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İÇİNDEKİLER

CHAPTER 1

THE APPLICATION OF NIRS TECHNIQUE IN RAW MATERIAL PROCUREMENT AND MIXED FEED PRODUCTION IN FEED MILLS

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1. Introduction

Raw materials constitute 70-90% of the cost in feed production (Modroño et al., 2017). The analysis of feed components in terms of essential dietary elements is one of the most crucial requirements in animal nutrition (Aureli et al., 2017). This is because the accuracy of ration depends on the correct analysis of ration components (Tahir et al., 2012). Accurate feed analysis is a necessary not only for economic reasons but also because the variation in nutrient content according to the quality of raw materials in the feed are essential to reduce the environmental footprint of livestock production and enhance animal productivity (Yıldız & Ceyla, 2009; Noel et al., 2022). Various analytical methods such as detergent chemical analyses, Weende analyses, *in vivo*, *in vitro*, and *in situ* methods have been developed to clarify the nutrient content of feeds. However, the practical application of all these techniques can be expensive and time-consuming as they require many chemicals and special equipment (Ünal, 2005; Aureli et al., 2017). Near-Infrared Reflectance Spectroscopy (NIRS) is a method that provides rapid, non-destructive predictions with high accuracy using an NIRS device (Figure 1), requiring minimal sample preparation and capable of analyzing multiple parameters simultaneously. However, NIRS remains a secondary analysis method today, and its accuracy still depends on the accuracy of primary laboratory techniques (Tahir et al., 2012; Cheli et al., 2012; Aureli et al., 2017). NIRS has real potential for routine and rapid transactions during feed delivery for factories and companies purchasing feed, as well as for ensuring the correct labelling of mixed feeds, which is one of the main problems in animal feed mills (Rego et al., 2020).

Figure 1. *NIRS device*

The application of NIRS technology for the analysis of basic components such as fat, protein, moisture, and cellulose in feed raw materials and finished products has been documented over the past fifteen years (Berzaghi & Riovanto, 2009). Feed manufacturers need precise and rapid information about the nutritional composition of feed raw materials. The art of nutritionists is reflected in their ability to utilize cost-effective feed ingredients without compromising on feed quality principles. A feed mill operates under time constraints when evaluating the acceptance or rejection of a feed raw material or negotiating an appropriate price for a feed (price-performance comparison). On the other hand, if the product to be purchased is a high-quality raw material despite its high price (or vice versa; low quality but affordable price), NIRS has become an essential method for feed mills due to their desire to include this feed in the ration at the lowest feed cost while meeting the nutritional requirements of the animals (Rahman et al., 2015). However, experienced personnel are required to operate NIRS. Additionally, the initial investment cost (device price) may seem high at first. There are also a series of disadvantages, such as the need to calibrate the device and regularly repeat these calibrations. Once these disadvantages are addressed, the advantages of being fast, non-destructive, and not causing environmental pollution, and becoming more cost-effective over time should not be overlooked (Ünal, 2005). The aim of this presented study is to assess the usability of NIRS technology in feed mills from raw material procurement to label analyses of final products.

2. History of NIRS

Near-Infrared Reflectance Spectroscopy (NIRS) was first utilized in agriculture in 1965 to analyze the moisture content of grain kernels and seeds. This pioneering work laid the foundation for modern NIRS technology in the food, feed, and grain industries. The most significant advancement in NIRS technology was the ability to determine the protein content of wheat. Additionally, NIRS technology has been developed to analyze starch, fat, sugar, and fiber in the feed industry. It has been found that NIRS can quickly analyze the quality of roughage and has the capacity to analyze parameters such as mineral content and metabolic energy. Until 1979, NIRS analyses required the grinding of samples. However, after it was discovered that protein and moisture analysis could be performed on whole wheat grains, the first commercially designed NIRS for analyzing whole grains was introduced. NIRS technology can analyze not only the chemical composition of feeds but also biological parameters such as digestibility and feed intake. Today, the NIRS method has become a routine analysis method in industries where rapid analysis is required in many countries. These industries include not only the feed industry but also chemical, pharmacological, and textile industries. The success of NIRS technology parallels advancements in computer technology, as the resolution of mathematical problems involved in the technique has been made possible through the use of computers (Ünal, 2005; Yıldız & Ceyla, 2009).

3. Basic Principle of NIRS Technique

The electromagnetic spectrum (EMS) region includes radiation with wavelengths ranging from 780 nm to 1 mm (Maduro Dias et al., 2024) and is known as infrared radiation (IR) (Yıldız & Ceyla, 2009). The interpretation of the abbreviation 'NIR' may vary based on the context in which it is used. NIR refers to wavelengths between 700-3000 nm, although different ranges may be used in chemical and biological applications in physics. Most quantitative reflectance analyses are conducted in the 1100 to 2500 nm region. The most important area of the NIRS device is the sample reading compartment. This compartment ensures that the rays sent for nutrient analysis are homogeneously reflected on all sides of the sample through the internal cube-corner mirror, and the returning rays are directed back to the detector (Karaman & Erdemir, 2018; Atalay & Bilal, 2020). NIR is an analytical technique used to analyze the chemical content of samples. It is based on the knowledge that each chemical element in the feed has a unique NIR spectrum. This technique requires converting spectral data into compositional information using mathematical and statistical techniques. In NIR, nutrient components are estimated by equations rather than actual measurements performed in the laboratory (Yıldız & Ceyla, 2009). In NIRS technique, the sample to be analyzed is subjected to an infrared radiation (IR) source within the NIR device (Figure 2). Nutrient contents of the material absorbs and reflects this light. The magnitude of the transmitted and reflected light is evaluated. The reflected light is converted into electrical energy and transferred to a computer. Upon placing a feed sample in the NIR, NIR device evaluates the spectrum reflections from the sample with a reference library containing previously analyzed feed elements to determine the nutrient content (Yıldız & Ceyla, 2009; Rahman et al., 2015; Noel et al., 2022). Today, NIRS has become a routine analysis method in industries where rapid analysis is required (Tahir et al., 2012; Evangelista et al., 2021). NIRS is adopted as an precise and rapid analytical method for analyzing the concentrations of major chemical compounds in organic materials, serving as an alternative to laboratory methods. (Yıldız & Ceyla, 2009).

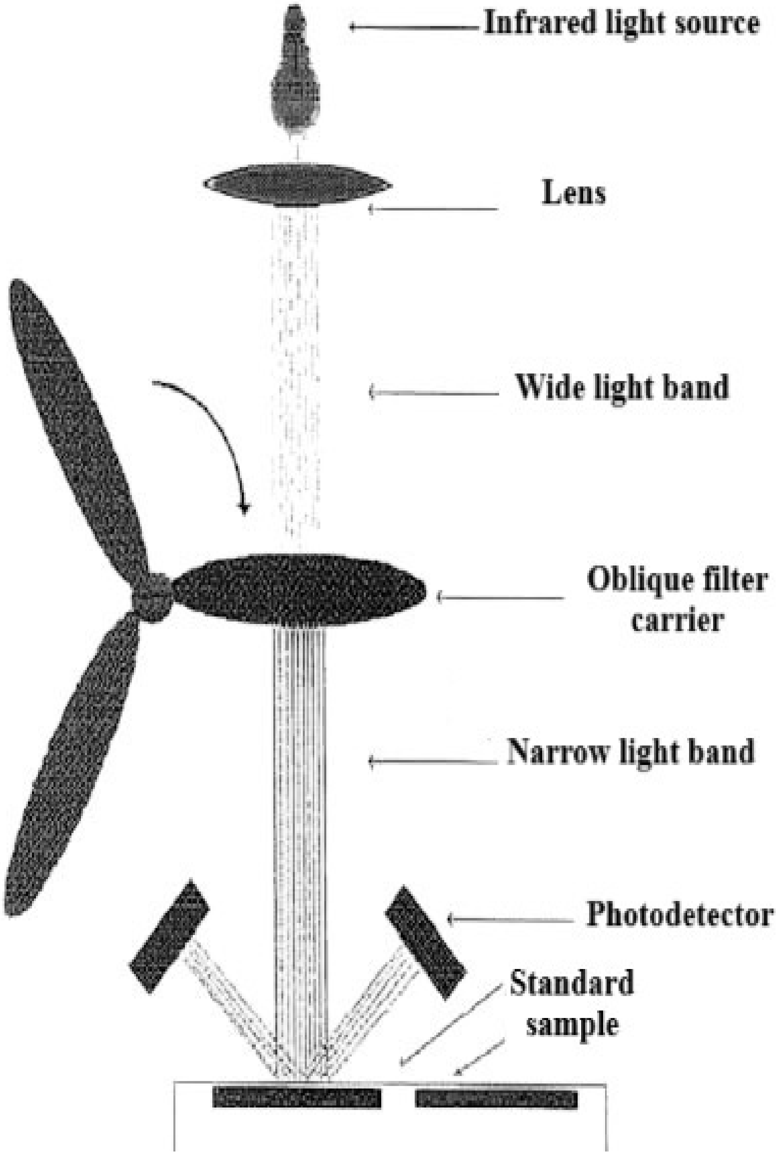

Figure 2. *Demonstration of the operating principle of the NIRS device*

4. Calibration of NIRS

One of the most important factors that affects the use of an infrared spectrometer is calibration (Evangelista et al., 2021). Developing an analytical methodology utilizing NIRS technology is a complex task. Calibration and cost are the biggest obstacles to the method's use (Rahman et al., 2015; Modroño et al., 2017) because NIRS data are proprietary (Rego et al., 2020). Since the calibrations used in NIRS technology consist of feed raw materials from various regions of the world, the chemical analysis results of some local feeds may be unavailable or have low accuracy. This is because the nutritional content of feeds is determined by various parameters such as the soil composition of the region where they are grown, the climate, the amount of fertilizer applied, and the harvest time (Pehlevan, 2014). NIRS is an indirect method, and the precision of the analysis results of feed or feed raw materials largely depends on the precision of the reference method. Therefore, it is crucial to establish reliable calibration models (Pehlivanoğlu, 2019). Comparing the actual value with the predicted value indicates the model's accuracy. Cross-validation is used for verification (Figure 3) (Pehlevan, 2014). Calibration sets lacking a sufficient distribution of samples can lead to inaccurate calibrations. Mixed feeds exhibit greater complexity in terms of wavelength due to the infinite number of possible combinations arising from the extensive variety of ingredients utilized (Rahman et al., 2015).

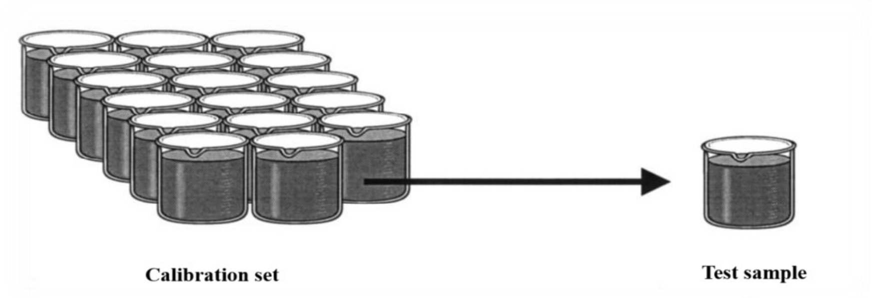

Figure 3. *Cross-validation*

Calibration entails creating a mathematical correlation between reference and wavelength data (Montanhini Neto et al., 2017). Ongoing calibration is essential to adjust devices for updated measurements and varying sample conditions, including chemical composition and temperature. Following the establishment of calibration curves, NIRS provides an efficient and affordable analysis that can scan numerous samples while being user-friendly (Evangelista et al., 2021). Calibration entails forming a mathematical correlation between spectral and reference data (Perez-Marín et al., 2008). Nowadays, animal nutritionists widely use NIRS technology to assess the nutrient content of ingredients (Balastreri et al., 2015). Market-available calibrations have been demonstrated to be highly precise for various nutrients present in different ingredients utilized in animal feed production (Gill, 2003). Nutritionists can dynamically adjust formulations in real-time based on the actual values of ingredients obtained from NIRS analysis, ensuring the accuracy and consistency of each produced feed (Coffey et al., 2015).

Developing a calibration model involves multiple stages: selecting the calibration sample set, collecting spectrum and reference data, executing the regression (calibration) model, and validating the model (Pehlevan, 2014; Pehlivanoğlu, 2019; Evangelista et al., 2021). For a calibration data set to be considered reliable, it should include between 20 and 200 samples. A calibration data set must reflect all natural discrepancies. Calibration quality is calculated by incorrect analyses (RMSECV or RMSEP) and the value of R2 (coefficient of determination, the percentage of variance explained in component values). Bias, described as the discrepancy between the forecasted and observed measurements, represents a systematic error known as the deviation value. More precisely, it is the discrepancy between the average actual value and the average measured value of the validation set samples. Cross-validation uses RMSECV (Root Mean Square Error of Cross-Validation) for calculation criteria. RPD (Residual Prediction Deviation) is the ratio of the standard deviation to the standard error of prediction (Figure 4). An R2 value greater than 90 for solids and greater than 99 for liquids indicates a good value. In other words, as the R2 value approaches 100%, the accuracy of the calibration set is considered high (Pehlevan, 2014; Elbirlik, 2019).

$$bias = \frac{\sum_{i=1}^{M} Y_i^{meas} - Y_i^{pred}}{M}$$

$$\text{RMSECV} = \sqrt{\frac{1}{M}\sum_{i=1}^{M}\left(Y_i^{meas} - Y_i^{pred}\right)^2}$$

$$\text{RPD} = \frac{SD}{SEP}$$

Figure 4. *Calibration formulations*

Different evaluations have been made regarding the reliability of NIRS calibration models based on R2 and/or RPD (briefly, ratio of performance to deviation) values. Studies have reported that models created with transformed data show successful predictions with high R2 (>0.90) and RPD (>3) values in calibration and validation sets (Pehlivanoğlu, 2019). The success of NIRS technology parallels advancements in computer technology. The development of computer software has made it possible to solve the mathematical problems contained in the technique (Ünal, 2005).

5. Feed Analysis Methods, Traditional Methods and NIRS

Feed analysis is a crucial aspect of animal nutrition. Knowing the nutrient content of feed raw materials allows for the formulation of balanced rations that ensure nutritional balance (Cheli et al., 2012). In the absence of precise information, nutritionists may refer to tabulated values for the nutrient content of the feed ingredients used or, alternatively, use predictive equations to estimate the expected actual values based on chemical analyses (Rahman et al., 2015; Montanhini Neto et al., 2017; Noel et al., 2022). Incorrect feed formulation can lead to errors in the desired label values throughout the production chain and in the final product, as well as changes in the performance parameters of animals consuming this feed. These errors are in direct relation to the discrepancy between the assumed nutrient matrix versus the actual nutrient value of the feed components. Therefore, there is significant focus on developing alternative, rapid, robust, and effective methods that can provide precise information about nutrient values in real-time during production (Montanhini Neto et al., 2017; Noel et al., 2022). Various methods are used to analyze animal feeds (Montanhini Neto et al., 2017). Prior to the 1860s, the nutritional evaluation of feeds relied on the concept of hay equivalency. In 1865, the Weende System, a chemical analysis method, was established. During the 1960s, Van Soest introduced an alternative method to feed analysis, followed by Tilley and Terry's development of *in vitro* methods. Nevertheless, these advancements depend on laboratory methods, which are often labor-intensive, impractical, and financially burdensome due to the chemicals involved, and they may pose potential environmental hazards. Consequently, the establishment of a quality monitoring system that delivers consistent, timely, and cost-effective results remains a significant challenge. In this process, the use of NIRS in feed analysis began in the 1970s (Maduro Dias et al., 2024).

Chemical analyses help to some extent in estimating the feed value (Pehlevan, 2014). The primary series of chemical analyses conducted using traditional methods (wet chemistry) designed for feed evaluation is referred to as "proximate analysis" in relation to the Weende system (Cheli et al., 2012). This system, designed in 19th century in Germany, provides rough measurements for crude ash (CA), crude fiber (CF), dry matter (DM), ether extract (EE), and crude protein (CP). Instead of being directly measured, nitrogen-free extract (NFE), which includes starches and sugars, is determined through the computation of the remainder (Zaefarian et al., 2021). Thus, initial summary information about the feed is obtained (Pehlevan, 2014). In the 1960s, Peter Van Soest's research program introduced a revolutionary approach to 'wet chemistry,' resulting in the creation of the detergent-based feed analysis system. Over time, researchers have replaced the Weende analysis system with the detergent-based system, at least for ruminant feeds (Cheli et al., 2012). In this system, instead of CF, analyses for Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF), and Acid Detergent Lignin

(ADL) are performed according to the Van Soest Method. It is a method used to determine the total carbohydrates in feeds (Pehlevan, 2014). The detergent system represented a paradigm shift, enabling the explanation of nutritional responses with regard to feed intake and digestibility. The nutritional foundation of the detergent analysis technique lies in the assessment of feed components with varying digestive efficiency. Within this framework, neutral detergent solubles (NDS) encompass the fully digestible fractions of carbohydrates, proteins, lipids, and some ash, whereas neutral detergent fiber (NDF) includes the partially digestible structural fiber, and lignin constitutes the completely indigestible portion of NDF. Although NDF has largely supplanted crude fiber (CF) in scientific circles, CF remains a valid analysis method as it is legally recognized for commercial purposes in numerous countries and is required to be listed on feed labels (Cheli et al., 2012). However, the practical use of all these techniques is expensive and extensive, requiring many chemicals, and obtaining results takes time. Environmental pollution caused by chemicals is also seen as another significant problem (Pehlevan, 2014). During the late 20th century, the application of 'wet chemistry' techniques started to diminish. Despite the continued widespread use and official recognition of many classical methods, they are gradually being supplanted by instrumental techniques. These modern methods offer lower detection limits, enhanced analyte specificity, simplified usage, cost reductions, and superior capabilities in sample processing and automation (Cheli et al., 2012).

Chemical analyses generally provide insights into the dietary composition of feed materials or diets but do not account for nutrient digestibility. It is important to acknowledge that no typical feed component is entirely digestible, and the full nutritional benefits are not achieved in the animal. A substantial portion of substrates remains partially digested, with approximately 10% to 20% typically being eliminated and undigested. As a result, the total nutrient content indicated by the ingredient does not reflect the actual quantities accessible to cells for metabolic processes in animals, and their effective utilization can only be precisely measured through *in vivo* studies (Zaefarian et al., 2021). Regardless of the methodology employed, chemical analysis of feeds remains an essential tool for feed evaluation. Nevertheless, chemical analysis does not encompass animal-feed interactions, including factors such as palatability, the influence of diet composition on feed intake and digestibility, or the functional properties of feed in the target animal. Understanding gastrointestinal physiology, the intricate processes of digestion and fermentation, along with their impact on nutrient absorption, have guided research towards developing feed evaluation methods that replicate the journey of nutrients through the digestive system. Therefore, methods for analyzing feed have been developed both within living organisms (*in vivo*) and in controlled laboratory environments (*in vitro*) (Cheli et al., 2012). Methods conducted in live organisms measure the direct response of animals to dietary changes and are the most effective way to determine the nutritional value of feed ingredients (Zaefarian et al., 2021). *In vivo* analysis provides an accurate assessment of digestibility by evaluating the effects of dietary treatments on the animal. Traditionally, digestibility studies have been conducted on sheep fed a single maintenance diet under highly controlled experimental conditions, which cannot encompass all practical feeding scenarios. As a result, various *in situ* and *in vitro* techniques have been devised to mimic the digestive process, aiming to evaluate the digestibility and degradability of feed materials. These methods potentially consider dynamic digestive factors such as transit time and the kinetics of nutrient breakdown (Cheli et al., 2012). *In vitro* techniques should be developed to accurately replicate the digestive processes occurring in the gastrointestinal tract (GIT) of animals (Zaefarian et al., 2021). Due to the intricate nature of *in vivo* digestion, it is evident that *in vitro* conditions cannot fully replicate those of *in vivo*. An effective *in vitro* method should be uncomplicated, fast, accurate, and consistent to reliably predict *in vivo* results. To ensure accuracy, *in vitro* data should be validated by comparing them with corresponding *in vivo* data obtained from identical samples (Zaefarian et al., 2021). Consequently, the analyses known as wet chemistry, referred to as the Weende system, and the analyses known as the detergent system are routinely used by feed mills. *In vivo*, *in vitro*, and *in situ* methods, on the other hand, find limited use mainly in scientific research and the R&D departments of companies due to reasons such as time and cost. These methods are gradually being supplanted by instrumental techniques such as NIRS, which offer lower detection limits, enhanced analyte specificity, simplified usage, cost reductions, and superior capabilities in sample processing and automation (Cheli et al., 2012; Zaefarian et al., 2021).

Over the past four to five decades, much research has been undertaken to develop and enhance chemical analyses and the prediction equations derived from them. Nevertheless, routine chemical analysis faces significant limitations, including the time-consuming nature of chemical analyses, high costs, the necessity for specialized laboratory equipment, the use of hazardous chemicals, environmental pollution, and waste disposal challenges (Pehlevan, 2014; Elbirlik, 2019; Zaefarian et al., 2021). Today, physical measurements (grain density and 1,000 grain weight, endosperm hardness), chemical analyses (Wet analyses such as Weende analyses and Van Soest analyses), tabulated values (NRC, 1994; INRA, 2002; Rostagno et al., 2017), prediction equations (metabolizable energy (ME) or apparent metabolizable energy (AME)), *in vivo*, *in vitro*, and *in situ* methods are still used as reference official analysis methods for feed analysis. The more accurate and reliable results provided by these methods are the main reasons for their continued widespread use today. In addition to these methods, the use of NIRS, a technique that has been developing over the past 40-50 years, is becoming particularly popular in feed mills. NIRS is recognized as an official analysis method by the Association of Official Analytical Chemists (AOAC) (Rahman et al., 2015; Zaefarian et al., 2021; Beć et al., 2022; Hossain et al., 2024). NIRS provides significant advantages in places such as feed mills and official or private enterprises that purchase grain, where rapid detection of grain quality is required (Pehlevan, 2014). Many studies on NIRS report that this method could eventually replace wet analyses. The ability of the NIRS device to simultaneously analyze several parameters is seen as an advantage compared to devices used in chemical analyses. It is said to be approximately one-fifth the cost of traditional chemical analyses, and studies indicate that it is also quite effective in predicting the digestibility and chemical composition of feeds. While traditional chemical analysis of feeds takes two to three days, a comparable analysis can be completed within 2-3 minutes using NIRS (Pehlevan, 2014; Rahman et al., 2015). Additionally, NIR spectroscopy is the sole technique that enables the analysis of large-scale samples and facilitates consistent real-time decision-making. Regarding feed safety issues, NIRS analysis has been reported to be a screening tool for detecting fungi and mycotoxins in grains (Cheli et al., 2012).

6. Advantages and Disadvantages of NIRS Application

The NIRS method has certain advantages and disadvantages compared to traditional analytical methods. These advantages and disadvantages are listed below.

6.1 Advantages

1. This analytical technique is significantly faster than traditional methods (minutes compared to days),
2. There is no need to use chemicals in this analytical method,
3. It provides effective control throughout the entire process, from raw material to the final product,
4. The samples used are not destroyed and can be reused multiple times,
5. The prepared compound feed formulations can be balanced in terms of nutrients and raw material composition,
6. In case of any nutrition-related problems, factories or producers can quickly take appropriate measures,
7. Multiple components can be analyzed simultaneously,
8. The analyses are easy to perform and do not require any chemicals,
9. Apart from the initial investment cost, it is a cheaper method compared to chemical methods,
10. It is simple to use, and the margin of error in obtaining results can be minimized (Yıldız & Ceyla, 2009; Elbirlik, 2019).

6.2 Disadvantages

1. It estimates nutrient contents solely through equations, not based on actual measurements,
2. Prediction equations must vary according to different feed types, growing conditions, and regions,
3. Calibration equations for intermediate feed products are not available,
4. The equations are highly variable, and their accuracy depends on the specific feed being tested,

5. Only one wavelength is used to estimate all nutrients. If a nutrient falls outside the regression line, it is difficult to determine whether it is a test error,
6. The biggest, and perhaps the only, disadvantage of NIRS is the high initial investment cost of the device and the need for experienced personnel for calibration (Ünal, 2005; Yıldız & Ceyla, 2009; Elbirlik, 2019).

7. Conclusion

The literature review suggests that the analysis of feed raw materials and pellet feeds using NIRS devices can be effectively used to obtain precise, accurate, cost-effective, and faster results. Analyzing a greater number of samples and being more meticulous in calibration will be beneficial for a more precise assessment of the outcomes. The extensive implementation of NIRS technology, which facilitates the rapid completion of analyses that typically require several days using traditional methods, is anticipated to significantly benefit feed mills. It is clear that future technological advancements (e.g. artificial intelligence (AI), internet of things (IoT)) will result in significant progress in NIRS devices. Recent studies have shown that calibration transfer is possible with the advancements in the internet world. Until recently, regional differences had to be considered during calibration, and corresponding adjustments were needed. New studies suggest that regional or even national differences can be eliminated. The integration of artificial intelligence with NIRS holds great promise for revolutionizing real-time monitoring and analysis across industries.

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CHAPTER 2

DETERMINATION OF SATISFACTION LEVELS OF PRODUCERS INVOLVED IN THE NATIONAL SHEEP BREEDING IN PUBLIC HANDS PROJECT IN ELAZIG PROVINCA

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INTRODUCTION

The livestock sector in Turkey is a strategically important industry, providing essential products that feed the population and meet basic needs, creating added value, fostering rural development, and generating employment opportunities. In Turkey, 79% of the existing small cattle are sheep, while 21% are goats (TOB, 2022). Sheep and goat farming plays a significant role in the country's economy through the production of meat, milk, mohair, wool, and leather. In our country, sheep farming provides livelihoods for people involved in animal husbandry in the Eastern and Southeastern Regions (Arıkan, 2021).

In Turkey, sheep farming primarily occurs in small enterprises to support livelihoods. However, it is undergoing rapid changes due to the impacts of current economic and livestock policies. Factors such as limited pasture and meadow areas, challenges in finding shepherds along with high shepherd wages, a decrease in the number of enterprises and the young population in rural areas due to migration to cities, low demand for small cattle products, rising input costs, poor organization, unfavorable market conditions for breeders, inadequate breeding enterprises, and insufficient support and incentives for small cattle farming in comparison to large cattle farming continue to shape the sector's structural status today (Cengiz et al., 2015; Ünal, 2021).

Livestock support aims to develop our country's livestock, ensure sustainability, enhance efficiency in implementing livestock policies, protect and develop local animal genetic resources on-site, maintain up-to-date records, combat animal diseases, and assist breeders in producing healthy animals. For this reason, small cattle breeders receive support from the Ministry of Agriculture and Forestry, General Directorate of Agricultural Research and Policies (TAGEM), under the "Sheep Breeding in National Project." These initiatives aim to boost productivity in local small cattle, establish breeding enterprises, produce quality breeding animals, transfer best practices and regulations to breeders, increase the profitability of enterprises, and contribute to the economy (Ünal, 2021). In this context, breeding activities are conducted in 60 provinces, with a total of 167 projects focused on 27 small cattle breeds in Turkey.

In the Eastern Anatolia Region, Elazığ province has a significant potential in terms of the number of small cattle. According to the data of the Turkish Statistical Institute (TÜİK), the current small cattle stock in Elazığ province in 2021 is 1,089,120 heads; 83.37% of this consists of sheep and 16.63% of goats (TÜİK, 2022). Small cattle breeding in the region is carried out using low-yielding local breeds, nomadic pasture-based feeding conditions and limited inputs. Şavak Akkarman sheep are widely bred in the province. In order to improve this breed, the Şavak Akkaraman sheep breeding project is implemented in Elazığ province as four sub-projects. With the planned study, determining the factors affecting the satisfaction level of the producer with the services provided within the scope of the animal breeding (şavak akkaraman) project in the public hands is important in terms of the support methods to be determined in the future.

When examining studies on satisfaction levels in agriculture and animal husbandry, it is evident that they center on agricultural consultancy services (İmamoğlu and Çobanoğlu, 2018), chambers of agriculture (Terin and Ateş 2010), the red meat producers' union (Akın, 2019), producers receiving machinery and equipment support through the Agriculture and Rural Development Support Institution (TKDK) (Tan, 2018), livestock producers (Bakır and Kibar, 2019), the satisfaction levels of dairy cattle enterprises with livestock support (Özdemir et al., 2022), and workforce satisfaction among enterprise owners in large livestock farming (Akın, 2020).

The primary motivation for planning this research is to assess the satisfaction levels of breeders involved in the breeding project, considering their perspectives and opinions about it. No existing study has measured the satisfaction levels of breeders in the public breeding project. This study aims to address this information gap by evaluating the satisfaction levels of producers benefiting from the breeding project, focusing on their bureaucratic processes, technical and economic efficiency, socio-economic contributions, and observational/experiential expectations. Particularly in long-term initiatives like the public breeding project, understanding the satisfaction levels of producers will inform future decisions aimed at enhancing the project's success.

MATERIALS and METHODS

The primary material for this research comprises data collected through a face-to-face survey completed by sheep breeders who are enterprises owners benefiting from the Sheep Breeding Project in Elazığ province.

Determination of enterprises to include in the sample

The sample for the study comprised sheep breeding enterprises participating in the Sheep Breeding Project in Elazığ province. For this purpose, within the scope of the ongoing breeding project in Elazığ province, there are 18 breeders in the I. sub-project, 35 in the II. sub-project, 48 in the III. sub-project, and 53 in the IV. sub-project, totaling 154 breeders. It was concluded that a total of 138 enterprises could represent the population using the Simple Random Sampling Method from the total of 154 breeders. The following formula was employed to calculate the sample size (Sümbüloğlu and Sümbüloğlu, 2005).

In the given formula:

N represents the total number of individuals in the population.

n denotes the sample size, or the number of individuals to be selected.

p is the probability of the event occurring.

q is the probability of the event not occurring (1 - p).

t is the theoretical value obtained from the t-table, corresponding to a specific degree of freedom and a chosen error level.

d represents the acceptable deviation, determined based on the event's occurrence frequency.

In this study, the total number of breeders benefiting from the public breeding project in Elazığ province is 154.

If $p = 0.90$, $q = 0.10$, and $t = 2.58$ are taken at a 10% error rate;

When 10% more than the calculated sample size is taken as a reserve, it is concluded that face-to-face surveys should be conducted in the field with at least $125 + 12.5 \cong 138$ enterprises.

Collecting data

In obtaining the data, the demographic and technical information of the enterprises included in the research scope was collected by visiting them according to the calculated sample, examining them on-site, and conducting field studies. The data obtained from face-to-face interviews with the producers were processed into survey forms, and detailed statistical analyses were conducted using the methods mentioned below.

Factor Analysis Method

The aim was to determine the views and opinions of producers receiving support from the breeding project regarding this program through factor analysis (measuring satisfaction levels). A questionnaire consisting of 34 items was developed to assess satisfaction levels. While preparing the items, the researchers created an item pool using the DELPHI process. In the next stage, the prepared questionnaire was evaluated by three experts, leading to the creation of the final version. There were no negative expressions in the prepared questionnaires. The questionnaire items were designed with a Likert-type scale scoring from 1 to 5 (Tavşancıl, 2010).

After administering the form, the validity and reliability of the scales were evaluated. To assess construct validity, reliability analyses were conducted using Cronbach's Alpha (α) coefficient (Durutürk et al., 2017). Factor analysis was performed separately for each scale to examine validity. The suitability for factor analysis was determined using Bartlett's test of sphericity and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy, confirming that the sample size was appropriate (Karahan et al., 2014). The items of the developed scale were evaluated under separate factors using the Varimax rotation method (Durutürk et al., 2015). In the next stage, after presenting the scale, its additivity was assessed with the Tukey additivity test, and a total score was calculated to reveal the satisfaction levels of the producers (Karahan et al., 2014). The SPSS 25 (IBM Corp, 2017) statistical package program was used for data evaluation.

RESULTS

The distribution of responses from the producers regarding the factors influencing their satisfaction level with the Sheep Breeding Project in Elazığ province is presented in Table 1.

Table-1. Distribution of responses given by producers to factors determining satisfaction level

Question	I strongly agree		I agree		I have no opinion		I disagree		I strongly disagree	
	n	%	n	%	n	%	n	%	n	%
BS1	10	7,20	70	50,70	12	8,70	18	13,00	28	20,30
BS2	14	10,10	65	47,10	16	11,60	28	20,30	15	10,90
BS3	7	5,10	68	49,30	21	15,20	19	13,80	23	16,70
BS4	4	2,90	68	49,30	26	18,80	20	14,50	20	14,50
BS5	5	3,60	66	47,80	26	18,80	21	15,20	20	14,50
BS6	20	14,50	56	40,60	30	21,70	15	10,90	17	12,30
BS7	1	0,70	28	20,30	27	19,60	49	35,50	33	23,90
BS8	6	4,30	53	38,40	21	15,20	35	25,40	23	16,70
TE1	6	4,30	63	45,70	24	17,40	35	25,40	10	7,20
TE2	1	0,70	22	15,90	43	31,20	44	31,90	28	20,30
TE3	2	1,40	32	23,20	32	23,20	45	32,60	27	19,60
TE4	2	1,40	27	19,60	31	22,50	43	31,20	35	25,40
TE5	3	2,20	49	35,50	25	18,10	34	24,60	27	19,60
TE6	6	4,30	63	45,70	21	15,20	28	20,30	20	14,50
TE7	7	5,10	72	52,20	22	15,90	21	15,20	16	11,60
TE8	5	3,60	67	48,60	30	21,70	22	15,90	14	10,10
TE9	7	5,10	52	37,70	23	16,70	34	24,60	22	15,90
TE10	4	2,90	28	20,30	26	18,80	59	42,80	21	15,20
SE1	5	3,60	69	50,00	23	16,70	23	16,70	18	13,00

SE2	6	4,30	42	30,40	33	23,90	41	29,70	16	11,60
SE3	13	9,40	57	41,30	35	25,40	19	13,80	14	10,10
SE4	2	1,40	27	19,60	66	47,80	23	16,70	20	14,50
SE5	7	5,10	32	23,20	35	25,40	39	28,30	25	18,10
SE6	5	3,60	28	20,30	34	24,60	51	37,00	20	14,50
SE7	5	3,60	37	26,80	28	20,30	45	32,60	23	16,70
GD1	2	1,40	47	34,10	24	17,40	44	31,90	21	15,20
GD2	7	5,10	42	30,40	33	23,90	36	26,10	20	14,50
GD3	2	1,40	49	35,50	22	15,90	42	30,40	23	16,70
GD4	3	2,20	63	45,70	23	16,70	32	23,20	17	12,30
GD5	2	1,40	54	39,10	25	18,10	39	28,30	18	13,00
GD6	3	2,20	60	43,50	24	17,40	25	18,10	26	18,80
GD7	2	1,40	23	16,70	33	23,90	59	42,80	21	15,20
GD8	19	13,80	53	38,40	20	14,50	20	14,50	26	18,80
GD9	1	0,70	31	22,50	24	17,40	50	36,20	32	23,20

The data in Table 1 are analyzed, and the general opinions of the participants regarding the "Sheep Breeding Project" are evaluated under the headings below.

Being informed before the application: More than half of the participants (50.7%) indicated that they had the necessary information at the time of application, while 33.3% reported deficiencies in this area.

Information from the relevant institution: 57.2% of participants believed that sufficient information was provided by the union, but 31.2% noted deficiencies in this regard.

Information on contract details: Approximately 50% of participants stated that they were aware of the contract details, while 30.5% reported having incomplete information in this area.

Ease of application: Although 49.3% stated that the application process was understandable, 29% expressed difficulties with this process.

Process of receiving support: While 47.8% of participants indicated that the process of receiving support from the public breeding project was easy, 29.7% reported challenges with this process.

Timely payments: 55.1% of participants stated that support payments were made on time, while 23.2% provided negative feedback on this issue.

Adequacy of grant amounts: The percentage of those who believed that the grant amounts were sufficient was low (21%), while 59.4% of participants expressed dissatisfaction with this issue.

Income increase and diversification: Over 50% of participants indicated that the project contributed to income increases, while 31.6% believed that the project diversified their income.

Income stability: 32.6% of participants stated that the project provided income stability, while 52.2% offered negative feedback on this issue.

Adequacy of the number of animals: 56.6% of participants felt that the income generated from the project was insufficient for sustainable production.

Adequacy of financial resources: 24.6% of participants indicated that they lacked sufficient financial resources to properly care for and feed the animals.

Conscious production: While 50% of participants stated that they engaged in more conscious production with the project, 34.8% expressed negative opinions on this issue.

Encouraging technology use: 58.0% of participants believe that the project does not encourage producers to utilize technology.

Contribution to employment: 42.8% of participants feel that the project contributes to employment, while 40.5% expressed a negative opinion on this matter.

Mobility in rural areas: 46.4% of participants believe that the project does not create any economic mobility in rural areas.

Encouraging community life: 51.5% of participants stated that the project does not promote life in rural areas.

Contribution to entrepreneurship: 49.3% of participants noted that the project does not support entrepreneurship.

Starting animal production: 34.1% of participants indicated that the project aided in starting animal production.

Expectations: 52.2% of participants claimed that their expectations from the project were not met.

This general assessment reveals that participants have mixed views about the project; while there are positive responses in certain areas, significant dissatisfaction exists, particularly regarding the adequacy of economic support, sustainability, and the overall ease of project implementation.

Questions were directed to the producers to determine the satisfaction levels of those who benefited from the rehabilitation project, and the findings regarding the reliability coefficients of the questions can be seen in Table 2.

Table 2. Reliability coefficients of questions to assess producers' satisfaction levels.

	Satisfaction Level Queries	If an item is removed from the scale, the valid mean	If an item is removed from the scale, the valid variance	If an item is removed from the scale, the valid reliability coefficient
BS1	With the sheep breeding project, there was an increase in my producer income.	71,4058	158,126	0,762
BS2	I diversified my income with the sheep breeding project.	71,5435	162,921	0,757
BS3	I achieved stability in my income (a certain standard) with the sheep breeding project.	71,4130	159,164	0,778
BS6	I became more conscious in my production with the sheep breeding project.	71,6304	159,899	0,756
BS7	The sheep breeding project is a project that contributes to conscious breeding.	70,6739	183,170	0,700
BS8	The technical support I receive within the scope of the sheep breeding project reflects positively on my income.	71,1739	161,853	0,790
TE1	My producer income increased with the sheep breeding project.	71,4348	164,145	0,777
TE3	I achieved stability in my income (a certain standard) with the sheep breeding project.	70,8333	166,987	0,764
TE4	The number of animals included in the sheep breeding project is sufficient for sustainable (continuous) production.	70,6957	175,702	0,752
TE6	I became more conscious in my production with the sheep breeding project.	71,3406	160,153	0,761
TE7	The sheep breeding project is a project that contributes to conscious breeding.	71,5290	159,974	0,799
TE8	The technical support I received within the scope of the sheep breeding project is positively reflected in my income.	71,4855	162,310	0,746
TE9	The sheep breeding project contributes to employment.	71,2029	160,849	0,726
SE1	The sheep breeding project is an effective and efficient project.	71,4348	162,306	0,707
SE3	The sheep breeding project is a positive movement for the branding of the sheep breed.	71,5507	162,892	0,797
SE6	The sheep breeding project encourages life in rural areas	70,9058	169,356	0,785
SE7	The sheep breeding project contributes to the entrepreneurship of breeders.	70,9710	164,393	0,735

GD2	GD1- Thanks to the support I received within the scope of the sheep breeding project, I started animal production	71,1449	161,264	0,741
GD3	I will continue the animal production I started with the sheep breeding project after the project	71,0362	164,488	0,728
GD5	I maintained my current production level thanks to the sheep breeding project	71,1667	163,775	0,771
GD6	Although the sheep breeding project did not contribute to production, it solved my financial difficulties	71,2101	162,810	0,761
GD7	I think the animal breeding project support in the public hands is sufficiently beneficial	70,7536	176,552	0,736
GD8	I have high expectations from the sheep breeding project	71,4275	158,480	0,734
GD9	The support was beneficial for me since I left my other current jobs thanks to the sheep breeding project	70,7029	177,320	0,701

The items with a reliability coefficient lower than 0.50 in the survey were removed from the scale (BS4, BS5, SE2, SE4, SE5, TE2, GD1, GD4, TE5, TE10). The reliability coefficients of the remaining 24 items in the study were determined to be above the acceptable value. Next, the reliability coefficient of the survey was analyzed. The method used to calculate this coefficient depends on factors such as the type, source, and frequency of variable applications. Differences in calculation methods also influence the interpretation of the reliability coefficient. This coefficient measures the extent to which the data is free from random errors, providing insight into the level of error in measurement results. Reliability values range from 0 to +1, with higher values being more desirable. A coefficient above 0.70 is generally considered acceptable. Since the measurement tool uses a 5-point Likert scale, Cronbach's Alpha was applied to assess reliability and internal consistency. The Cronbach's Alpha coefficient for the questionnaire used in this study is presented in Table 3 below.

Table-3. Total reliability coefficients of satisfaction level measurement questions

	Number of items	Reliability coefficient
Satisfaction Level Queries	24	0,855

The Cronbach's alpha reliability coefficient calculated for the 24 items used in the application was 0.855. This coefficient being above 0.60 indicates that the prepared questionnaire is quite suitable for measuring risk factors.

The results of the factor analysis using the Varimax Method for each factor are shown in Table 4.

Table-4. Factor analysis results obtained with the Varimax Method

Factors	Sum of Squares of Factor Loadings Following Varimax Rotation		
	Total	Explained Variance %	Cumulative Variance %
Factor 1	6,655	27,730	27,730
Factor 2	2,171	9,044	36,774
Factor 3	1,263	5,264	42,038
Factor 4	1,227	5,112	47,150
Factor 5	1,119	4,660	51,810

Kaiser-Meyer-Olkin sampling adequacy: 0.852; Bartlett's test of sphericity chi-square value: 987.231; degrees of freedom: 276, p = 0.001.

When Table-4 is analyzed, it can be stated that there are five factors based on the application data for 24 items, with 51.81% of the feature measured by this five-factor measurement tool. In social sciences, it is generally considered adequate for the total explained variance to be at least 50%. A Kaiser-Meyer-Olkin sample adequacy statistic above 0.50 indicates that the sample size is sufficient. Bartlett's chi-square test of sphericity assesses the appropriateness of the data for factor analysis. A higher ratio indicates a greater suitability of the dataset for factor analysis. Therefore, it can be concluded that the data is appropriate for factor analysis ($p < 0.001$).

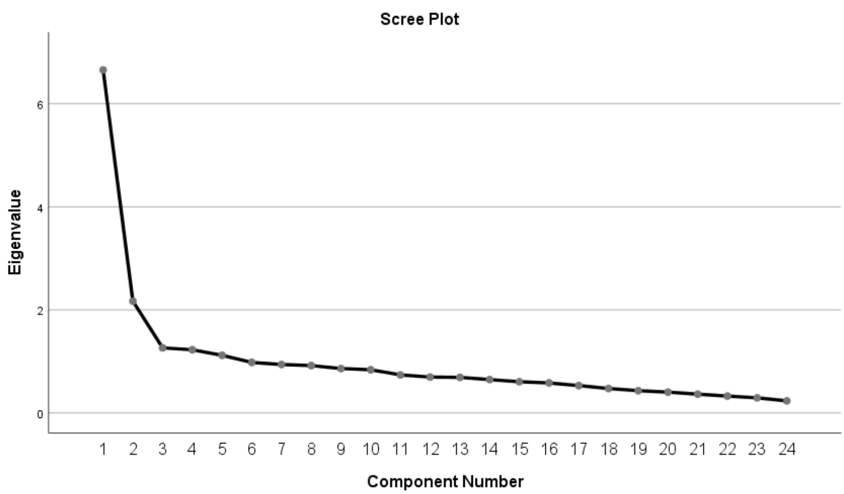

Figure-1. Principal component graph with eigenvalues

This situation can also be partially analyzed from the graph. In Figure 1, the point where the elbows begin to straighten, or the cut-off point of the eigenvalues, is the 5th principal component.

The distribution of factor loadings that determine the satisfaction level of producers is shown in Table 5 below.

Table-5. Factor loadings of the factors determining the satisfaction level of producers

	Factor Subitems	1	2	3	4	5
BS8	I fulfilled the obligations I had to do within the scope of the sheep breeding project without difficulty.	0,788				
GD6	Although the animal breeding project support in the public hands did not contribute to production, it solved my financial difficulties.	0,665				
BS6	The animal breeding project support in the public hands was received/paid on time.	0,648				
TE6	I became more conscious in production with the sheep breeding project.	0,641				
GD8	I have high expectations from the sheep breeding project.	0,571				
TE8	The technical support I received within the scope of the sheep breeding project reflects positively on my income.	0,401				
TE7	The sheep breeding project is a project that contributes to conscious breeding.	0,398				
GD5	Thanks to the sheep breeding project, I maintained my current production level.	0,374				
TE1	There was an increase in my producer income with the sheep breeding project.	0,365				
SE6	The sheep breeding project encourages life in rural areas.		0,747			
GD9	The support was beneficial for me since I left my other current jobs thanks to the animal breeding project support in the public hands.		0,645			
SE7	The sheep breeding project contributes to the breeders becoming entrepreneurs.		0,618			
TE9	The sheep breeding project contributes to employment.		0,412			
TE4	The number of animals included in the sheep breeding project is sufficient for sustainable (continuous) production.			0,672		
BS7	The grant amounts given in the sheep breeding project are sufficient.			0,663		
TE3	I have stabilized my income with the sheep breeding project.			0,469		
GD2	I will continue the animal production that I started with the sheep breeding project after the project.			0,449		
GD7	I think the animal breeding project supports in the public hands are sufficiently useful.				0,788	
BS2	I was sufficiently informed by the relevant institution during the application to the sheep breeding project.				0,349	
BS1	I had the necessary information during the application to the sheep breeding project.					0,706

BS3	I know the details about the contract of the sheep breeding project.					0,624
SE3	The sheep breeding project is a positive movement for the branding of the sheep breed.					0,601
SE1	The sheep breeding project is an effective and efficient project.					0,586
GD3	My current production has increased with the support of the animal breeding project in public hands.					0,511

When Table 5 is examined, a total of five factors were identified, and the distribution of the questions among these factors was noted. The questions for the measurement tool collected into five main factors are distributed as follows.

1. Economic and conscious production (BS8, GD6, BS6, TE6, GD8, TE8, TE7, GD5, TE1)

These factors express the various benefits and contributions provided to producers by the "People's Animal Breeding Project". The project shares a common feature in that it offers both financial and technical support, assisting producers in increasing their income, producing sustainably, and maintaining their current production levels. Furthermore, the timely support provided under the project and the ease of meeting obligations bolster producers' positive expectations for the initiative. These factors demonstrate that the project supports both economic and sustainable animal husbandry processes.

2. Contribution to rural development and entrepreneurship (TE4, BS7, TE3, GD2)

These factors highlight that the "Sheep Breeding in Public Hands Project" promotes rural life, helps producers achieve economic independence, and fosters entrepreneurship. The project supports the growth of employment in rural areas and enhances the professional development of individuals in agriculture and animal husbandry by enabling them to transition from their current jobs. Simultaneously, it makes rural living more appealing and bolsters the local economy by promoting entrepreneurship.

3. Sustainable Production and Stable Income (TE4, BS7, TE3, GD2)

These factors highlight that the "Sheep Breeding in Public Hands Project" offers sustainable and stable production conditions. The support amounts provided within the project's framework, along with the number of animals included, give producers a long-term planning opportunity and ensure income stability. Moreover, the benefits gained through the project enhance producers' motivation to continue animal production post-project. This situation guarantees both economic security and a solid foundation for ongoing production.

4. Information and Participant Satisfaction (GD7, BS2)

These factors indicate that the "Sheep Breeding in Public Hands Project" was consciously evaluated and deemed beneficial by participants due to the ample information provided. The support offered during the project's application process enabled participants to maximize their benefits from the project. Moreover, participants mentioned they were generally satisfied with the project and found the support offered to be effective.

5. Increase in productivity (BS1, BS3, SE3, SE1, GD3)

These factors demonstrate that the "Sheep Breeding in Public Hands Project" was well understood by the participants, with project details mastered and effectively utilized. The clarity of information and contract details during the participation process enabled the participants to use the project more efficiently. Additionally, the project contributed to the improvement of animal breeds, while achieving an increase in production and efficiency.

When all these factors are considered, the Sheep Breeding in Public Hands Project stands out as a comprehensive initiative that offers economic stability and efficiency to participants, boosts production capacity, fosters entrepreneurship in rural areas, and promotes responsible breeding. The project significantly contributes to the sustainability of participants' animal production processes, rural development, and employment through effective information dissemination and the financial and technical support it provides. In this context, the Sheep Breeding in Public Hands Project is recognized as a vital tool for sustainable animal husbandry and long-term regional development.

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CHAPTER 3

EFFECTIVENESS ANALYSIS OF PRODUCERS INVOLVED IN THE NATIONAL SHEEP BREEDING IN PUBLIC HANDS PROJECT IN ELAZIG PROVINCE

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INTRODUCTION

The livestock sector in Turkey is a strategically important industry that contributes to society by providing essential products, creating added value, fostering rural development, and generating employment opportunities. In Turkey, 79% of the existing small cattle are sheep, while 21% are goats (TOB, 2022). Sheep and goat farming play a significant role in the economy through meat, milk, mohair, wool, and leather production. In our country, sheep farming is vital for the livelihoods of those engaged in animal husbandry in the Eastern and Southeastern Regions (Arıkan, 2021).

While sheep farming in Turkey is primarily conducted by small enterprises for sustenance, it is undergoing rapid transformation due to the overall economic and animal husbandry policies today. Factors such as insufficient pasture and meadow areas, difficulties in finding shepherds and the high costs associated with shepherding, a decline in the number of enterprises and young populations in rural areas due to migration to cities, low demand for small cattle products, rising input costs, lack of organization, unfavorable market conditions for breeders, inadequate breeding enterprises, and small cattle breeding receiving less support compared to large cattle farming are shaping the current structural status of the sector (Cengiz et al., 2015; Ünal, 2021).

Livestock support initiatives aim to enhance Turkey's livestock sector and ensure sustainability, improve the effectiveness of livestock policies, protect and develop local animal genetic resources, maintain up-to-date records, combat animal diseases, and assist breeders in producing healthy animals. As such, small cattle breeders are supported through the "Small Cattle Breeding Project" by the Ministry of Agriculture and Forestry, General Directorate of Agricultural Research and Policies (TAGEM). These projects aim to boost productivity in local small cattle, establish breeding enterprises, produce quality breeding animals, transfer breeding practices and regulations to breeders, improve enterprise profitability, and contribute to the economy (Ünal, 2021).

In this context, breeding activities are being conducted in 60 provinces, encompassing a total of 167 projects for 27 small cattle breeds in Turkey. Elazığ province in the Eastern Anatolia Region holds substantial potential in terms of small cattle numbers. According to data from the Turkish Statistical Institute (TÜİK), the small cattle population in Elazığ province was recorded at 1,089,120 heads in 2021; 83.37% of this number comprises sheep, while 16.63% are goats (TÜİK, 2022).

Small cattle farming in the region relies on low-yielding local breeds, nomadic pasture-based feeding practices, and limited resources. The Şavak Akkarman sheep are commonly bred in the province. To enhance this breed, a Şavak Akkaraman sheep breeding project is currently being implemented in Elazığ province, consisting of four sub-projects. Assessing the effectiveness of the support provided through the animal breeding (Şavak Akkaraman) project is crucial for determining future support amounts and methods.

When the studies conducted on the sheep breeding project in public hands are examined, it becomes evident that the project focuses on various aspects: fertility characteristics of the flocks (Yayvan, 2021; Elçi, 2022; Kırbaş et al., 2022), reproductive diseases (Yılmaz, 2020), survival and growth performance of lambs (Kul et al., 2015; Yayvan, 2021; Elçi, 2022), care and feeding practices (Oğuz et al., 2019; Zengin, 2020), fleece characteristics (Bağkesen and Koçak, 2018), milk characteristics (Aydemir, 2022), structural characteristics of the enterprises (Güngör, 2021; Ünal, 2021), socio-economic and demographic characteristics of the enterprises (Ünal, 2021), and economic analysis (Güngör, 2021).

The primary motivation for planning the research is the absence of studies measuring the efficiency of animal production activities conducted by the breeders involved in the improvement project at the enterprise level, along with the support they receive. The planned study aims to address this information gap by determining whether the producers benefiting from the improvement project operate effectively at the enterprise level and their respective efficiency levels. By examining the distances of the enterprises from the effective production limit and their clustering around this limit, accurate insights can be gained regarding the efficiency levels of the enterprises and their potential for increasing productivity. Identifying ineffective enterprises allows for recognizing common factors that contribute to inefficiency. Particularly in long-term projects like improvement initiatives, generating necessary solutions for enterprises to become effective will positively influence their income, and additional measures can be pursued to enhance these areas with newly implemented support.

The need to conduct impact analyses of policies and supports implemented in animal husbandry was also highlighted by the Ministry of Agriculture and Forestry, and was identified among the priority R&D issues by the General Directorate of Agricultural Research (TAGEM). Adapting the methodology used in the current study to similar support projects within the animal husbandry sub-sectors will facilitate analyses that guide policymakers in making critical decisions. Meanwhile, the Elazığ Province Breeding Sheep and Goat Breeders Association considers the current data sharing and collection regarding the project to be appropriate and offers institutional support for the project. At this juncture, it is anticipated that sharing the study's findings with the implementing unit of the small cattle breeding project will play a vital role, enhancing scientific contributions as a reference for establishing and developing cooperation between non-governmental organizations and universities, boosting synergy between institutions, and creating new fields of study in the future.

Although Elazığ province is highly advantageous for sheep breeding, the lack of information among breeders about effective and efficient practices diminishes their production potential in animal husbandry. As part of the animal breeding project, efforts are underway to enhance the genetic capacity of herds owned by producers with support. However, there is a limited understanding of the impact of this support in a enterprisess context. It seems that studies assessing the technical and economic characteristics of sheep breeding enterprises and the factors influencing these activities are scarce. The project designed to address these issues aims to identify the technical and economic activities of sheep breeding enterprises and the factors affecting their efficiency scores.

The aim is to determine the factors influencing efficiency and those causing inefficiency among enterprises by calculating the efficiency measurements of enterprisesses benefiting from the improvement project in Elazığ Province. To achieve this objective, the data collected from a survey administered to producers within the selected sample will be evaluated using data envelopment analysis.

MATERIALS and METHODS

The primary material for this research comprises data collected through a face-to-face survey completed by sheep breeders who are enterprises owners benefiting from the Sheep Breeding Project in Elazığ province.

Determination of enterprises to include in the sample

The sample for the study comprised sheep breeding enterprises participating in the Sheep Breeding Project in Elazığ province. For this purpose, within the scope of the ongoing breeding project in Elazığ province, there are 18 breeders in the I. sub-project, 35 in the II. sub-project, 48 in the III. sub-project, and 53 in the IV. sub-project, totaling 154 breeders. It was concluded that a total of 138 enterprises could represent the population using the Simple Random Sampling Method from the total of 154 breeders. The following formula was employed to calculate the sample size (Sümbüloğlu and Sümbüloğlu, 2005).

In the given formula:

N represents the total number of individuals in the population.

n denotes the sample size, or the number of individuals to be selected.

p is the probability of the event occurring.

q is the probability of the event not occurring (1 - p).

t is the theoretical value obtained from the t-table, corresponding to a specific degree of freedom and a chosen error level.

d represents the acceptable deviation, determined based on the event's occurrence frequency.

In this study, the total number of breeders benefiting from the public breeding project in Elazığ province is 154.

If p = 0.90, q = 0.10, and t = 2.58 are taken at a 10% error rate;

When 10% more than the calculated sample size is taken as a reserve, it is concluded that face-to-face surveys should be conducted in the field with at least 125 + 12.5 ≅ 138 enterprises.

Data Evaluation and Analysis Method

In the study, data envelopment analysis (DEA) will be conducted to evaluate the efficiency of the enterprises involved in the improvement project in terms of technical features and to identify the factors influencing their technical efficiency and efficiency scores. Demographic information and technical characteristics of the enterprises (Appendix-2) were compiled from various sources (Ünal, 2021; Güngör, 2021; Arıkan, 2021).

The demographic characteristics of the enterprises will include the breeder's age, educational background, professional experience, type of animal husbandry activity, membership in a union or cooperative, benefits received from animal husbandry support, supply of feed utilized in the enterprise, breed raised, record-keeping status of the enterprise, land ownership status, pasture utilization, milking techniques, and presence of foreign labor.

The technical features of the enterprises will be evaluated using data envelopment analysis. In this context, the number of animals, the number of shearers, workers, and shepherds, the amount of concentrated feed used, the amount of roughage used, and the number of pasture rents will serve as input variables for the enterprises. Meanwhile, the milk income, meat income, fleece income, lamb sales income, scrap animal price, state support, the amount of milk produced, and the number of offspring born will represent the output variables of the enterprises (Akçay et al., 2017).

In the scope of the study, firstly, descriptive statistics for all collected variables will be calculated. DEA will be utilized to compute the efficiencies of the enterprises. The most suitable model will be selected in DEA for easier interpretation of the results for both application and field use. Truncated regression analysis will be employed to identify the factors believed to influence the efficiency scores of the enterprises. MaxDEA 7

Basic (Cheng, 2014) will be used to determine the efficiencies resulting from DEA, while the Stata 12/MP4 (Stata 12/MP4, 2015) statistical package will be employed to compute the descriptive statistics and identify the effective factors on the efficiency scores.

RESULTS

The socio-demographic and enterprisess-related findings from the research are presented in Table 1.

Table-1. Socio-demographic and management-related findings of the enterprises

Parameters	Range	N	%
Age	20-35	65	47.10
	36-45	36	26.09
	46-55	21	15.22
	56 and +	16	11.59
Educational Status	Reading-Writing	13	9.42
	Primary School	36	26.09
	Secondary School	50	36.23
	High School	35	25.36
	University	4	2.90
Activity Period	≤5 years	14	10.14
	6-10 years	55	39.86
	11-15 years	41	29.71
	16 and +	28	20.29
Activity Type	Milk	0	0
	Beef	11	7.97
	Breeding	0	0
	Milk and Beef	127	92.03
Union Membership	Yes	138	100
	No	0	0
Benefiting from Support	Yes	138	100
	No	0	0
Feed Supply	Outsourcing	119	86.23
	Own production	19	13.77
Breed	Akkaraman	138	100
	Morkaraman	0	0
Land Status	Property	130	94.20
	Rent	8	5.80
Record Keeping	Yes	57	41.30
	No	81	58.70
Benefiting from Pasture	Yes	88	63.77
	No	50	36.23
Milking Technique	Mechanical Milking	0	0
	Hand Milking	138	100
Foreign Workforce	Yes	109	78.99
	No	29	21.01

When examining Table 1, most producers are between the ages of 20 and 35 (65 people). Producers in the middle age group (36 to 45 years) also make up a significant share (36 people). It is believed that this age group may have more experience than younger producers, who are often new to the sector. The level of education is typically at the primary and secondary school levels, with only a few producers having a university education (4 people). Most producers have been operating for 6 to 10 years (55 people), indicating medium-term experience. The majority of producers engage in both milk production and fattening activities (127 people), while a smaller number focus solely on fattening (11 people). All producers are members of the union (138 people) and benefit from subsidies, reflecting an organized project structure with support from the state. Most producers purchase their feed from abroad (119 people), with only a few producing their own feed (19 people). This situation suggests dependence on foreign sources for feed supply and a low capacity for domestic production.

All producers raise Akkaraman sheep, indicating uniform breed selection that is likely suited to regional characteristics. Most producers use their own land (130 people), while only a small fraction operates on rented land (8 people), suggesting a tendency to make long-term plans regarding their land usage.

There is a distinction among producers regarding record keeping: 57 producers keep records, while 81 do not, which indicates a deficiency in data collection and monitoring. Most producers utilize pastures (88 people), though some do not (50 people), reflecting widespread use of natural resources.

All producers milk by hand (138 people), and the absence of mechanized milking signifies reliance on more traditional methods. There is a high rate of foreign labor usage (109 people), indicating that a significant portion of the labor force is sourced from abroad.

Overall, the producers in the Elazığ Province Sheep Breeding Project are primarily middle-aged, educated at the primary and secondary levels, have been active for many years, and raise the Akkaraman breed. They benefit from support and are union members. However, improvements are necessary in certain areas, such as record keeping and feed production. The input and output variable values of the 138 sheep farming enterprises involved in the study are presented in Table 1.

The values of the input and output variables from the 138 sheep farming enterprises included in the study are shown in Table 1.

Table-1. Average values of input and output variables of enterprises

	Input-Output Variable	Average TL/Year
Input Variables	Feed cost	121.955
	Labor cost	38.801
	Veterinary-health cost	11.723
	Loan interest	1.191
	Other costs	4.344
	General administration costs	5.795
	Amortization	17.870
	Maintenance-repair costs	15.658
Output Variables	Cheese income	20.330
	Meat income	35.069
	Fleece income	1.037
	Lamb sales income	138.006
	Scrap animal cost	18.145
	Government support	16.559

The average values of the enterprises' input variables were calculated as follows: feed costs of 121,955 TL annually, labor costs of 38,801 TL annually, veterinary health costs of 11,723 TL annually, loan interest of 1,191 TL annually, other expenses of 4,344 TL annually, general administrative expenses of 5,795 TL annually, depreciation of 17,870 TL annually, and maintenance and repair expenses of 15,658 TL annually. The average values of output variables were calculated as 20,330 TL annually for cheese income, 35,069 TL annually for meat income, 1,037 TL annually for wool income, 138,006 TL annually for lamb sales income, 18,145 TL annually for discarded animals, and 16,559 TL annually for state support.

The efficiency status of the sheep farming enterprises assessed in this research, based on data envelopment concerning their economic characteristics, is detailed in Table 2.

Table-2. Efficiency status of enterprises

		CCR		BCC	
		Input Oriented	Output Oriented	Input Oriented	Output Oriented
Active Enterprisess	n	52	52	63	63
	%	%37,68	%37,68	%45,65	%45,65
Inactive Enterprisess	n	86	86	75	75
	%	%62,32	%62,32	%54,34	%54,34

According to the DEA results using the CCR method (constant returns to scale), 52 enterprises (37.68%) were found to be efficient, while 86 enterprises (62.32%) were deemed inefficient. Using the BCC method (variable returns to scale), 63 enterprises (45.65%) were found efficient, and 75 enterprises (54.34%) were considered inefficient. When comparing the two methods, the BCC method identified a higher number of efficient enterprises than the CCR method.

For manufacturing enterprises, producing a certain output in the most efficient way is crucial, while minimizing the relevant input variables is essential. Therefore, only input-oriented DEA models under the assumption of variable returns to scale were included in the super efficiency model analysis. In Table 3, the Andersen and Petersen Method, or the super efficiency model, is presented for comparing and ranking efficient enterprises based on their economic characteristics.

Table-3. Input-Oriented BCC Super Efficiency Model Results

Ranking	Enterprises Number	Score	Ranking	Enterprises Number	Score	Ranking	Enterprises Number	Score
1	99	8,954	47	131	1,722	93	11	0,501
2	36	8,378	48	2	1,693	94	34	0,499
3	1	7,713	49	95	1,656	95	50	0,497
4	101	7,410	50	32	1,637	96	98	0,493
5	38	6,608	51	5	1,608	97	15	0,491
6	111	6,237	52	136	1,584	98	78	0,489
7	48	5,313	53	10	1,566	99	80	0,485
8	115	4,919	54	73	1,475	100	23	0,479
9	52	4,538	55	133	1,381	101	86	0,471
10	117	4,181	56	7	1,349	102	108	0,463
11	54	4,013	57	70	1,325	103	16	0,450
12	90	3,897	58	21	1,313	104	79	0,414
13	27	3,817	59	84	1,264	105	113	0,381
14	118	3,737	60	35	1,239	106	109	0,352
15	55	3,594	61	43	1,154	107	132	0,349
16	123	3,497	62	106	1,020	108	37	0,338

17	60	3,352	63	56	1	109	82	0,322
18	125	3,338	64	130	0,942	110	104	0,313
19	62	3,214	65	119	0,934	111	97	0,294
20	75	3,013	66	67	0,921	112	100	0,252
21	12	2,962	67	44	0,917	113	6	0,239
22	138	2,924	68	22	0,914	114	127	0,229
23	91	2,898	69	85	0,885	115	69	0,205
24	28	2,898	70	135	0,875	116	81	0,181
25	120	2,872	71	40	0,860	117	103	0,173
26	57	2,872	72	9	0,853	118	25	0,166
27	112	2,851	73	72	0,822	119	64	0,154
28	49	2,785	74	41	0,811	120	88	0,140
29	122	2,761	75	13	0,796	121	107	0,136
30	45	2,737	76	129	0,780	122	39	0,128
31	87	2,671	77	76	0,737	123	51	0,126
32	24	2,633	78	66	0,703	124	102	0,126
33	71	2,600	79	61	0,656	125	114	0,122
34	68	2,571	80	14	0,633	126	17	0,117
35	134	2,533	81	77	0,608	127	18	0,112
36	20	2,520	82	137	0,600	128	42	0,105
37	116	2,490	83	74	0,584	129	29	0,103
38	53	2,412	84	63	0,571	130	105	0,087
39	3	2,378	85	126	0,566	131	19	0,052
40	58	2,325	86	33	0,558	132	92	0,050
41	83	2,294	87	96	0,541	133	30	0,047
42	4	2,251	88	46	0,530	134	93	0,037
43	8	2,173	89	128	0,521	135	47	0,020
44	59	2,128	90	65	0,513	136	110	0,013
45	99	2,111	91	26	0,507	137	31	0,008
46	36	2,103	92	89	0,503	138	94	0,003

When interpreting the results of the "Input-Oriented BCC Super Efficiency Model," obtained through data envelopment analysis, the efficiency and performance rankings of the enterprisesses are considered.

A) Most Effective Enterprisesses:

The enterprisesses ranked highest have achieved the highest efficiency scores according to the BCC Super Efficiency Model. These enterprises utilize their resources most effectively. For instance, while enterprisess number 99 holds first place with 8.954 points, enterprisess number 36 ranks second with 8.378 points.

B) Medium Level Efficiency:

The enterprisesses in the middle ranks demonstrate a certain level of efficiency, but they are not as effective as those at the top. For example, enterprisess number 62 is in 19th place with 3.214 points, indicating a need for improvements in resource utilization.

C) Low Efficiency:

The enterprisesses in the lower ranks have received very low efficiency scores. These enterperises struggle to use their resources effectively, indicating significant potential for improvement. For example, while enterprisess number 94 is in last place with a score of 0.003, it must take serious steps to enhance its efficiency.

D) Distribution of Efficiency Scores:

Overall, the distribution of efficiency scores spans a wide range. The highest score is 8.954, and the lowest score is 0.003. This disparity highlights the significant differences among enterprisesses, with some operating at very high efficiency, while others lag behind considerably.

E) Improvement Suggestions:

For enterprisesses with low scores, it is advised that they reduce input amounts or increase outputs, in accordance with the BCC model, to enhance their performance. Enterprisesses with high scores can maintain their efficiency by continuing their current strategies. Based on these assessments, it will be beneficial for enterprisesses to review their performance and conduct necessary improvement and optimization activities.

Especially in sheep farming enterprises, the sale of milk produced by turning it into tulum cheese, a local product, is an activity that increases the output of the enterprises. The sale of milk by turning it into cheese is a common feature of efficient enterprises.

In this study, Data Envelopment Analysis (DEA) was used to measure the efficiency levels of the enterprises in the light of data obtained from 138 sheep farming enterprises. The main purpose of the study is to examine the efficiency of enterprises operating in the sheep farming sector in terms of input and output components, to determine enterprises with high and low efficiency levels and to reveal the general situation in the sector.

The analysis results show that there are significant differences in the efficiency levels of sheep farming enterprises. The number of enterprises that are fully efficient (with an efficiency score of 1.00) in terms of efficiency is limited compared to the total number of enterprises. This situation shows that most enterprises cannot use their existing resources optimally and have the potential to increase their efficiency. It has been determined that there is waste in input use and inadequacy in output levels, especially in inefficient enterprises. It is thought that these enterprisesses should review the production and management strategies of more efficient enterprisesses operating on similar scales and conditions.

If a generalization is to be made for inefficient enterprisesses to enhance their efficiency within the DEA model, it has been shown that enterperises with low efficiency scores should either reduce their input components or increase the output garnered from existing inputs to boost their efficiency. Additionally, it has been noted that some enterprisesses face disadvantages in terms of scale efficiency and cannot reach optimal production levels. Operating at a more suitable scale can help these enterprisesses improve their efficiency over the long term.

The findings indicate that a significant number of enterprises in the sheep sector require structural changes to enhance their efficiency. In the realm of efficiency-boosting strategies, factors such as adopting modern breeding techniques, optimizing herd management and feeding strategies, and ensuring access to suitable technology and information are becoming increasingly important. Furthermore, organizing training programs for ineffective enterprises in the sector and establishing information-sharing networks will also enhance the overall efficiency of the sector.

As a result, this study highlights strategies to improve the efficiency of sheep enterprises by revealing their current status. For the sustainability and competitiveness of the sector, it is crucial for enterprisesses with low efficiency levels to consider improvement suggestions based on DEA results. In doing so, a more effective production structure can be established in the sheep sector, further contributing to the country's economy and enhancing efficiency in this area.

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