated about the utility of the application and its intentions for later use. Questions are presented in Table 2. The user acceptance test pursued the following principles: (1) the test is a process of executing a program to find errors; (2) a practical test is one with a high probability of detecting an error not yet discovered, and (3) a successful test is one that detects an undiscovered error. The test was sent via the Internet with a link to the App for the person to apply it. The user was supposed to download the App and user it on-farm. The questions were analyzed using an adapted Likert scale.

Table 2. User acceptance test questions.

Statement number	Summary of survey statements
1	Is the App simple to use?
2	The methodology for using the App is clearly defined in the instructions?
3	I was comfortable installing the reference leaves for each set of measurements
4	Were the results what you expected?
5	I considered the weather conditions when making measurements and interpreting results.
6	The App figures were useful in making my decisions
7	Would you consider using the App in the future?
8	Would you recommend the App to others?

Source: The authors

The user test of the application was applied through a questionnaire in the manual of good practices for broiler production, with the script comprising the respective classes: (1) overall rearing ambient and comfort - environmental temperature (°C) and relative humidity (%); (2) airspeed (m/s); (3) overall quality of drinking water-nipple drinker flow regulation or regulation of pendulum water flow; (4) feeder; type of feeder - regulation of feeder type or tubular feeder regulation; (5) litter moisture - litter quality; (6) compliance with light program; (7) the gathering of dead birds to determine whether or not it is a critical control point.

The App was tested in 10 broiler farms composed of 10 commercial houses with a capacity of 36,000 birds/house and dimensions of 15 x 150 m, with negative pressure ventilation, with an average density of 13 birds/m^2, and age 45 days.

The App was evaluated and validated according to the Brazilian standard (ABNT, 2011), which recommends a minimum sampling of eight participants in the testing stage. The Likert scale is a psychometric response scale commonly used in questionnaires and most used in opinion polls. When responding to a questionnaire based on this scale, the farmers (or technicians) assessed with the opinion ranging from 'strongly disagree' to 'totally agree'. The intermediate scores were 'do not agree or disagree', and 'agree'. There was also the option of 'I do not know how to express an opinion on this'. It was also possible to specify the level of agreement with a statement.

In this context, the study aimed to contribute to the reduction of losses in the production process and to guarantee food security for industrial poultry production, resulting in greater confidence in the production chain.

3. Results and Discussion

Each response used the system on an average of approximately 50 occasions (range 17-160). Most users found the App simple to use (statement 1, Table 1) and easy-to-follow instructions (statement 2). The users generally felt that the results were what they expected (statement 4), and we understood that they reflected the input registered. Informal feedback suggested that even people unfamiliar with the App could respond to the questions adequately and understand the overall score. There was less certainty about the usefulness of the App for decision-making (statement 6), but none of the testers disagreed with that question.

A total of 40 and 60% of the responders considered the App simple to use (Agree and Strongly Agree in statement 1). The answers of statement 2 varied when replying to the described methodology for using the App, meaning that the instructions need to be improved. The answers were balanced when the questions were related to the information on the set of measurements, such as the ambient temperature, relative humidity, wind speed, etc. (statement 3). Statements 4 and 5, which dealt with the expected results, and weather input, were mostly positive (Agree and Strongly Agree), while the output (statement 6) also showed mostly positive answers. Some users recommended using more complex questions; however, we applied the items found in the good practice norms for broiler production. More than 80% of

testers would consider using the App in the future and recommend it to others (statements 7 and 8). The percentages of the user acceptance test are presented in Table 3.

Table 3. Responses to user acceptance tests (n = 10) with statements about application performance and intentions for future use.

Statement number	Summary of survey statements	SD (%)	D (%)	N (%)	A (%)	SA (%)
1	Is the App simple to use?	0	0	0	40	60
2	The methodology for using the App is clearly defined in the instructions?	30	30	10	20	10
3	I was comfortable installing the reference items for each set of measurements	0	40	10	30	20
4	Were the results what you expected?	0	10	0	30	60
5	I considered the weather conditions when making measurements and interpreting results.	0	0	0	10	90
6	The App figures were useful in making my decisions	0	0	20	30	50
7	Would you consider using the App in the future?	0	0	0	40	60
8	Would you recommend the App to others?	0	0	0	20	80

Strongly Disagree (SD), Disagree (D), Neutral (N), Agree (A), and Strongly Agree (SA). Source: The authors

In the developing world, cell phone ownership is increasing rapidly (ITU, 2016). Thus, there was an increase in mobile tools that help small farmers access agricultural, health, educational, and financial services (Baumüller, 2012). The most recent rise of smartphones now creates possibilities to use applications based on visual tools (which make them usable for users with no or low literacy), and that can work with data obtained from embedded sensors. There is a consensus that such applications offer new potential for smallholders to improve their agricultural production systems.

An example is that of small farmers in Senegal who could use a cloud-based decision support tool to apply fertilizer with greater precision (Saito et al., 2015). In Argentina, a smartphone application is used to improve the time of fungicide applications (Carmona et al., 2018). This indicates the potentials that the applications offer to farmers. However, they can also provide new opportunities for researchers to collect data in complex smallholder systems. Until now, these potentials have been little explored for socioeconomic studies, data on smallholder systems.

In agriculture, there is a growing emphasis on agricultural research, partly motivated by infrastructure priorities (Roo et al., 2017). In farm research, there is usually a need to collect not only agronomic data from field experiments but also to collect data from farmers participants through interviews (Van Vugt et al., 2017). Since smallholders do not usually keep any records, researchers who collect socioeconomic or agronomic data from small farmers are based on recall issues.

In addition to allowing one to make wireless calls, smartphones offer internet access, e-mail, messaging services, and many customizable function options through dedicated Apps. Tablets are also considered mobile systems as well as smartphones. However, they differ from them by their size, screen resolution, and allowing to make conventional calls by Skype and/or similar and by allowing inputs directly on the screen, through touch and/or finger movement. With their borderless and less noticeable, smartphones and tablets are used to navigate both the real and the virtual world, shape relationships, consume.

According to the survey "The Mobile Consumer" (Newman et al., 2019), the use of smartphones in Brazil reaches 36% of Brazilian adults interviewed - all internet users. Smartphones have changed the way consumers search for information, make purchases, and socialize. Smartphone users use their media to perform several simultaneous tasks: 88% use the phone during other activities, such as listening to music (63%) and/or watching TV (46%). Given the importance of their products, smartphone manufacturers invest rapidly in developing applications that increase their users' routines and multiply the possibilities of their devices.

The field of Precision Livestock Farming has grown substantially in the last years (Banhazi & Black, 2009). The replacement of repetitive tasks within companies with automated systems should significantly improve quality control and job satisfaction, lowering risks commonly linked with work intensification. Additional investment will generally be required to develop the tools needed to guarantee the efficient application of all aspects of the good practice systems. Researchers need to develop essential hardware and software tools for the animal industry (Van Hertem et al., 2017). Besides, more critical thought is frequently needed when setting research priorities. A significant challenge is identifying those changes in the industrial sector that are likely to result in profitable changes in productivity.

4. Final Remarks

We proposed a mobile App to forecast the compliance of good practices in broiler farm during the phases of growth. The use of the developed mobile App might help improve the

broiler industry since it stimulates the possibility of investigating losses and identifying its most important causes when related to good practices of production. It makes possible corrective actions with practicality in the evaluation of broiler production, and therefore reducing costs and losses in the production process.

Future research should include improving the explanation of the App use and also address focused solutions for specific broiler farm management issues.

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