THE FEEDING RATION OPTIMISATION MODEL FOR SIMENTAL BULLS

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Abstract: *Feeding costs represent an important parameter in the economics of cattle beef. In this paper we present a feeding ration optimisation model for simental bulls. The model is based upon calculation of component requirements with respect to expected daily gains and mathematical programming. The model is implemented in software What's best Industrial.*

Key words: *Simental bulls, feeding ration, optimisation, model*

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1. Introduction

Fodder costs can represent over 40 % of total costs in cattle breeding and can thus can decisively impact the economic feasibility of the operation. The importance of balanced feeding rations and cost efficiency is thus a decisive parameter in economics of cattle breeding (Janzekovic et al., 2014). According to calculation of Slovenian Agricultural Institute (2014) the feeding costs in dairy cows represent 38 % of total costs and 48 % in bull breeding. Thus the control of feeding costs can be crucial for the success of cattle breeding operation. The feeding rations can be by calculated with the use of different methods. When only two ingredients are mixed the Pearson square can be mixed (Wagner & Stanton, 2012). However, we usually deal with large number of ingredients and components. In such cases mathematical programming can be used (Rozman et al., 2003). This usually means that objective function of feeding costs is minimized so that we satisfy all nutritional constrains

Recently, the mathematical programming methods have become an important tool for solving management planning problems and economic analysis in agriculture and their use has been facilitated by major advances in competing technology (Hazzel & Norton, 1986). The overview of the use of mathematical programming models in agriculture is provided by Glen (1987). Also, there have been many important applications of mathematical programming for solving diet problems in cattle breeding operations. Glen (1980) developed a method for determining optimal feeding systems which meet the nutrient standards recommended by the US National Research Council. The approach involves first using linear programming (LP) to determine least cost rations to produce specified live weight gains in animals of known live weight. Dynamic programming (DP) is then used to determine the optimal sequence of rations to feed in order to produce animals of specified live weight from animals of known initial weight at minimum cost, using the least cost rations determined from the LP model. Tozer (2000) presents four mathematical programming models were developed to formulate rations for large breed replacement dairy heifers in each of 11 different weight classes from 50 to 550 kg and daily growth rates of 600, 700, and 800 g, with the objective of achieving a final calving weight of 600 kg. First, a base linear programming model was developed; then, to account for variability in the crude protein content of ration ingredients three other methods were used: right-hand side adjustment, incorporation of a safety margin, and stochastic programming. The stochastic programming model performed better, on the bases of cost and protein-feeding, than did the right-hand side adjustment or the safety margin methods. Mathematical programming models have been upgraded and improved by the introduction of multi objective (Lara & Bonero, 1992; Tozer & Stokes, 2001; Castrodeza et al., 2005).

The main objective of this study is to present an optimisation model for bulls' diet problem that has been developed for a case study farm. The paper is organised as follows: first we present the model methodology and then the practical application on a case study. We also show comparison of real gains with the calculated in the model. Final remarks and main findings conclude this paper.

2. Methodology

In the process of fattening young animals we want to take advantage of the genetic potential for growth capacity, which depends on the ability of the genetically fixed formation of proteins and the adequate intensity of the diet. In commercial fattening on the 487 young bulls housed in 8 groups according to live weight. For these animals we anticipated growth dynamics and customized the feed ration (Table 2, column two).

In order to ensure expected weight gains we need to:

- To feed exact quantities of feeding components as calculated by feeding rations
- Cleaning of stall feeding facilities and automatic drinkers
- Removal of rotten silage in silo before pick-up into the feed mixer
- Ensure optimal microclimatic conditions and animal health according to preventive and curative program of veterinary service

Control of the actual consummation of a given quantity of ration was carried out by measuring the quantities of raw materials added to the feed mixer, measurements of quantities lodged ration in a manger and quantity of residues of the ration in the manger. In order to increase accuracy of measurements was repeated all procedure three times in succession for each feeding group.

First we need to determine the consummation capacity of animals to which we estimated that the meat cattle ingested 22 g DM/kg body weight (Oresnik and Kermauner, 2002). This was followed by the formation of the expected daily gain (g/day) for each group with the aim to achieving the breeding goal according to Čeponu et al. (2004), which is mainly dependent on the intensity of fattening. For the assessment of the need for proteins (DRP) and metabolic energy (ME), we used tabular value from the DLG tables (1997).

Feed ration were calculated by using an optimization program What`s best industrial, acting on the basis of mathematical programming so as to minimize the target function of the cost feed ration with the constraints under norms for the estimated daily gain as shown in Equation 1:

$$\min.\ CU * X \qquad (1)$$

$$C*X >= N$$
$$C*X <= K*N$$
$$X >= 0$$

Where it is:

CU – matrix of prices of certain types of feedstock in the feed ration

C – matrix content of individual nutrients (DM, DRP, ME,..) in particular feedstock of feed ration
X – matrix of amounts of certain feedstock of feed ration
N – matrix of normative values according to foreseen body weight of bulls and the foreseen daily gain

The feed up to and including 250 kg of body weight was used protein concentrate with no added urea above this weight was in the protein concentrate added urea (non-protein nitrogen).

Table 1 shows the normative values taken from the DLG-Futterwerttabellen (1997) for digestible crude protein (DCP) and ME (MJ), the Orešnik and Kermauner (2002) for dry matter (DM) and in planning growth degree was considered a breeding objective for simental breed (Čepon et al., 2004). These normative value as our target values are calculated in the calculation of the final installment coordinate with ± 10% tolerance.

Live weight (kg)	Expected daily gain (g)	DM (g)	RF (g)	DRP (g)	ME (MJ)
200	1200	4400	880	570	53,0
250	1300	5500	1100	650	66,0
300	1400	6600	1320	705	75,0
350	1400	7700	1540	740	83,0
400	1300	8800	1760	745	90,0
450	1200	9900	1980	735	95,0
500	1100	11000	2200	725	100,0
≥550	1000	12100	2420	710	110,0

DM – dry mater, RF – raw fiber, DRP – digestible raw proteins, ME – metabolic energy
Tab. 1. Normative for optimization of feeding ratios for fattening bulls

By using the computer program What's best Industrial by Lindo Systems that works in Excel (Fig 1 and Fig 2) and calculates the feed rations on the basis of the entered restrictions, requirements and relationships between feedstock of the feed ration, which were included in the ration calculation. As a result of mathematic operations we get an optimal feed ration for different categories of fattening bulls.

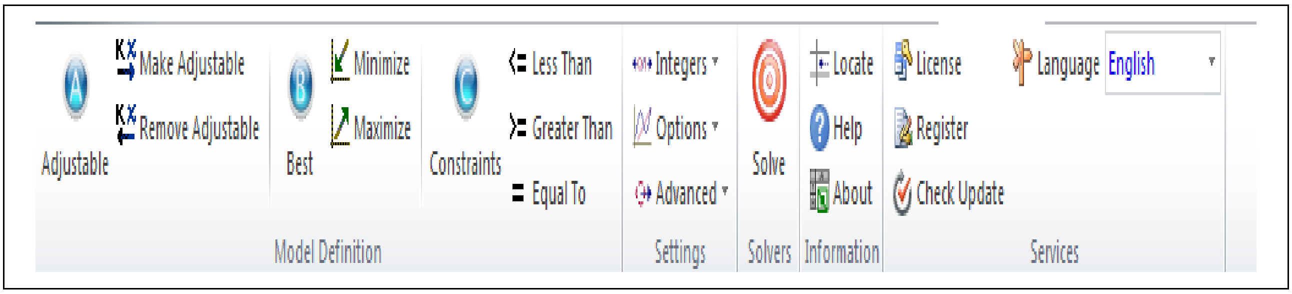

Fig. 1. What's best Industrial control panel

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	200 kg 1200 g/day														
2		Components													
3		SSg/kg	SBg/kg	SVg/kg	SMg/kg	SPg/kg	BDI g/kg	PSBg/kg	ŠE g/kg	Ca g/kg	P g/kg	NEL MJ/kg	ME MJ/kg		
4	maize	678,30	58,80	20,40	36,30	10,30	552,50	40,80	607,50	0,08	2,08	6,41			
5	grass sillage	406,20	72,58	105,90	18,80	39,60	163,50	51,70	208,60	4,65	1,18	2,29			
6	maize sillage	351,70	23,50	72,50	7,60	12,60	235,50	12,50	220,90	0,81	0,71	2,34			
7	straw	860,00	31,82	368,90	11,18	67,10	381,00	10,00	0,00	5,47	1,78	5,21	7,49		
8	mineral additive	838,40	188,40	47,30	25,40	39,70		158,90	726,70	9,60	5,40		12,02		
9															
10															
11															
12	200 kg 1200 g/dan														
13															
14		kg	SSg	SBg	SVg	SMg	SPg	BDIg	PSBg	ŠEg	Ca g	P g	NEL MJ	ME MJ	
15	maize	2,55	1731,95	150,14	52,09	92,69	26,30	1410,74	104,18	1551,17	0,20	5,31	16,37	28,71	
16	grass sillage	2,93	1188,80	212,41	309,93	55,02	115,89	478,50	151,31	610,49	13,61	3,45	6,70	11,76	
17	maize sillage	5,85	2058,59	137,55	424,36	44,48	73,75	1378,44	73,17	1292,98	4,74	4,16	13,70	24,03	
18	straw	0,30	258,00	9,55	110,67	3,35	20,13	114,30	3,00	0,00	1,64	0,53	1,56	2,25	
19	mineral additive	1,50	1257,60	282,60	70,95	38,10	59,55	0,00	238,35	1090,05	14,40	8,10	0,00	18,03	
20	total	13,13	6494,94	792,25	968,00	233,65	295,63	3381,98	570,00	4544,70	34,60	21,55	38,33	84,78	
21	normativ		4400	850	880				570	3030					
22															
23															
24															
25															
26															
27	Constriants					% odst		max				min			
28	SS	6495	>=	4400		1,48	Not <=	1,10		1,48	>=	0,90			
29	SV	968	>=	880		1,10	=<=	1,10		1,10	>=	0,90			
30	PSB	570	=>=	570		1,00	<=	1,10		1,00	>=	0,90			
31	ŠE	4545	>=	3030		1,50	Not <=	1,10		1,50	>=	0,90			
32															
33															
34															
35	Dodatek	1,50	=<=	1,50											
36															
37	straw or hay	0,30	=>=	0,30		0,30	<=	1,50							
38															
39	grass sillage	2,93	>=	2,50		2,93	<=	5,50							
40	grass sillage/maize sillage	2,00	=>=	2,00											

WBL Status List1 List2 List3

Fig. 2. The solved model with constraints in the Excel sheet

3. Results and discussion

The feed rations for 8 groups of bulls were tested include corn silage as the main component, grass silage, ensiled maize meal and complete feed for the animal category from 200 kg to 250 (Additive I) and from 300 kg to slaughter (Additive II).

Nutrients in sampel	Corn meal silage (g/kg DM)	Grass silage (g/kg DM)	Maize silage (g/kg DM)	Additive I (%)	Additive II (%)
Crude protein	86,7	178,5	66,8	18,47	20,1
Crude fibre	30,1	260,7	206,1	4,73	3,78
Crude fats	53,5	46,2	21,6	2,54	2,56
Crud ash	15,2	97,4	35,8	3,97	5,66
Non nitrogen extract	814,5	417,3	669,6		
Digestible crud protein	60,1	127,3	35,7	15,89	17,81
NEL (MJ)	9,46	5,63	6,65		
ME (MJ)				12,02	11,91

Corn meal silage - CMS, Grass silage - GS, Maize silage - MS, Straw–S, Additive – A
Tab. 2. Results of chemical analyses of feed used in feeding meal

3.1 Feed ratio calculation

The resulting values of the chemical analyzes of feed for DM, DRP, RF was entered in the excel file, which served as the basis for calculating feed arches used program. The program is automatically provided and proposed amount (kg) of the individual feedstock of feed ration.

Feedstock	Category (kg)							
	200 - 250	250 - 300	300 - 350	350 - 400	400 - 450	450 - 500	500-550	≥550
N	23	51	83	71	48	53	58	91
CMS (kg)	1,00	2,00	0,50	0,50	0,50	0,71	0,50	0,60
GS (kg)	4,00	4,00	6,00	6,00	6,00	5,50	5,50	5,50
MS (kg)	6,00	7,75	8,39	11,20	12,67	13,00	14,55	16,38
S (kg)	0,00	0,30	0,33	0,44	0,38	0,57	1,50	1,50
A (kg)	1,50	1,50	1,50	1,50	1,40	1,50	1,50	1,50
Sum (kg)	**12,50**	**15,55**	**16,72**	**19,64**	**20,95**	**21,28**	**23,55**	**25,48**
EDG (kg/day)	1,200	1,300	1,400	1,400	1,300	1,200	1,100	1,000
ADG (kg/day)	0,881	1,093	1,275	1,345	1,259	1,263	1,049	1,178

N – number of animals, CMS - Corn meal silage, GS - Grass silage, MS - Maize silage, S - Straw, A - Additive, EDG - Expected daily gain, ADG – Actual daily gain
Tab. 3. Calculated feed ratios for different bulls' categories

3.2 The achieved weight gain during the fattening period

When feeding the bulls with computer balanced feed rations for the animal categories according to body weight were observed daily gains shown in the chart first.

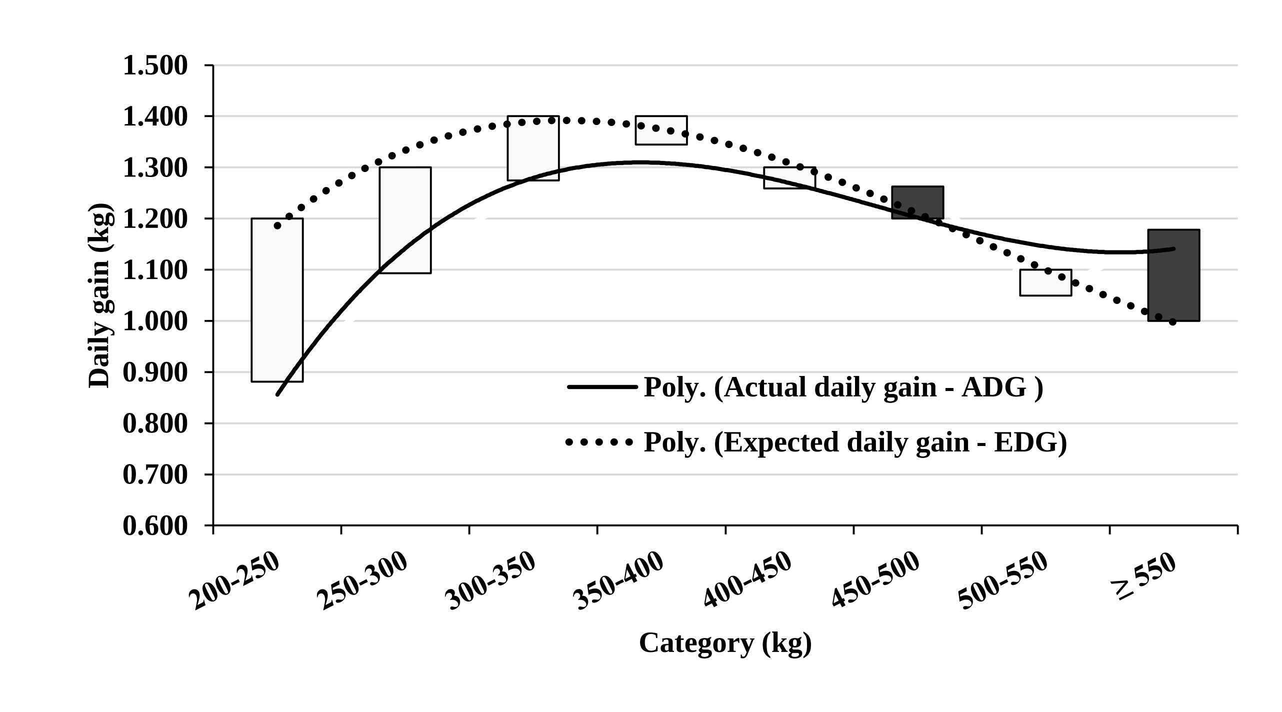

Fig. 3. Expected and actual daily gain

In the initial period of fattening (Fig. 3) from 200 to 250 kg it was found the biggest difference between planned and actual weight gain increment achieved, namely 0.319 kg. This difference is due to changes in feed and the transfer of animals from the quarantine barn in feedlots. Daily gain were rapidly increasing and in the weight category of 350 kg has already reached 1.345 grams per day which is close to the planned increase. Interestingly intersecting growth curves for body weight of 480 kg, while they were planned and actually achieved the same growth (1.261 g). Due to its increased consummation capacity of bulls and consequently the energy richer feed ration are achieved daily gain in the final stage of fattening the weight from 500 kg to slaughter exceeded the planned figures.

4. Conclusions

In this study, we found:

- Optimization of feed rations with computer support is a very simple approach to facilitate the achievement of the planned high daily growth degree bovine fattening
- classification of animals into groups based on body weight for every 50 kg proved to be appropriate and necessary in providing the nutrients in fattening pigs of different ages

- During the period of most intensive growth was achieved Simmental bulls 1345g of daily weight gain, which also enables the breeding objective enshrined in the breeding program for the mottled breed of cattle in Slovenia.

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