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Optimization as a Cost Reduction Tool in the Formulation of The Diet For Beef Cattle

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Abstract: *The impacts on forage quantity and quality depend on the region and period of growth and climate variations caused by the times of the year may even become a wasteland. One of the exits employed in field is the use of supplementary feeding, with focused commercials, which often increase the cost of the final product. On the above, this study aimed to use optimization to formulate an additional minimum cost diet for cattle with an average weight of 250 kg of daily nutritional requirement for weight gain of 1.2 kg/day with the use of specific software was linear programming can be performed by means of an objective function involving the nutritional variables, corn, soybean meal, wheat bran and having an answer the supplementary diet optimized value at a lower cost. At the end of the survey was possible to conclude that the variable of greatest influence was the bran and the use of optimization allows you to achieve the lowest possible cost in the formulation of bovine diet given the nutritional requirements, which makes this tool important in sustainable management of agricultural production.*

Keywords: *Linear Programming; Ruminants; Supplementary feeding.*

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I. Introduction

According to [13] the global demand for livestock products is expected to double by 2050, consequence of the increase of the world's population. In this period, climate change will be a constant threat to beef cattle production, due to the impact on forage quality, water availability, influence on reproduction and stress.

When addressing the topic "animal feed" for bovine production is common to study the amount and quality of pastureland, involved in the process. However, when it comes to tropical countries, forage availability is directly related to local climatic conditions [5].

According to [6] and [7], at certain times of the year, droughts caused in the winter or fall significantly reduce the amount and quality of forage, to the point of compromising the production of meat or milk.

The impacts on forage quantity and quality depend on the region and period of growth and climate variations caused by the times of the year may even become a wasteland [11].An increase of 2°C will produce negative impacts on the production of pasture and livestock causing the need for supplementation in the diet [15].

Due to these facts, one of the maids in the outputs field is the use of a supplementary feeding with silage or hay commercial concentrates and grains, which often increase the cost of the final product.

Second [16] to formulate supplementary diets is a recurring problem for cattle breeders.Generally, food is made by specifying the nutritional requirements, among other parameters, the use of an algorithm is the best way to find a viable and economic formulation.

In recent years, research has been directed to the techniques of modeling, simulation and optimization capable of representing and improve discrete event systems, in order to support decision-making aimed at the solution of stochastic problems and reducingcosts [14].

On the above, this study aimed to use optimization to show that it is possible to formulate an additional minimum cost diet for cattle with an average weight of 250 kg, daily nutritional requirement for weight gain of 1.2 kg/day.

II. Material And Methods

The survey was conducted at the Faculty of Agricultural Sciences / Federal University of Grande Dourados (UFGD), in the city of Dourados-MS, Brazil, Longitude 54º,59'W; Latitude 22º,14' S, Altitude 463 meters, climate Monsoon Am, dry winter, according to Köppen classification, mean precipitation of 1500 mm³ per year and mean temperature of 22ºC per year [1].

The database of the chemical-bromatological compositionsof the possible foods used in this study was generated by[12] and supplemented with information from [8]. It wasconsidered an expected daily gain of 1.2 kg between 250 kgand 453.6 kg, according to the ideal prediction proposed by[8], with diet according to Table no 1 and nutritionalevaluation of Table no 2. The values considered for theproducts were referenced by [3] and converted into Braziliancommercial dollar, base month December/2018, accordingto Table no 3.

Table no 1: Forecasting data from [8]

WEIGHT(kg)	DM (kg/day)	TDN(kg/day)	ME(Mcal/kg)	CP (% MS)	Ca (% MS)	P (% MS)
250.00	5.00	4.5	2.74	12.40	0.49	0.24

DM = dry matter; TDN = total digestive nutrients; ME =metabolizable energy; CP = crude protein; Ca = Calcium; P =Phosphorus

Table no 2: Chemical-bromatological evaluation of foods indicated by [12] and [8].

PRODUCT	CORN	SOYBEAN (BRAN)	WHEAT (BRAN)	SUPPLEMENT
DM(%)	22.85	89.66	89.87	0
TDN(% MS)	60.84	83.73	79.99	0
ME(Mcal/kg)	2.20	3.03	2.89	0
CP(% MS)	9.58	58.62	17.13	0
Ca (g/kg)	0.27	0.28	1.06	26.3
P (g/kg)	0.20	0.63	8.60	7.5
COST (US$/kg)	0.16	0.34	0.14	0.15

DM = dry matter; TDN = total digestive nutrients; ME =metabolizable energy; CP = crude protein; Ca = Calcium; P =Phosphorus

Table no 3: Current food values. Fonte: [3], adapted

Food	Commercial value	Unitary value (kg)
Corn	US$ 9.92/60 kg	US$ 0.16
Soybean (bran)	US$ 139.17/ton	US$ 0.14
Wheat (bran)	US$ 340.20/ton	US$ 0.34

According to [4] a deterministic global optimization algorithmfor problems with restriction in the input variables is based onthe non-uniform space coverage technique, and for theproposed study the mathematical formulation was obtainedfollowing the deduction:

Objective Function: Min Q(x)=

$$\sum_{j=1}^{n} C_j^T \cdot x_j$$

Restriction:

$$\sum_{j=1}^{n} a_{ij} \cdot x_j \geq b_i (\mathrm{i} = 1, 2, 3, \ldots, \mathrm{m})$$

and$x_j \geq 0$ (j = 1, 2, 3, …, n)

where,
cj - Profit of each unit of the product "j";
xj - Quantity of the product "j" used;
aij - Quantity of the nutrient "i" contained per unit of the component "j";
bi - Nutrient quantity "i" needed.

The model was used to construct the software LINDO 6.1®:
!C = corn, S1= soybean (bran), W= wheat (bran) and S2= supplement.
! Minimize the cost of the final product
MIN 0.16C + 0.34S1 + 0.14W + 0.15S2
ST
! Restriction 1: Need for daily dry matter

DM) 0.2285C + 0.8966 S1 + 0.8987 W >= 5
! Restriction 2: Need for total digestive nutrients daily
TDN) 0.6084 C + 0.8373 S1 + 0.7999 W >= 4.5
! Restriction 3: Metabolic energy spends on daily digestion
ME) 2.20 C + 3.03 S1 + 2.89 W >=2.74
! Restriction 4: Need for daily crude protein
CP) 0.0958 C + 0.5862 S1 + 0.1713 W >=0.62
! Restriction 5: Need for daily calcium
Ca) 0.27 C + 0.28 S1 + 1.06 W + 26.3 S2 >= 2.45
! Restriction 6: Need for daily phosphorus
P) 0.20 C + 0.63 S1 + 8.6 W + 7.5 S2>=1.2
! No negativity
C>=0
S1>=0
W>=0
S2>=0
END

After the construction of the model, it was possible to verifythe optimized amount of corn, soybean meal and wheat andsupplement in order to have the lowest feed cost at the end of the process.

III. Result

With the input data proposed in the methodology, the software LINDO 6.1® obtained the results of Table no 4, Table no 5 and Table no 6, arranged in the same interface of theapplication:

Table no 4: Objective function value. Fonte: The authors.

Objective function: 0.7875984		
VARIABLE	**VALUE**	**REDUCED COST**
C	0.000000	0.053517
S1	0.000000	0.193454
W	5.625703	0.000000
S2	0.000000	0.150000

C = corn; S1 = soybean (bran); W = wheat (bran); S2 = supplement

Table no 5: Objective coefficient ranges. Fonte: The authors.

VARIABLE	CURRENT COEF	ALLOWABLE INCREASE	ALLOWABLE DECREASE
C	0.160000	INFINITY	0.053517
S1	0.340000	INFINITY	0.193454
W	0.140000	0.070362	0.140000
S2	0.150000	INFINITY	0.150000

C = corn; S1 = soybean (bran); W = wheat (bran); S2 = supplement

Table no 6: Ranges in which the basis is unchanged. Fonte: The authors.

ROW	CURRENT RHS	ALLOWABLE INCREASE	ALLOWABLE DECREASE
DM	5.000000	0.055820	INFINITY
TDN	4.500000	INFINITY	0.049683
ME	2.740000	13.518282	INFINITY
CP	0.620000	0.343683	INFINITY
Ca	2.450000	3.513245	INFINITY
P	1.200000	47.181049	INFINITY

DM = dry matter; TDN = total digestive nutrients; ME =metabolizable energy; CP = crude protein; Ca = Calcium; P = Phosphorus

IV. Discussion

In Table no4 it is possible to observe that the result of the objective function of the formulation indicated a value of 0.78. That is, the data generated state that it is possible to minimize the cost of the ration in approximately 0.78 US$/kg. A study conducted by [2] demonstrated the efficiency of optimization as a management tool when verifying the decrease in the influence of annual seasonality in terms of percentage of animals in milking and milk production, allowing to minimize costs with management of animals considered out of season.

The variables used obtained values of C = corn, S1 =soybean (bran), W = wheat (bran) and S2 = supplement equal to C = 0; S1 = 0; W = 5.626 and S2 = 0 (Table no 4). This result indicated that only the variable wheat bran (W) is viable, justifying the investment. In Table no 5 the variable wheat bran (W) allows an increase of up to 0.070 US$/kg, so that raising up to this value, it will still be a basic variable that exceeds the others. With regard to its decrease, it can be reduced to 0.140 US$/kg which still maintains equal to 0 the other variables. When analyzing the other variables, even if they have an increase tending to infinity, they still would not become viable.

According to [9] The optimization of processes using linear programming enables the formulation of lower cost diets that meet the specific needs of nutrients. [17] When studying convergence analyses through simulations showed that the formulation of an optimized proposal disappears as the size of historical data tends to infinity.

It is important to emphasize that the low cost is not alwaysthe main objective sought in the formulation of a ration. InBulgogi, a popular Korean cuisine, for example, is required that the meat consumed has a specific sensory attribute (interms of flavor and softness) that are usually obtained bythe type of food provided to the animal, in this case large amounts of concentrate in the diet [10].

When analyzing the total digestive nutrients (TDN) (Table no 6) it was noted that the restriction allows an infinite increase, which means that the animal can ingest total digestivenutrients without restriction of quantity. Regarding itsdecrease, the restriction allows a value of up to 0.049683kg/day, because if the animal ingest lower values it will not reach the ideal amount for weight gain.

[15] used a simplified method of food diet optimizationapplied to a beef cattle fusing system to evaluate theutilization of nutrients in different situations. The method was studied in order to reduce the feeding costs and at the end of the research demonstrated that the tool that allows optimizing the diet is efficient because it meets the nutritional requirements of feeding for beef cattle at low cost.

V. Conclusion

With the use of optimization, it was possible to achieve the lowest possible cost in the formulation of the bovine diet meeting the nutritional requirements that makes this tool important in the sustainable management of agricultural production.

The work focused on the nutritional formulation of cattle by the process of mathematical modeling and linear programming, presents a reliable result if it involves the deterministic factors, such as chemical composition of food and knowledge about ruminant feeding.

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