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Mobile applications to obtain minimum cost feed mixes

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Abstract: In this study, ration preparation software to minimize the cost of feed for ruminant livestock such as cattle, sheep, and goats for both milk and meat yield was developed for Web- and Android-based systems using genetic algorithms. To maximize accessibility on PCs, smartphones, and tablet PCs, we used Web- and Android-based software to find cheaper feed mixes that satisfy the nutritional requirements of ruminants. With this novel system, farmers and scientists can obtain low-cost feed mixes via the Web or smartphones, regardless of time or location. This application is useful for feed producers and farmers because they can use this software from any location and at any time. Users can input their new feed resources for preparing rations.

Key words: Feed, ration preparation, C#, Java, genetic algorithms

1. Introduction

Under the current scenario of rapid human population increase, achieving efficient and productive agricultural resource usage while conserving biodiversity is a global challenge [1]. Livestock directly contributes to nutrition security. Animal-sourced foods like milk, meat, and eggs are the best sources of high-quality protein and micronutrients that are essential for the normal development and good health of humans. Livestock support the food supply by converting low-value materials into milk, meat, and eggs. However, livestock also decrease the food supply by competing with people for food, especially grain [2]. Furthermore, contemporary food consumption is inefficient with one-third of all food being wasted and a further third used inefficiently to feed livestock. This conventional consumption results in environmental costs that are often overlooked [1]. Effective feeding and management of livestock has been part of humanity's strategy to obtain food and other animal-based products [3]. Effective use of feed resources is an essential subject because feeding is the most crucial factor affecting production costs in the animal breeding industry; feeding accounts for about 70%–75% of total production costs. The feeding requirements change according to the animals' age and type, and the expected productivity of the animals. Additionally, the feeding cost is also important to the feed industry in order to meet the nutritional requirements of animals [4]. The feed is one of the most critical factors that affect profitability in livestock enterprises. If this cost is decreased for every unit, farm profitability increases [5]. Therefore, optimization techniques need to be utilized.

Many methods have been developed for the formulation of an animal's diet. These include the square method, two × two matrix methods, simultaneous equation method, trial and error method, and linear programming method to formulate the least-cost diet [6,7]. Genetic algorithms (GAs) have been applied to optimize the cost of feed mixtures, and software programs have been developed [4,7]. GAs have a high potential for fulfilling the role of a basic search tool during the optimization process [8]. The significant advantage of a GA is its effectiveness in finding the best-so-far feasible solution by exploring various parts of the feasible region [9,10].

In recent years, GAs have been used widely in various areas of science and technology such as engineering, bioinformatics, manufacturing, mathematics, economics, chemistry, and physics. One of the advantages of GAs over standard nonlinear programming techniques is that a GA can find a global minimum instead of a local minimum. The other advantage is that a GA does not need the derivative of a function to be calculated, which is challenging, or the derivative may not be readily available to be calculated [11]. A GA can obtain solutions quickly and be easily applied to complex optimization problems

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[4,12]. The study of Sahman et al. applied a GA to optimize the cost of feed mixtures within laboratory conditions. Information and communication technology has long been utilized to meet the requirements of the agricultural sector [13]. Another study aimed to design and test software that prepares a feed mix that is cheaper than standard feed. This software prepares the concentrated feed or mixed roughage concentrated feed according to a predetermined nutrient content [5].

In this study, Web- and Android-based software was used to find cheaper feed mixes that satisfy the nutritional requirements for ruminants; this was done to ensure that this information is freely accessible on PCs, smartphones, and tablet PCs.

2. Materials and methods

2.1. Data and computing

A ration preparation software to minimize the cost of feed for ruminant livestock such as cattle, sheep, and goats (both for milk and meat yields) was designed and programmed for Web- and Android-based systems.

For data recording and managing administrative tasks, a database was designed using MS Access. The database hosts the feed information, such as name, type, price, dry matter, and metabolizable energy of feedstock, and has an administrative table for the name, surname, ID, password, address, email, etc.

The software was developed with C#.NET, which is a popular platform for the next wave of technology deployments because of its applicability in creating applications that run on devices such as handheld computers, smartphones, and Web applications [14].

The nutritional needs for some animal species were obtained from the NRC [15] and CSIRO [16], and the nutritional values of feed materials were obtained from the study by Sauvant et al. [17]. These values were recorded in the database. Additionally, the database was designed to allow users to input nutritional values of their analyzed feed resources. The flow chart of the software is shown in Figure 1.

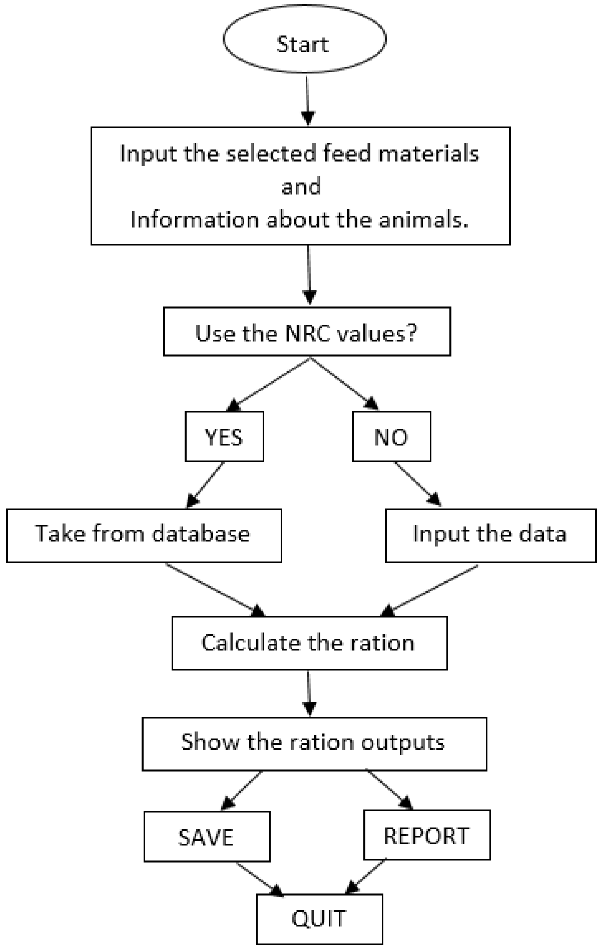

Figure 1. Flow chart for software.

First, animal and feed data that may meet the nutritional requirements of the animals were entered into the system. Then a GA was run as follows:

Coding the solutions: The initial condition of developing a GA is to determine all individuals as a bytes array with the same dimensions. Each array represents any point of the solution to the problem [18]. For our problem, the requirement values (dry matter, metabolizable energy, total digestible nutrients, etc.), feed materials (wheat, barley, maize, etc.), and the preferred minimum cost value can be determined by the user with this software. After determining the requirements, the user begins to find the solution.

Constituting the first population: In this phase, a solution cluster is created for all potential solutions. A random number generator is used to produce the first population of chromosomes, which was done with binary coding [19]. After the user has determined the feed and animal requirements, the solution is tested within a solution cluster consisting of 48 different solutions.

Calculating the fitness function value: A fitness function value is calculated for the result and the entire population is evaluated using that value. Therefore, the convergence of individuals in each generation to the fitness function value is certain. Individuals that do not converge are eliminated from the solution cluster. This approach increases the fitness value of the appropriate solution [18]. From the fitness value, the proposed ration should meet the animal requirements. If the solution does not fit the requirements, it is eliminated from the solution cluster. The cost of the rations was assigned as the fitness value for the selected solutions. Therefore, the solution with the lowest cost was determined as the best solution, and it was sequentially used in other steps.

Selection: At this step, the individuals, given the fitness, are gathered in a matching pool. Individuals that will be crossed are selected by selection methods, such as elite selection, rank selection, tournament selection, and roulette wheel selection [20]. In this study, the roulette wheel method was used. The calculated fitness values were sorted in ascending order because the minimum cost was required and half of the solution cluster (48) was selected. Twenty-four new solutions created by crossover and mutation substituted the 24 eliminated solutions.

Crossover: Crossover is done to produce a new chromosome or child. In the crossover, the child is produced by combining two parents at a random crossover point, while in mutation the child is produced by changing the value of the bit in the chromosome [21]. The 24 best fitting solutions were randomly crossed over with each other and 24 new solutions were created.

Mutation: The mutation operator improves the diversity of the population with the destruction of some amount of data of the optimum population [22]. The 24 new solutions obtained from the crossover were mutated with a randomness rule.

New generation and stopping the loop: The loop is stopped if the fitness value is provided, a predefined number of the generation is obtained, or a predefined number of iterations is reached [23]. In this technique, a new generation was obtained with the 24 best fitting solutions and the 24 new solutions obtained from crossover and mutation. The loop was stopped if the best fitting solution among them satisfied the user requirements; otherwise, the GA was rerun. When the predefined iteration number was reached, the loop was stopped.

The application of the genetic algorithm to the ration problem is shown in Figure 2.

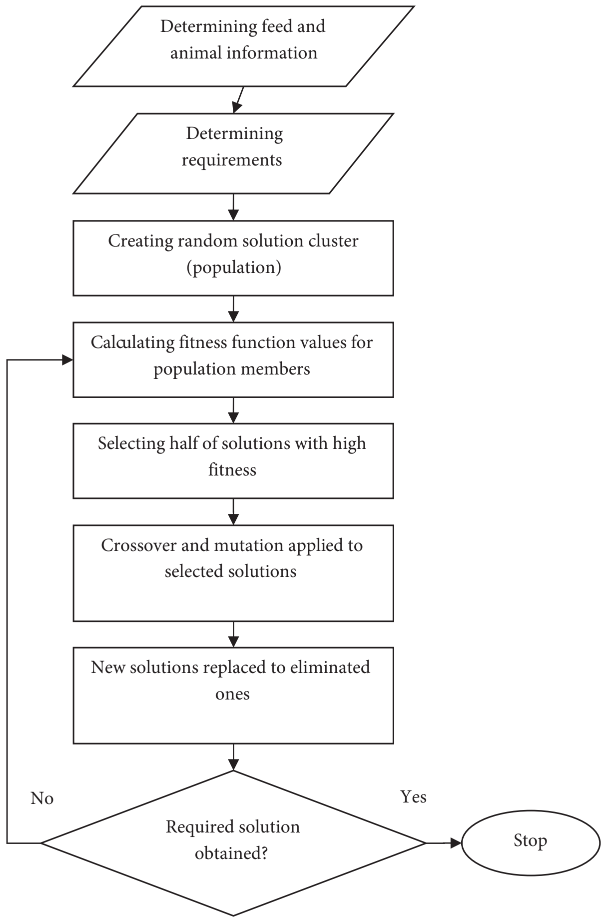

Figure 2. Application of the genetic algorithm to the ration problem.

As shown in Figure 1, after the software is started, the first step is the selection of animal requirements and feed materials. When the nutrient requirements' NRC values are selected, data are taken from the database; otherwise, new data should be input. After this selection, a ration calculation runs using the GA, as shown in Figure 2. After the calculation, the ration outputs are shown. Users can save or report the output.

2.2. Software interface

The homepage of the system was published at http://www.rasyonhazirla.com, which is shown in Figure 3.

On this webpage, both 100-kg and animal-specific rations can be calculated by selecting the feed materials and determining the animal information, such as beef and dairy.

A sample ration preparation for the Web application is shown in Figure 3. The homepage is shown in Figure 3a, which is included in the Android and Web applications. A username and password are used to log in to the system; this situation is shown in Figure 3b. Figures 3c and 3d present the feed sources that can be selected and the animal requirements that can be determined. This software has the following features: 1) "Feed Operations" for adding, deleting, and updating the properties of feed resources; 2) "Prepare Mixed Feed" for preparing a mixed ration of 100 kg; and 3) "Prepare Individual Feed" for preparing rations for specific animal requirements. After running the "Solve the Ration" feature shown in Figures 3c and 3d, the minimum cost solution is obtained, as shown in Figure 3. If the user is not satisfied with the solution, the "Continue" button can be used to obtain new solutions.

The sample ration preparation for the Android application is shown in Figure 4. The main form is shown in Figure 4a, which includes the following features: 1) "Feed Operations" for adding, deleting, and updating properties of feed resources; 2) "Prepare Mixed Feed" for preparing a mixed ration of 100 kg; 3) "Prepare Individual Feed" for preparing a ration for specific animal requirements; 4) "About" to obtain information about the software; and

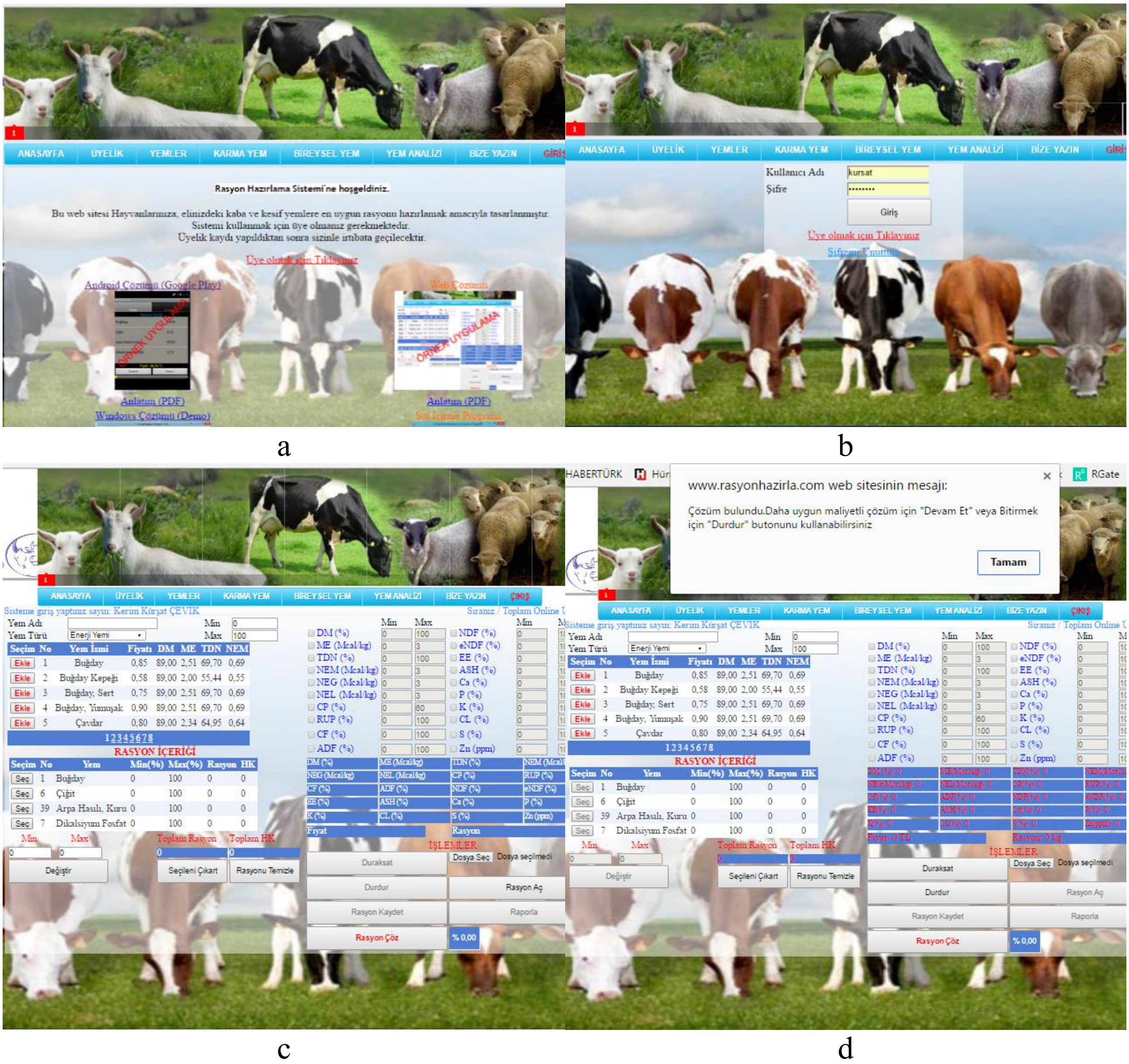

Figure 3. Homepage of the system.

5) "Exit" to terminate the application. A sample solution was performed for preparing mixed feed, as shown in Figure 4b. In this step, feed sources can be selected (Figure 4c) and animal requirements can be determined (Figure 4d). As shown in Figure 4c, wheat, sunflower, and barley were chosen as energy and protein sources and dicalcium phosphate, dolomitic calcium oxide, and calcium carbonate were selected as feed supplements. As illustrated in Figure 4d, animal requirements were determined. After running the "Solve the Ration" button, as displayed in Figure 4b. The minimum cost solution can be obtained, as shown in Figure 4e. If the user does not like the solution, the "Continue" button can be used to obtain new solutions. In each sample ration solution, 5.51 kg of wheat, 13.95 kg of sunflower, 76.32 kg of barley, and 4.22 kg of dicalcium phosphate were used for 100 kg of ration.

3. Results and discussion

This paper presents ration preparation software to minimize the cost of feed for ruminant livestock for both milk and meat yields; the software was designed and programmed for Web- and Android-based systems using GAs. The objective of the study, which was to find cheap feed mixes that satisfy the nutritional requirements of ruminants and allow this information to be easily accessible on PCs, smartphones, and tablet PCs, was

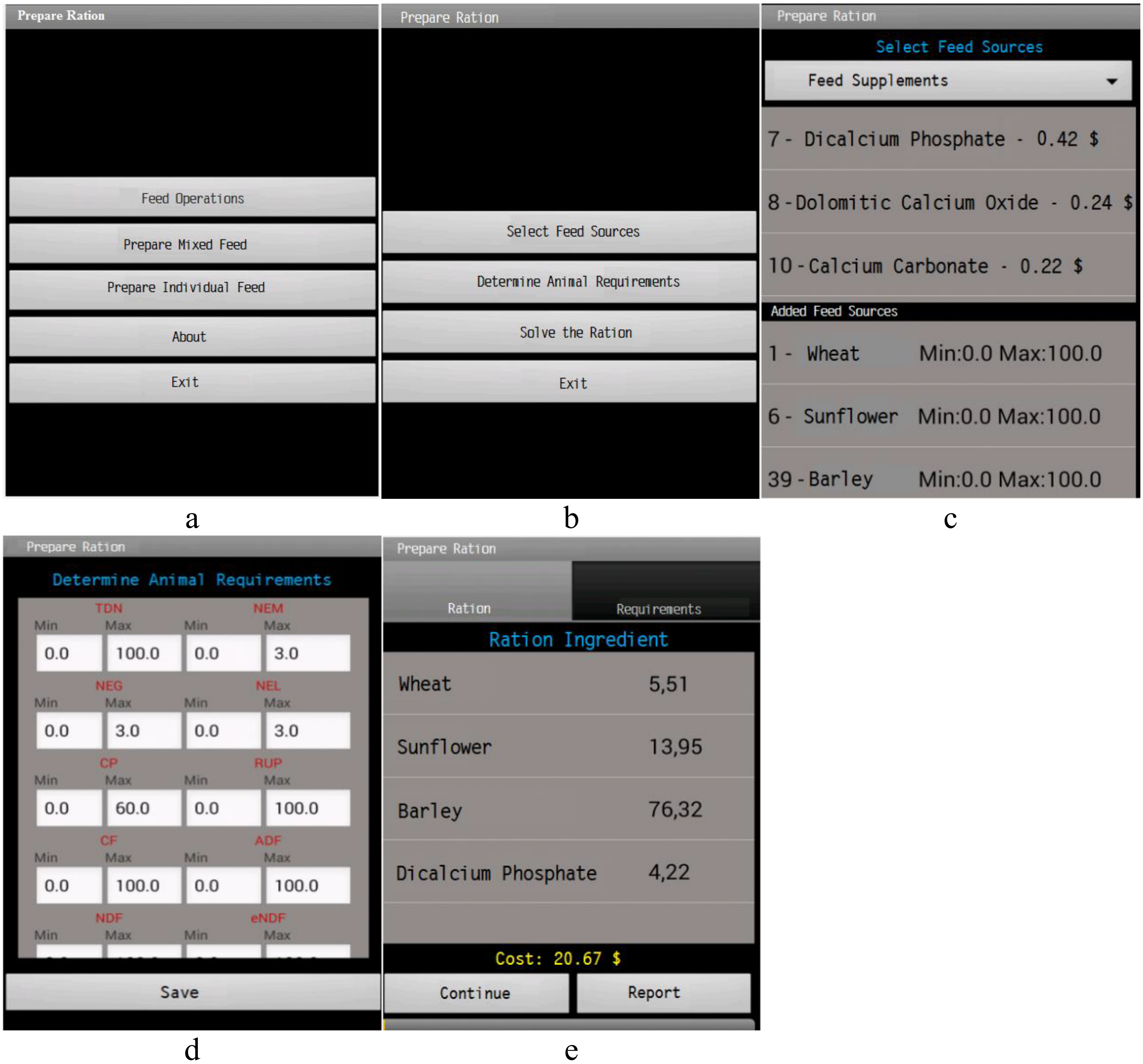

Figure 4. Mobile application start page.

successfully achieved. The software was designed to be used on the Web and smartphones to make it user-friendly.

Obtaining the minimum cost feed ration was achieved by using GAs. The solution was obtained quickly and easily given the complex problem of optimal animal requirements and cost.

The rapid growth and development of the Internet and telecommunication technologies suggests that new applications and studies that are currently inconceivable will be feasible in the future. There are many possibilities to develop new applications by integrating smartphones to every area of humanity requirement. The use of GAs has enabled reliable solutions to be obtained. With this novel system, farmers and scientists can obtain low cost feed mixes via Web or smartphones, regardless of time or location.

This application is useful for feed producers and farmers because they can use this software from any location and at any time. Users can input their new feed resources for preparing rations.

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