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Research Article

Formulation of total mixed ration (TMR) for commercial dairy farms

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A B S T R A C T

The Total Mixed Ration (TMR) is an effective and profitable way to supply all the required nutrients uniformly in each bite of the dairy animal to optimize farm inputs for a desired level of milk production. The TMR makes it easy to set realistic goals for sustainable milk production from healthy, productive and fertile dairy cows by meeting their nutrient requirements in more accurate way than the conventional approaches. The TMR reduces feed sorting, optimizes intake of dietary fiber, soluble starch, degradable and non-degradable proteins in the rumen, and thus, enhances dry matter intake, optimizes feed utilization, lowers ruminal acidosis and eventually improves lipid profile of milk for human consumption. This paper typically discusses the step by step procedures involved in setting variable milk targets and demonstrates easy and accurate way of calculating how much locally available feed is required to achieve the desired production targets. It takes into consideration the concrete guidelines of Agricultural Research Council for developing countries. Inevitable drawbacks of adopting TMRs in small scale dairy farms are also discussed and suggestions provided to overcome.

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1. INTRODUCTION

Total mixed ration (TMR) implies blending all the feedstuffs together into a complete ration for providing required nutrients uniformly in each bite consumed by the animal to ensure maximum benefit and optimum profit (Grille et al., 2019; Haselmann et al., 2019; Pastorini et al., 2019). The concept of TMR first came to light during 1950s (Harshbarger, 1952). The additional advantage of TMR as opposed to traditional systems of feeding forages supplemented with concentrates was explained later on (McCoy et al., 1966) and a 100-year multi-dimensional history of TMR feeding has also been highlighted further (Schingoethe, 2017).

Now-a-day, TMR is the most adopted method for feeding high yielding indoor-housed dairy cow in the world (Schingoethe, 2017). Till date, consistent evidences indicate that, TMR improves milk yield (Kajla et al., 2019; Sarker et al., 2019), lipid profile of milk (Mendoza et al., 2016; Utama et al., 2018; Pastorini et al., 2019), forage utilization (Haselmann et al., 2019), blood parameters (Grille et al., 2019), energy status (Capelesso et al., 2019), daily gain (Kim et al., 2012; Meenongyai et al., 2017), N-utilization (Miyaji & Matsuyama, 2016) and economic efficacy (Lee et al., 2015) of feeding dairy cows.

In conventional dairy rations, differences in particle size are inevitable which affect yield and quality of milk in dairy cows (Schingoethe, 2017). Although, development of the Penn State Particle Separator (PSPS) has facilitated understanding of particle size (Cavallini et al., 2018; Little et al., 2018; Grille et al., 2019; Haselmann et al., 2019; Pastorini et al., 2019), practical solutions remain unresolved without application of TMR. In TMR, there is no choice among feeds offered. Each bite consumed is a uniform and nutritionally complete. Free-choice mineral supplements are unnecessary. Complete rations coupled with lactation groups permit special formulation for high producers and other special groups. Non-protein nitrogen compounds, especially urea can be more easily and safely used in TMR. Overall, a TMR with fresh forage serves to dilute and mask the flavor of unpalatable ingredients of the ration (Schingoethe, 2017).

Many changes in forage types are possible in a TMR without depressing feed intake or milk production. Reduction in labor is possible through TMR feeding. By providing a specific and obligatory ratio of forage to concentrate, one can prevent many unusual episodes of milk fat depression by ensuring that fiber in the consumed diet is adequate. It is not necessary to feed concentrates in the milking parlor. It was reported that, feeding forage and concentrates separately resulted in cows consuming a high proportion of concentrates than intended increasing the risk of ruminal acidosis (Beauchemin et al., 2002; Maekawa et al., 2002). Today, various systems of feeding animals have been developed but many of them are not in use because they look too complicated. This article aims to present the principles of compounding a TMR in a simplified form, and suggests rations which can be easily adopted in any dairy farm with moderate technical knowledge.

2. MATERIALS AND METHODS

Calculation of metabolizable energy (ME) and crude protein (CP)

Suppose, live weight of the reference milking cow is 300 kg, daily milk yield is 12.0 kg; milk contains 4.0% fat and 8.5% SNF. In this case, we can apply the following formula to calculate the ME and CP requirement of the cow (ARC, 1980):

Requirement of metabolizable energy (ME):

A. Requirement of ME for maintenance of body (ME_m MJ/d):

$$ME_m = 8.3 + 0.091W = 8.3 + 0.091 \times 300 = 35.6$$

B. Requirement of ME for milk production (ME_p MJ/kg):

$$ME_p/\text{kg milk} = 1.694 \times EV_l = 1.694 \times (0.0386\ BF + 0.0205\ SNF - 0.236) = 1.694 \times (0.0386 \times 40 + 0.0205 \times 85 - 0.236) = 5.17$$

Where,

EVL = Energy value of milk = (0.0386 BF + 0.0205 SNF - 0.236 MJ/kg)

BF = Butter fat (g/kg)

SNF = Solids not fat (g/kg)

Total ME_p = 5.17 x 12 = 62.0

Total ME = 35.6 + 62.0 =97.6

Requirement of crude protein (CP):

A. Requirement of protein for body maintenance (g/d):

a. Endogenous urinary loss of protein (EUP) $= 6.25\,(5.9206 \times \log_{10} W - 6.76) = 6.25\,(5.9206 \times \log_{10} 300 - 6.76) = 49.4$

b. Dermal loss of protein (DP) $= 6.25\,(0.018 \times W^{0.75}) = 6.25\,(0.018 \times 300^{0.75}) = 8.1$

B. Loss of protein through milk secretion (MP):

$$MP = 35.0 \times 12 = 420.0$$

C. Requirement of tissue protein (TP g/d):

$$TP = EUP + DP + MP = 49.4 + 8.1 + 420.0 = 477.5$$

D. Requirement of rumen degradable protein (RDP g/d):

$$RDP = 7.8\ ME = 7.8 \times 97.6 = 761.6$$

E. Requirement of rumen undegradable protein (UDP g/d):

$$UDP = 1.91\ TP - 6.25\ ME = 1.91 \times 477.5 - 6.25 \times 97.6 = 302.0$$

Requirement of crude protein (CP g/d):

$$CP = RDP + UDP = 761.6 + 302.0 = 1063.6$$

Therefore,

Daily requirement of ME = 97.6 MJ
Daily requirement of CP= 1063.6 g

Forage particle size

Optimum forage particle size is an important part of ration formulation. However, until recently, particle size has been difficult to measure on farms. Many dairy nutritionists have developed subjective measures and most of them are effective making ration changes with respect to particle size measurements. The original particle separator, first introduced in 1996 (Lammers et al., 1996), has been proven valuable in measuring feed particle size. The new Penn State Particle Separator (Kononoff et al., 2003; Heinrichs, 2007) (PSPS) provides additional tool to quantitatively determine the particle size of forages and TMR.

The main goal of analyzing TMR particle size is measuring the distribution of feed and forage particles that the cow will actually consume. For estimation of particle size, forage after chopping is placed in the PSPS for shaking. An optimum forage particle size is ensured, if approximately 5% of the feed is more than 0.75 inches in length, 95% is less than 0.75 inches in length, 40% falls between 0.31 and 0.75 inches in length and 15% is less than 0.07 inches in length. Before preparation of TMR, forage particle size needs to be standardized accordingly.

Feeding frequency

The frequency of feeding TMR is not as important as when individual feed components are fed. Generally, twice a day delivery of TMR to milking cows is the practice on most farms. Once a day feeding is possible in cool weather and when ration heating is not a problem. When rations remain fresh in bunks, increasing feeding frequency will generally not increase total daily DM intake, but it does encourage cows to eat smaller meals more frequently improving feed utilization. Dry cows and growing heifers can be fed once a day.

Preparation of forage mixture

From our baseline survey, it is postulated that farmers had persistent challenges of seasonal fluctuation for both green and dry roughages unlike concentrates which had steady supply round the year. We therefore, propose two different types of forage mixture, i.e., with and without dry roughage. Although nutritive values of rice straw are poor, however, this is the principal crop residue in most of the developing countries. Therefore, a 60: 40 green to dry roughage mixture is proposed.

Grouping the animal

Cows can be grouped based on actual or fat-corrected milk, days in milk, reproductive status, age, nutrient requirement and health for feeding TMR. Grouping based on fresh cows, early, mid and late lactation animals are more common. Similarly, multi-group TMRs can be used for early and close-up dry cows. The higher the number of animal groups in a farm, the more accurate, efficient and economic will be the feed management systems for the animals.

Management of feed bunk

The goal in feed bunk management is to obtain maximum DM intake. In order to ensure optimum DM intake, feed should be uniformly spread throughout feed bunk. Cows should have a minimum of 18-30 inches feeding space. Total feed refusals should be less than 5% of total fed offered. Feed bunks should be empty no more than 2-3 hours per day (Shaver, 1993; Linn, 1995).

3. RESULTS

Roughage mixture

Roughage mixture can be prepared by using different grasses, e.g., napier, para, german, guinea, dal, star, signal, ruzi, rhodes, buffel, setaria, plicatulum, stylo, centro and serato. Maize or sorghum fodders either in single or with combinations can also be used. Use of rice straw is optional. No need to use rice straw if sufficient green fodders are available round the year. As the amount of straw/hay increases, metabolizable energy content of the ration proportionately decreases or vice versa. Here we propose a roughage mixture with rice straw and german grass (Table 1).

Table 1. Roughage mixture for milking cow

Feeds	Qty[1].	ME[2]	CP[1]	CF[1]	Ca[1]	P[1]
Rice straw	40.0	240.0	1.2	14.0	0.1	0.0
German grass	60.0	570.0	5.4	19.9	0.8	0.7
Total	100	810.0	6.6	34.0	0.9	0.7

1 = kg; 2 = Mega joule (MJ)

Concentrate mixture

Concentrate mixture is prepared with the sources of energy, protein, vitamin, mineral, common salts and some other feed additives if required. Concentrate mixture compositions and calculated nutrient content are presented in Table 2.

Table 2. Proportion and chemical composition of the concentrate mixture for milking cow (Banerjee, 1998)

Ingredients	Qty.	Chemical composition (%)				
		ME[1]	CP	CF	Ca	P
Broken maize*	10	125	0.85	0.24	0.01	0.00
Rice polish	15	180	1.65	0.51	0.16	0.16
Wheat bran	30	360	3.75	1.32	0.62	0.61
Molasses	2	22	0.06	0.11	0.06	0.06
Soybean meal	2	22	0.80	0.13	0.08	0.08
Khesari husk	10	110	2.30	0.74	0.51	0.50
Pea husk	10	100	2.00	0.84	0.61	0.60
Mug husk	10	110	2.20	0.94	0.71	0.70
Mustard cake	10	120	2.80	1.04	0.81	0.80
Min-premix	0.25	0	0	0.03	0.02	0.02
Vit-premix	0.25	0	0	0.03	0.03	0.03
Common salt	0.5	0	0	0.07	0.06	0.06
Total	100	1150	16.4	6.00	3.70	3.60

1 = Mega joule; *Maize should either be boiled or replaced with 25% rice polish and 75% wheat bran

Mineral mixture

Mineral mixture should be prepared with macro and micro minerals required by the milking cows. The mixture will dominate Ca, and P. A sample mineral mixture is proposed in Table 3.

Table 3. Mineral requirements for the milking cow (Banerjee, 1998)

Nutrient	Type of animal		
	Dairy cow	Heifer	Dry cow
Ca (% DM)	0.67-0.90	0.4	0.45
P (% DM)	0.38-0.45	0.3	0.23
Mg (% DM)	0.27-0.30	0.16	0.16
K (% DM)	1.0	0.6	0.6
S (% DM)	0.20 (0.25)	0.16	0.2
Na (% DM)	0.22	0.2	0.5
Cl (% DM)	0.29	0.2	0.2
Zn (ppm)	55.0	40.0	40.0
Cu (ppm)	11.0	10.0	13.0
Mn (ppm)	40.0	30.0	30.0

Vitamin mixture

Vitamin mixture consists of both water and fat soluble vitamins in solid form. A sample mixture is presented in Table 4.

Table 4. Vitamin mixture for the milking cow (Banerjee, 1998)

Name of vitamin	Amount
Vitamin A	2000 IU
Vitamin D	200 IU
Vitamin E	10 IU
Vitamin K	0.5 IU
Vitamin B_1	0.5 mg
Vitamin B_2	0.8 mg
Vitamin B_6	0.5 mg
Calcium pentotheanate	4.0 mg
Niacin	4.0 mg
Inositol	10.0 mg
Para-amino benzoic acid	10.0 mg
Biotin	40.0 µg
Folic acid	0.2 mg
Vitamin B_{12}	3.0 µg
Choline chloride	200.0 mg

Roughage-concentrate mixture

Ratio of roughage to concentrate affects intake of organic matter and dry matter, milk yield, milk fat and milk protein percent. The ratio of roughage to concentrate may vary from 80:20 to even 40:60. However, a 60:40 is recommended (Cowsert and Montgomery, 1969; Coppock et al., 1974; Miller and Muntifering, 1985; Waldo, 1986; Siciliano-Jones and Murphy, 1989; Sutton, 1989; Colucci et al., 1990; Beauchemin et al., 1994, 2003; Bourquin et al., 1994; Reed et al., 1997; Žitňan et al., 1998a; b; Yang et al., 2001; Sano et al., 2004; Soita et al., 2005; Krizsan et al., 2010; Aguerre et al., 2011; Li et al., 2012, 2014; Nasrollahi et al., 2014; Aziz ur Rahman et al., 2017; Na et al., 2017; Bayat et al., 2017; Thomson et al., 2017b; a; Jaakamo et al., 2019) (Table 5). Based on assumption that, some dairy farms may have sufficient green forage materials, four alternative rations without dry forages are also proposed (Table 11-14).

Chemical composition of common fodders

Chemical composition and nutritive values of the most commonly used cereal grains, protein supplements and fodders are given in Table 6. Composition may vary according to stage of maturity, variety, soil condition, application of manure and fertilizer in the field and season of the year.

Table 5. Roughage and concentrate mixture for milking cow

Amount	Amount (kg)	ME (MJ)	CP (kg)	CF (kg)
Roughage	60.0	486.0	396.0	2037.6
Concentrate	40.0	459.6	656.4	239.7
Total	100	9.5	10.5	22.8

Requirement of total dry matter	=	97.6/9.5	= 10.3	kg
Requirement of roughage dry matter	=	(10.3×60)/100	= 6.2	kg
Requirement of concentrate dry matter	=	(10.3×40)/100	= 4.1	kg
Requirement of straw dry matter	=	(6.2×40)/100	= 2.5	kg
Requirement of straw	=	(2.5/0.9)	= 2.8	kg
Requirement of German grass dry matter	=	(6.2×60)/100	= 3.7	kg
Requirement of German grass	=	3.7/0.20	= 18.5	kg
Requirement of concentrate	=	(4.1/0.9)	= 4.5	kg

Therefore, daily requirement of the cow

Rice straw	=	2.8	kg
German grass	=	18.5	kg
Concentrate	=	4.5	kg

Requirement of additional concentrate

Gestation period		Amount	
3 - 5	Month	0.5	kg
6	Month	0.8	kg
7	Month	1.2	kg
8	Month	1.5	kg
9	Month	2.5	kg

Table 6. Chemical composition of common tropical dairy feeds (% air DM or otherwise)

Ingredients	**DM (%)**	**ME (MJ)**	**CP (%)**	**CF (%)**	**EE (%)**	**Ca (%)**	**P (%)**
Rice straw	90.0	6.0	3.0	35.0	2.0	0.3	0.0
German grass	25.0	8.5	10.0	30.0	2.0	0.2	0.0
Napier grass	30.0	8.0	9.5	33.0	2.0	0.2	0.0
Helencha	12.0	8.0	15.0	12.0	3.0	0.3	0.2
Water hyacinth	8.0	7.0	10.0	20.0	3.0	0.3	0.2
Broken maize	90.0	12.5	8.5	2.4	2.6	0.1	0.4
Wheat	90.0	12.0	13.0	3.0	2.0	0.1	0.4
Wheat bran	90.0	12.0	14.0	12.2	3.8	0.1	1.2
Rice polish	90.0	12.0	12.0	12.4	12.7	0.4	1.2
Molasses	90.0	9.0	2.5	-	-	1.5	0.7
FF Soybean	90.0	14.5	35.0	5.0	18.0	0.3	0.6
Soybean meal	90.0	9.0	40.0	6.0	2.9	0.3	0.7
Mustard cake	90.0	9.0	30.0	6.0	7.0	0.9	1.2
Til cake	90.0	9.0	28.0	6.0	7.0	2.9	1.3
Coconut cake	90.0	9.0	20.0	6.0	13.0	0.2	0.5
Pea husk	90.0	9.0	20.0	7.0	3.0	0.6	0.2
Gram husk	90.0	9.0	20.0	13.0	4.0	1.3	1.3
Mug husk	90.0	9.0	25.0	6.0	5.0	0.5	0.3
Khesari husk	90.0	9.0	25.0	6.0	4.0	0.3	0.1
Protein conc.	90.0	11.0	55.0	3.0	13.0	6.5	2.5
Fish meal	90.0	11.0	50.0	5.0	13.0	7.7	3.9
Limestone	98.0	-	-	-	-	38.0	-

Ingredients	DM (%)	ME (MJ)	CP (%)	CF (%)	EE (%)	Ca (%)	P (%)
DCP	98.0	-	-	-	-	24.3	18.2
MCP	98.0	-	-	-	-	16.9	24.6
Rock phosphate	98.0	-	-	-	-	33.0	18.0
Bone meal	95.0	-	-	-	-	27.6	11.9

4. DISCUSSION

Original method for formulation of ration suggested by Agricultural Research Council (ARC, 1980) is sophisticated and difficult to adapt for the small scale dairy farmers. Here, we propose an oversimplified way for calculating nutrient requirements of the dairy cows using the same method just matching weight and production with the calculated chart. Four different categories of productivity have been considered, i.e., low (live weight 300 kg and milk yield 10 kg/d), medium (live weight 300 kg and milk yield12 kg/d), moderate (live weight 300 kg and milk yield 14 kg/d) and high (live weight 300 kg and milk yield 10 kg/d).

For each category, two different rations are suggested, i.e., ration with rice straw and ration without rice straw/hay. Roughage and concentrate mixtures are proposed according to cost and availability under Bangladesh perspective.

There was a significant difference (P<0.05) in daily milk yield between the 100% and 75% vs. 25% grass (Sanh et al., 2002).In another study, responses in milk production, milk composition and rumen fermentation of dairy cows receiving a corn straw or mixed forage diet was investigated. It was concluded that, cows fed corn straw based diet had minor differences in rumen pH and total VFA suggesting feasibility of corn straw use in cattle diet.

Understanding from the baseline survey in different commercial dairy farms, a 60:40 roughage-concentrate ratio is strongly recommended to avoid incidence of sub-acute ruminal acidosis. Since the proposed ratio incur huge amount of green forages, less optimal alternatives are also proposed. Increased feeding frequency reduces feed sorting (DeVries et al., 2005), decreases lying time of the cows (Mäntysaari et al., 2006), improves post-ruminal digestibility, milk yield and composition (Campbell and Merilan, 1961; Shabi et al., 1999), improves milk fat and milk protein (Eicher et al., 1999), affects glucose, beta-hydroxybutyrate and urea concentrations in cows (Eicher et al., 1999) and increased proteolysis (Chen et al., 1987). Sometimes, feeding frequency is independent of dry matter intake and milk yield (Rustomo et al., 2006). Therefore, a standard feeding frequency of 2-3 is recommended since more frequent feeding disturbs cows (Thornton, 2010) and cows producing milk of commercially acceptable milk fat percentage are almost unlikely to benefit from increased feeding frequency (Gibson, 1984).

We strongly recommend 60:40 forage to concentrate ratio for production, health and welfare of the milking animals. In many cases, sequential offer of hay and TMR do not affect feed intake, efficiency and milk quality, even feed protein utilization for milk protein is not impaired if concentrates are reduced in a moderate to low quantity (Leiber et al., 2015). However, feeding level and feeding strategy affect milk yield, body weight and fertility of crossbred lactating cow. However, as the ratio of dry forages increases in diet, palatability decreases proportionately (Sanh et al., 2002) which results decreased milk yield.

A decreased ratio of forage to concentrate resulted in increased milk yield and body weight gain of the cow and a tendency to higher milk protein content, but lowered milk fat content (Sanh et al., 2002). There was no significant effect on postpartum estrus. Feed conversion was not different between ratios but feed cost per kg milk produced was lowest for cows given 70% forage. The ration with 50% forage was optimum in terms of milk yield, body weight gain and feed conversion, but in terms of feed cost, the ratio of 70% forage was the best.

Thus, the *ad libitum* forage feeding system increases feed intake and milk yield. In the regions, where natural grasses grow easily around the year are the important sources of available fodder for small scale dairy farmers where the ratio of 30% concentrate and 70% forage may be recommended (Sanh et al., 2002).

Table 7. Ration for the low milk producing dairy cow (milk yield 3.3% of live weight)

Requirement of ME (MJ/day)					Requirement of CP (g/day)							Allowance of CP			Dry matter		Roughage: Concentrate								
																	60:40			55:45			50:50		
Live weight (kg)	Milk yield (kg)	ME for body maintenance	ME for milk yield	Total ME	Endogenous Protein (EUP)	Dermal Protein (DP)	Milk protein (MP)	Tissue Protein (TP)	RDP	UDP	CP	CP Available (g/d)	CP Surplus (g/d)	CP Allowance (%)	Requirement of DM	DMI (%)	Straw	Grass	Conc.	Straw	Grass	Conc.	Straw	Grass	Conc.
200.0	6.7	26.5	34.4	60.9	42.9	6.0	233.1	282.0	475.1	157.9	633.0	673.3	40.3	6.4	6.4	3.2	1.8	11.5	3.0	1.7	10.6	3.4	1.5	9.6	3.8
210.0	7.0	27.4	36.1	63.5	43.7	6.2	244.8	294.6	495.7	165.6	661.3	702.4	41.1	6.2	6.7	3.2	1.9	12.0	3.1	1.7	11.0	3.5	1.6	10.0	3.9
220.0	7.3	28.3	37.9	66.2	44.4	6.4	256.4	307.3	516.2	173.3	689.5	731.4	42.0	6.1	7.0	3.2	2.0	12.5	3.3	1.8	11.5	3.7	1.6	10.4	4.1
230.0	7.7	29.2	39.6	68.8	45.1	6.6	268.1	319.9	536.7	180.9	717.6	760.5	42.9	6.0	7.2	3.1	2.0	13.0	3.4	1.9	12.0	3.8	1.7	10.9	4.3
240.0	8.0	30.1	41.3	71.4	45.8	6.9	279.7	332.4	557.2	188.4	745.6	789.6	44.0	5.9	7.5	3.1	2.1	13.5	3.5	1.9	12.4	4.0	1.8	11.3	4.4
250.0	8.3	31.1	43.0	74.1	46.5	7.1	291.4	344.9	577.7	195.9	773.6	818.7	45.0	5.8	7.8	3.1	2.2	14.0	3.7	2.0	12.9	4.1	1.8	11.7	4.6
260.0	8.7	32.0	44.7	76.7	47.1	7.3	303.0	357.4	598.3	203.3	801.6	847.7	46.2	5.8	8.1	3.1	2.3	14.5	3.8	2.1	13.3	4.3	1.9	12.1	4.7
270.0	9.0	32.9	46.5	79.3	47.7	7.5	314.7	369.9	618.8	210.7	829.5	876.8	47.4	5.7	8.4	3.1	2.4	15.0	3.9	2.2	13.8	4.4	2.0	12.5	4.9
280.0	9.3	33.8	48.2	82.0	48.3	7.7	326.3	382.3	639.3	218.0	857.3	905.9	48.6	5.7	8.6	3.1	2.4	15.5	4.1	2.2	14.2	4.6	2.0	12.9	5.1
290.0	9.7	34.7	49.9	84.6	48.9	7.9	338.0	394.8	659.8	225.3	885.1	935.0	49.8	5.6	8.9	3.1	2.5	16.0	4.2	2.3	14.7	4.7	2.1	13.4	5.2
300.0	10.0	35.6	51.6	87.2	49.4	8.1	349.7	407.2	680.3	232.6	912.9	964.1	51.2	5.6	9.2	3.1	2.6	16.5	4.3	2.4	15.1	4.9	2.2	13.8	5.4
310.0	10.3	36.5	53.3	89.9	49.9	8.3	361.3	419.6	700.9	239.8	940.6	993.1	52.5	5.6	9.5	3.1	2.7	17.0	4.5	2.4	15.6	5.0	2.2	14.2	5.6
320.0	10.7	37.4	55.1	92.5	50.4	8.5	373.0	431.9	721.4	246.9	968.3	1022.2	53.9	5.6	9.7	3.0	2.7	17.5	4.6	2.5	16.1	5.2	2.3	14.6	5.7
330.0	11.0	38.3	56.8	95.1	50.9	8.7	384.6	444.3	741.9	254.1	996.0	1051.3	55.3	5.6	10.0	3.0	2.8	18.0	4.7	2.6	16.5	5.3	2.4	15.0	5.9
340.0	11.3	39.2	58.5	97.7	51.4	8.9	396.3	456.6	762.4	261.2	1023.6	1080.4	56.7	5.5	10.3	3.0	2.9	18.5	4.8	2.7	17.0	5.4	2.4	15.4	6.1
350.0	11.7	40.2	60.2	100.4	51.9	9.1	407.9	468.9	782.9	268.3	1051.2	1109.4	58.2	5.5	10.6	3.0	3.0	19.0	5.0	2.7	17.4	5.6	2.5	15.8	6.2
360.0	12.0	41.1	61.9	103.0	52.3	9.3	419.6	481.2	803.5	275.3	1078.8	1138.5	59.7	5.5	10.8	3.0	3.1	19.5	5.1	2.8	17.9	5.7	2.6	16.3	6.4
370.0	12.3	42.0	63.7	105.6	52.8	9.5	431.2	493.5	824.0	282.4	1106.3	1167.6	61.2	5.5	11.1	3.0	3.1	20.0	5.2	2.9	18.3	5.9	2.6	16.7	6.5
380.0	12.7	42.9	65.4	108.3	53.2	9.7	442.9	505.8	844.5	289.4	1133.9	1196.7	62.8	5.5	11.4	3.0	3.2	20.5	5.4	2.9	18.8	6.0	2.7	17.1	6.7
390.0	13.0	43.8	67.1	110.9	53.6	9.9	454.5	518.0	865.0	296.3	1161.4	1225.7	64.4	5.5	11.7	3.0	3.3	21.0	5.5	3.0	19.3	6.2	2.7	17.5	6.9
400.0	13.3	44.7	68.8	113.5	54.0	10.1	466.2	530.3	885.5	303.3	1188.8	1254.8	66.0	5.5	12.0	3.0	3.4	21.5	5.6	3.1	19.7	6.3	2.8	17.9	7.0
410.0	13.7	45.6	70.6	116.2	54.4	10.3	477.9	542.5	906.1	310.2	1216.3	1283.9	67.6	5.6	12.2	3.0	3.5	22.0	5.8	3.2	20.2	6.5	2.9	18.3	7.2
420.0	14.0	46.5	72.3	118.8	54.8	10.4	489.5	554.8	926.6	317.1	1243.7	1313.0	69.2	5.6	12.5	3.0	3.5	22.5	5.9	3.2	20.6	6.6	2.9	18.8	7.4
430.0	14.3	47.4	74.0	121.4	55.2	10.6	501.2	567.0	947.1	324.0	1271.2	1342.1	70.9	5.6	12.8	3.0	3.6	23.0	6.0	3.3	21.1	6.8	3.0	19.2	7.5
440.0	14.7	48.3	75.7	124.1	55.6	10.8	512.8	579.2	967.6	330.9	1298.5	1371.1	72.6	5.6	13.1	3.0	3.7	23.5	6.1	3.4	21.5	6.9	3.1	19.6	7.7
450.0	15.0	49.3	77.4	126.7	55.9	11.0	524.5	591.4	988.1	337.8	1325.9	1400.2	74.3	5.6	13.3	3.0	3.8	24.0	6.3	3.5	22.0	7.1	3.1	20.0	7.8
460.0	15.3	50.2	79.2	129.3	56.3	11.2	536.1	603.6	1008.7	344.6	1353.3	1429.3	76.0	5.6	13.6	3.0	3.8	24.5	6.4	3.5	22.5	7.2	3.2	20.4	8.0
470.0	15.7	51.1	80.9	131.9	56.6	11.4	547.8	615.8	1029.2	351.4	1380.6	1458.4	77.7	5.6	13.9	3.0	3.9	25.0	6.5	3.6	22.9	7.4	3.3	20.8	8.2
480.0	16.0	52.0	82.6	134.6	57.0	11.5	559.4	627.9	1049.7	358.3	1408.0	1487.4	79.5	5.6	14.2	3.0	4.0	25.5	6.7	3.7	23.4	7.5	3.3	21.2	8.3
490.0	16.3	52.9	84.3	137.2	57.3	11.7	571.1	640.1	1070.2	365.1	1435.3	1516.5	81.2	5.7	14.4	2.9	4.1	26.0	6.8	3.7	23.8	7.6	3.4	21.7	8.5
500.0	16.7	53.8	86.0	139.8	57.6	11.9	582.8	652.3	1090.7	371.8	1462.6	1545.6	83.0	5.7	14.7	2.9	4.2	26.5	6.9	3.8	24.3	7.8	3.5	22.1	8.7
510.0	17.0	54.7	87.8	142.5	57.9	12.1	594.4	664.4	1111.3	378.6	1489.9	1574.7	84.8	5.7	15.0	2.9	4.2	27.0	7.1	3.9	24.7	7.9	3.5	22.5	8.8
520.0	17.3	55.6	89.5	145.1	58.3	12.3	606.1	676.6	1131.8	385.4	1517.1	1603.8	86.6	5.7	15.3	2.9	4.3	27.5	7.2	4.0	25.2	8.1	3.6	22.9	9.0
530.0	17.6	56.5	91.2	147.7	58.6	12.4	617.7	688.7	1152.3	392.1	1544.4	1632.8	88.4	5.7	15.6	2.9	4.4	28.0	7.3	4.0	25.7	8.2	3.7	23.3	9.1
540.0	18.0	57.4	92.9	150.4	58.9	12.6	629.4	700.8	1172.8	398.8	1571.6	1661.9	90.3	5.7	15.8	2.9	4.5	28.5	7.4	4.1	26.1	8.4	3.7	23.7	9.3
550.0	18.3	58.4	94.6	153.0	59.2	12.8	641.0	713.0	1193.4	405.5	1598.9	1691.0	92.1	5.8	16.1	2.9	4.5	29.0	7.6	4.2	26.6	8.5	3.8	24.2	9.5
560.0	18.6	59.3	96.4	155.6	59.4	13.0	652.7	725.1	1213.9	412.2	1626.1	1720.1	94.0	5.8	16.4	2.9	4.6	29.5	7.7	4.2	27.0	8.7	3.9	24.6	9.6
570.0	19.0	60.2	98.1	158.3	59.7	13.1	664.3	737.2	1234.4	418.9	1653.3	1749.1	95.8	5.8	16.7	2.9	4.7	30.0	7.8	4.3	27.5	8.8	3.9	25.0	9.8
580.0	19.3	61.1	99.8	160.9	60.0	13.3	676.0	749.3	1254.9	425.6	1680.5	1778.2	97.7	5.8	16.9	2.9	4.8	30.5	8.0	4.4	27.9	9.0	4.0	25.4	10.0
590.0	19.6	62.0	101.5	163.5	60.3	13.5	687.6	761.4	1275.4	432.3	1707.7	1807.3	99.6	5.8	17.2	2.9	4.9	31.0	8.1	4.5	28.4	9.1	4.0	25.8	10.1
600.0	20.0	62.9	103.2	166.1	60.6	13.6	699.3	773.5	1296.0	438.9	1734.9	1836.4	101.5	5.8	17.5	2.9	4.9	31.5	8.2	4.5	28.9	9.3	4.1	26.2	10.3

Table 8. Ration for the medium milk producing dairy cow (milk yield 4.0% of live weight)

Requirement of ME (MJ/day)					Requirement of CP (g/day)							Allowance of CP			Dry matter		Roughage: Concentrate								
																	60:40			55:45			50:50		
Live weight (kg)	Milk yield (kg)	ME for body maintenance	ME for milk yield	Total ME	Endogenous Protein (EUP)	Dermal Protein (DP)	Milk protein (MP)	Tissue Protein (TP)	RDP	UDP	CP	CP Available (g/d)	CP Surplus (g/d)	CP allowance (%)	Requirement of DM	DMI (%)	Straw	Grass	Conc.	Straw	Grass	Conc.	Straw	Grass	Conc.
200.0	8.0	26.5	41.3	67.8	42.9	6.0	280.0	328.9	529.2	204.2	733.3	749.8	16.5	2.25	7.1	3.6	2.0	12.9	3.4	1.8	11.8	3.8	1.7	10.7	4.2
210.0	8.4	27.4	43.4	70.8	43.7	6.2	294.0	343.9	552.4	214.2	766.6	782.7	16.1	2.10	7.5	3.5	2.1	13.4	3.5	1.9	12.3	3.9	1.8	11.2	4.4
220.0	8.8	28.3	45.5	73.8	44.4	6.4	308.0	358.9	575.6	224.2	799.8	815.6	15.8	1.98	7.8	3.5	2.2	14.0	3.7	2.0	12.8	4.1	1.8	11.7	4.6
230.0	9.2	29.2	47.5	76.8	45.1	6.6	322.0	373.8	598.8	234.1	832.9	848.5	15.6	1.87	8.1	3.5	2.3	14.5	3.8	2.1	13.3	4.3	1.9	12.1	4.8
240.0	9.6	30.1	49.6	79.7	45.8	6.9	336.0	388.7	622.0	244.0	866.0	881.4	15.4	1.78	8.4	3.5	2.4	15.1	4.0	2.2	13.9	4.4	2.0	12.6	4.9
250.0	10.0	31.1	51.7	82.7	46.5	7.1	350.0	403.6	645.3	253.8	899.0	914.3	15.3	1.70	8.7	3.5	2.5	15.7	4.1	2.3	14.4	4.6	2.0	13.1	5.1
260.0	10.4	32.0	53.7	85.7	47.1	7.3	364.0	418.4	668.5	263.5	932.0	947.2	15.3	1.64	9.0	3.5	2.5	16.2	4.2	2.3	14.9	4.8	2.1	13.5	5.3
270.0	10.8	32.9	55.8	88.7	47.7	7.5	378.0	433.2	691.7	273.2	964.9	980.1	15.3	1.58	9.3	3.5	2.6	16.8	4.4	2.4	15.4	4.9	2.2	14.0	5.5
280.0	11.2	33.8	57.9	91.7	48.3	7.7	392.0	448.0	714.9	282.8	997.8	1013.0	15.3	1.53	9.6	3.4	2.7	17.4	4.5	2.5	15.9	5.1	2.3	14.5	5.7
290.0	11.6	34.7	59.9	94.6	48.9	7.9	406.0	462.8	738.1	292.4	1030.6	1045.9	15.4	1.49	10.0	3.4	2.8	17.9	4.7	2.6	16.4	5.3	2.3	14.9	5.9
300.0	12.0	35.6	62.0	97.6	49.4	8.1	420.0	477.5	761.4	302.0	1063.4	1078.9	15.5	1.46	10.3	3.4	2.9	18.5	4.8	2.7	17.0	5.4	2.4	15.4	6.0
310.0	12.4	36.5	64.1	100.6	49.9	8.3	434.0	492.3	784.6	311.5	1096.1	1111.8	15.6	1.43	10.6	3.4	3.0	19.1	5.0	2.7	17.5	5.6	2.5	15.9	6.2
320.0	12.8	37.4	66.1	103.6	50.4	8.5	448.0	507.0	807.8	321.0	1128.8	1144.7	15.8	1.40	10.9	3.4	3.1	19.6	5.1	2.8	18.0	5.8	2.6	16.4	6.4
330.0	13.2	38.3	68.2	106.5	50.9	8.7	462.0	521.7	831.0	330.5	1161.5	1177.6	16.1	1.38	11.2	3.4	3.2	20.2	5.3	2.9	18.5	5.9	2.6	16.8	6.6
340.0	13.6	39.2	70.3	109.5	51.4	8.9	476.0	536.3	854.2	339.9	1194.1	1210.5	16.3	1.37	11.5	3.4	3.3	20.8	5.4	3.0	19.0	6.1	2.7	17.3	6.8
350.0	14.0	40.2	72.3	112.5	51.9	9.1	490.0	551.0	877.5	349.3	1226.8	1243.4	16.6	1.35	11.8	3.4	3.3	21.3	5.6	3.1	19.5	6.3	2.8	17.8	7.0
360.0	14.4	41.1	74.4	115.5	52.3	9.3	504.0	565.6	900.7	358.7	1259.4	1276.3	16.9	1.34	12.2	3.4	3.4	21.9	5.7	3.1	20.1	6.4	2.9	18.2	7.2
370.0	14.8	42.0	76.5	118.4	52.8	9.5	518.0	580.3	923.9	368.0	1291.9	1309.2	17.3	1.34	12.5	3.4	3.5	22.4	5.9	3.2	20.6	6.6	2.9	18.7	7.3
380.0	15.2	42.9	78.5	121.4	53.2	9.7	532.0	594.9	947.1	377.3	1324.5	1342.1	17.6	1.33	12.8	3.4	3.6	23.0	6.0	3.3	21.1	6.8	3.0	19.2	7.5
390.0	15.6	43.8	80.6	124.4	53.6	9.9	546.0	609.5	970.3	386.6	1357.0	1375.0	18.0	1.33	13.1	3.4	3.7	23.6	6.2	3.4	21.6	6.9	3.1	19.6	7.7
400.0	16.0	44.7	82.7	127.4	54.0	10.1	560.0	624.1	993.6	395.9	1389.5	1407.9	18.4	1.33	13.4	3.4	3.8	24.1	6.3	3.5	22.1	7.1	3.2	20.1	7.9
410.0	16.4	45.6	84.7	130.4	54.4	10.3	574.0	638.7	1016.8	405.1	1421.9	1440.8	18.9	1.33	13.7	3.3	3.9	24.7	6.5	3.6	22.6	7.3	3.2	20.6	8.1
420.0	16.8	46.5	86.8	133.3	54.8	10.4	588.0	653.3	1040.0	414.4	1454.4	1473.7	19.3	1.33	14.0	3.3	4.0	25.3	6.6	3.6	23.2	7.4	3.3	21.1	8.3
430.0	17.2	47.4	88.9	136.3	55.2	10.6	602.0	667.8	1063.2	423.6	1486.8	1506.6	19.8	1.33	14.3	3.3	4.1	25.8	6.8	3.7	23.7	7.6	3.4	21.5	8.4
440.0	17.6	48.3	90.9	139.3	55.6	10.8	616.0	682.4	1086.5	432.8	1519.2	1539.5	20.3	1.33	14.7	3.3	4.1	26.4	6.9	3.8	24.2	7.8	3.4	22.0	8.6
450.0	18.0	49.3	93.0	142.3	55.9	11.0	630.0	696.9	1109.7	442.0	1551.6	1572.4	20.8	1.34	15.0	3.3	4.2	27.0	7.0	3.9	24.7	7.9	3.5	22.5	8.8
460.0	18.4	50.2	95.1	145.2	56.3	11.2	644.0	711.5	1132.9	451.1	1584.0	1605.3	21.3	1.35	15.3	3.3	4.3	27.5	7.2	4.0	25.2	8.1	3.6	22.9	9.0
470.0	18.8	51.1	97.1	148.2	56.6	11.4	658.0	726.0	1156.1	460.3	1616.4	1638.2	21.9	1.35	15.6	3.3	4.4	28.1	7.3	4.0	25.7	8.3	3.7	23.4	9.2
480.0	19.2	52.0	99.2	151.2	57.0	11.5	672.0	740.5	1179.3	469.4	1648.7	1671.1	22.4	1.36	15.9	3.3	4.5	28.6	7.5	4.1	26.3	8.4	3.7	23.9	9.4
490.0	19.6	52.9	101.3	154.2	57.3	11.7	686.0	755.0	1202.6	478.5	1681.0	1704.0	23.0	1.37	16.2	3.3	4.6	29.2	7.6	4.2	26.8	8.6	3.8	24.3	9.5
500.0	20.0	53.8	103.4	157.2	57.6	11.9	700.0	769.5	1225.8	487.6	1713.4	1736.9	23.6	1.38	16.5	3.3	4.7	29.8	7.8	4.3	27.3	8.8	3.9	24.8	9.7
510.0	20.4	54.7	105.4	160.1	57.9	12.1	714.0	784.0	1249.0	496.7	1745.7	1769.8	24.2	1.38	16.9	3.3	4.8	30.3	7.9	4.4	27.8	8.9	4.0	25.3	9.9
520.0	20.8	55.6	107.5	163.1	58.3	12.3	728.0	798.5	1272.2	505.7	1778.0	1802.7	24.8	1.39	17.2	3.3	4.8	30.9	8.1	4.4	28.3	9.1	4.0	25.8	10.1
530.0	21.2	56.5	109.6	166.1	58.6	12.4	742.0	813.0	1295.4	514.8	1810.2	1835.6	25.4	1.40	17.5	3.3	4.9	31.5	8.2	4.5	28.8	9.3	4.1	26.2	10.3
540.0	21.6	57.4	111.6	169.1	58.9	12.6	756.0	827.5	1318.7	523.8	1842.5	1868.5	26.1	1.41	17.8	3.3	5.0	32.0	8.4	4.6	29.4	9.4	4.2	26.7	10.5
550.0	22.0	58.4	113.7	172.0	59.2	12.8	770.0	841.9	1341.9	532.9	1874.7	1901.5	26.7	1.42	18.1	3.3	5.1	32.6	8.5	4.7	29.9	9.6	4.3	27.2	10.7
560.0	22.4	59.3	115.8	175.0	59.4	13.0	784.0	856.4	1365.1	541.9	1907.0	1934.4	27.4	1.44	18.4	3.3	5.2	33.2	8.7	4.8	30.4	9.8	4.3	27.6	10.8
570.0	22.8	60.2	117.8	178.0	59.7	13.1	798.0	870.9	1388.3	550.9	1939.2	1967.3	28.0	1.45	18.7	3.3	5.3	33.7	8.8	4.8	30.9	9.9	4.4	28.1	11.0
580.0	23.2	61.1	119.9	181.0	60.0	13.3	812.0	885.3	1411.5	559.9	1971.4	2000.2	28.7	1.46	19.0	3.3	5.4	34.3	9.0	4.9	31.4	10.1	4.5	28.6	11.2
590.0	23.6	62.0	122.0	183.9	60.3	13.5	826.0	899.7	1434.8	568.9	2003.6	2033.1	29.4	1.47	19.4	3.3	5.5	34.9	9.1	5.0	31.9	10.3	4.6	29.0	11.4
600.0	24.0	62.9	124.0	186.9	60.6	13.6	840.0	914.2	1458.0	577.8	2035.8	2066.0	30.1	1.48	19.7	3.3	5.6	35.4	9.3	5.1	32.5	10.4	4.6	29.5	11.6

Table 9. Ration for the moderate milk producing dairy cow (milk yield 4.7% of live weight)

Requirement of ME (MJ/day)					Requirement of CP (g/day)							Allowance of CP			Dry matter		Roughage: Concentrate								
Live weight (kg)	Milk yield (kg)	ME for body maintenance	ME for milk yield	Total ME	Endogenous Protein (EUP)	Dermal Protein (DP)	Milk protein (MP)	Tissue Protein (TP)	RDP	UDP	CP	CP Available (g/d)	CP Surplus (g/d)	CP Allowance (%)	Requirement of DM (Kg/d)	DMI (%)	60:40			55:45			50:50		
																	Straw	Grass	Conc.	Straw	Grass	Conc.	Straw	Grass	Conc.
200.0	9.3	26.5	48.3	74.8	42.9	6.0	326.9	375.8	583.2	250.5	833.6	850.0	16.3	1.96	7.9	3.9	2.2	14.2	3.7	2.0	13.0	4.2	1.9	11.8	4.6
210.0	9.8	27.4	50.7	78.1	43.7	6.2	343.2	393.1	609.1	262.8	871.9	887.7	15.8	1.81	8.2	3.9	2.3	14.8	3.9	2.1	13.6	4.4	1.9	12.3	4.8
220.0	10.3	28.3	53.1	81.4	44.4	6.4	359.6	410.4	635.0	275.1	910.1	925.5	15.4	1.69	8.6	3.9	2.4	15.4	4.0	2.2	14.1	4.5	2.0	12.9	5.0
230.0	10.7	29.2	55.5	84.7	45.1	6.6	375.9	427.7	660.9	287.4	948.3	963.3	15.0	1.58	8.9	3.9	2.5	16.1	4.2	2.3	14.7	4.7	2.1	13.4	5.2
240.0	11.2	30.1	57.9	88.1	45.8	6.9	392.3	445.0	686.9	299.5	986.4	1001.1	14.7	1.49	9.3	3.9	2.6	16.7	4.4	2.4	15.3	4.9	2.2	13.9	5.5
250.0	11.7	31.1	60.3	91.4	46.5	7.1	408.6	462.2	712.8	311.6	1024.4	1038.9	14.5	1.41	9.6	3.8	2.7	17.3	4.5	2.5	15.9	5.1	2.3	14.4	5.7
260.0	12.1	32.0	62.7	94.7	47.1	7.3	425.0	479.4	738.7	323.7	1062.4	1076.6	14.3	1.34	10.0	3.8	2.8	17.9	4.7	2.6	16.4	5.3	2.3	15.0	5.9
270.0	12.6	32.9	65.2	98.0	47.7	7.5	441.3	496.5	764.6	335.7	1100.3	1114.4	14.1	1.28	10.3	3.8	2.9	18.6	4.9	2.7	17.0	5.5	2.4	15.5	6.1
280.0	13.1	33.8	67.6	101.4	48.3	7.7	457.7	513.7	790.5	347.7	1138.2	1152.2	14.0	1.23	10.7	3.8	3.0	19.2	5.0	2.8	17.6	5.6	2.5	16.0	6.3
290.0	13.5	34.7	70.0	104.7	48.9	7.9	474.0	530.8	816.5	359.6	1176.0	1190.0	13.9	1.19	11.0	3.8	3.1	19.8	5.2	2.9	18.2	5.8	2.6	16.5	6.5
300.0	14.0	35.6	72.4	108.0	49.4	8.1	490.4	547.9	842.4	371.5	1213.8	1227.8	13.9	1.15	11.4	3.8	3.2	20.5	5.3	2.9	18.8	6.0	2.7	17.1	6.7
310.0	14.5	36.5	74.8	111.3	49.9	8.3	506.7	564.9	868.3	383.3	1251.6	1265.5	13.9	1.11	11.7	3.8	3.3	21.1	5.5	3.0	19.3	6.2	2.8	17.6	6.9
320.0	14.9	37.4	77.2	114.6	50.4	8.5	523.0	582.0	894.2	395.1	1289.3	1303.3	14.0	1.09	12.1	3.8	3.4	21.7	5.7	3.1	19.9	6.4	2.8	18.1	7.1
330.0	15.4	38.3	79.6	118.0	50.9	8.7	539.4	599.0	920.1	406.9	1327.0	1341.1	14.1	1.06	12.4	3.8	3.5	22.4	5.8	3.2	20.5	6.6	2.9	18.6	7.3
340.0	15.9	39.2	82.1	121.3	51.4	8.9	555.7	616.1	946.1	418.6	1364.7	1378.9	14.2	1.04	12.8	3.8	3.6	23.0	6.0	3.3	21.1	6.8	3.0	19.2	7.5
350.0	16.3	40.2	84.5	124.6	51.9	9.1	572.1	633.1	972.0	430.3	1402.3	1416.7	14.3	1.02	13.1	3.7	3.7	23.6	6.2	3.4	21.6	6.9	3.1	19.7	7.7
360.0	16.8	41.1	86.9	127.9	52.3	9.3	588.4	650.1	997.9	442.0	1439.9	1454.4	14.5	1.01	13.5	3.7	3.8	24.2	6.3	3.5	22.2	7.1	3.2	20.2	7.9
370.0	17.3	42.0	89.3	131.3	52.8	9.5	604.8	667.0	1023.8	453.7	1477.5	1492.2	14.7	1.00	13.8	3.7	3.9	24.9	6.5	3.6	22.8	7.3	3.3	20.7	8.1
380.0	17.7	42.9	91.7	134.6	53.2	9.7	621.1	684.0	1049.7	465.3	1515.1	1530.0	14.9	0.99	14.2	3.7	4.0	25.5	6.7	3.7	23.4	7.5	3.3	21.2	8.3
390.0	18.2	43.8	94.1	137.9	53.6	9.9	637.5	701.0	1075.7	476.9	1552.6	1567.8	15.2	0.98	14.5	3.7	4.1	26.1	6.8	3.8	24.0	7.7	3.4	21.8	8.5
400.0	18.7	44.7	96.5	141.2	54.0	10.1	653.8	717.9	1101.6	488.5	1590.1	1605.6	15.5	0.97	14.9	3.7	4.2	26.8	7.0	3.8	24.5	7.9	3.5	22.3	8.7
410.0	19.1	45.6	98.9	144.6	54.4	10.3	670.1	734.8	1127.5	500.1	1627.6	1643.3	15.8	0.97	15.2	3.7	4.3	27.4	7.2	3.9	25.1	8.1	3.6	22.8	9.0
420.0	19.6	46.5	101.4	147.9	54.8	10.4	686.5	751.7	1153.4	511.6	1665.0	1681.1	16.1	0.97	15.6	3.7	4.4	28.0	7.3	4.0	25.7	8.2	3.7	23.3	9.2
430.0	20.1	47.4	103.8	151.2	55.2	10.6	702.8	768.7	1179.4	523.1	1702.5	1718.9	16.4	0.96	15.9	3.7	4.5	28.6	7.5	4.1	26.3	8.4	3.7	23.9	9.4
440.0	20.5	48.3	106.2	154.5	55.6	10.8	719.2	785.6	1205.3	534.6	1739.9	1756.7	16.8	0.96	16.3	3.7	4.6	29.3	7.7	4.2	26.8	8.6	3.8	24.4	9.6
450.0	21.0	49.3	108.6	157.8	55.9	11.0	735.5	802.4	1231.2	546.1	1777.3	1794.5	17.1	0.96	16.6	3.7	4.7	29.9	7.8	4.3	27.4	8.8	3.9	24.9	9.8
460.0	21.5	50.2	111.0	161.2	56.3	11.2	751.9	819.3	1257.1	557.6	1814.7	1832.2	17.5	0.97	17.0	3.7	4.8	30.5	8.0	4.4	28.0	9.0	4.0	25.4	10.0
470.0	21.9	51.1	113.4	164.5	56.6	11.4	768.2	836.2	1283.0	569.1	1852.1	1870.0	17.9	0.97	17.3	3.7	4.9	31.2	8.1	4.5	28.6	9.2	4.1	26.0	10.2
480.0	22.4	52.0	115.8	167.8	57.0	11.5	784.6	853.1	1309.0	580.5	1889.5	1907.8	18.3	0.97	17.7	3.7	5.0	31.8	8.3	4.6	29.1	9.4	4.2	26.5	10.4
490.0	22.9	52.9	118.2	171.1	57.3	11.7	800.9	869.9	1334.9	591.9	1926.8	1945.6	18.8	0.97	18.0	3.7	5.1	32.4	8.5	4.7	29.7	9.5	4.2	27.0	10.6
500.0	23.4	53.8	120.7	174.5	57.6	11.9	817.3	886.8	1360.8	603.3	1964.1	1983.4	19.2	0.98	18.4	3.7	5.2	33.1	8.6	4.8	30.3	9.7	4.3	27.5	10.8
510.0	23.8	54.7	123.1	177.8	57.9	12.1	833.6	903.6	1386.7	614.7	2001.5	2021.1	19.7	0.98	18.7	3.7	5.3	33.7	8.8	4.8	30.9	9.9	4.4	28.1	11.0
520.0	24.3	55.6	125.5	181.1	58.3	12.3	849.9	920.4	1412.6	626.1	2038.8	2058.9	20.2	0.99	19.1	3.7	5.4	34.3	9.0	4.9	31.5	10.1	4.5	28.6	11.2
530.0	24.8	56.5	127.9	184.4	58.6	12.4	866.3	937.3	1438.6	637.5	2076.1	2096.7	20.6	0.99	19.4	3.7	5.5	34.9	9.1	5.0	32.0	10.3	4.6	29.1	11.4
540.0	25.2	57.4	130.3	187.8	58.9	12.6	882.6	954.1	1464.5	648.8	2113.3	2134.5	21.1	1.00	19.8	3.7	5.6	35.6	9.3	5.1	32.6	10.5	4.7	29.6	11.6
550.0	25.7	58.4	132.7	191.1	59.2	12.8	899.0	970.9	1490.4	660.2	2150.6	2172.3	21.7	1.01	20.1	3.7	5.7	36.2	9.5	5.2	33.2	10.6	4.7	30.2	11.8
560.0	26.2	59.3	135.1	194.4	59.4	13.0	915.3	987.7	1516.3	671.5	2187.9	2210.0	22.2	1.01	20.5	3.7	5.8	36.8	9.6	5.3	33.8	10.8	4.8	30.7	12.0
570.0	26.6	60.2	137.6	197.7	59.7	13.1	931.7	1004.5	1542.3	682.8	2225.1	2247.8	22.7	1.02	20.8	3.7	5.9	37.5	9.8	5.4	34.3	11.0	4.9	31.2	12.2
580.0	27.1	61.1	140.0	201.0	60.0	13.3	948.0	1021.3	1568.2	694.2	2262.3	2285.6	23.3	1.03	21.2	3.6	6.0	38.1	10.0	5.5	34.9	11.2	5.0	31.7	12.4
590.0	27.6	62.0	142.4	204.4	60.3	13.5	964.4	1038.1	1594.1	705.5	2299.6	2323.4	23.8	1.04	21.5	3.6	6.1	38.7	10.1	5.6	35.5	11.4	5.1	32.3	12.7
600.0	28.0	62.9	144.8	207.7	60.6	13.6	980.7	1054.9	1620.0	716.7	2336.8	2361.2	24.4	1.04	21.9	3.6	6.2	39.4	10.3	5.7	36.1	11.6	5.1	32.8	12.9

Table 10. Ration for the high milk producing dairy cow (milk yield 5.3% of live weight)

Requirement of ME (MJ/day)					Requirement of CP (g/day)							Allowance of CP			Dry matter		Roughage: Concentrate								
																	60:40			55:45			50:50		
Live weight (kg)	Milk yield (kg)	ME for body maintenance	ME for milk yield	Total ME	Endogenous Protein (EUP)	Dermal Protein (DP)	Milk protein (MP)	Tissue Protein (TP)	RDP	UDP	CP	CP Available (g/d)	CP Surplus (g/d)	CP Allowance (%)	Requirement of DM	DMI (%)	Straw	Grass	Conc.	Straw	Grass	Conc.	Straw	Grass	Conc.
200.0	10.7	26.5	55.1	81.6	42.9	6.0	373.1	422.0	636.4	296.1	932.4	944.7	12.2	1.3	8.6	4.3	2.4	15.5	4.0	2.2	14.2	4.5	2.0	12.9	5.6
210.0	11.2	27.4	57.8	85.3	43.7	6.2	391.8	441.6	665.0	310.7	975.7	987.1	11.4	1.2	9.0	4.3	2.5	16.2	4.2	2.3	14.8	4.8	2.1	13.5	5.8
220.0	11.7	28.3	60.6	88.9	44.4	6.4	410.4	461.3	693.5	325.3	1018.8	1029.5	10.7	1.1	9.4	4.3	2.6	16.8	4.4	2.4	15.4	5.0	2.2	14.0	6.1
230.0	12.3	29.2	63.3	92.6	45.1	6.6	429.1	480.9	722.1	339.8	1061.9	1072.0	10.0	0.9	9.7	4.2	2.8	17.5	4.6	2.5	16.1	5.2	2.3	14.6	6.3
240.0	12.8	30.1	66.1	96.2	45.8	6.9	447.7	500.4	750.7	354.3	1105.0	1114.4	9.4	0.9	10.1	4.2	2.9	18.2	4.8	2.6	16.7	5.4	2.4	15.2	6.6
250.0	13.3	31.1	68.9	99.9	46.5	7.1	466.4	519.9	779.3	368.6	1147.9	1156.8	8.9	0.8	10.5	4.2	3.0	18.9	4.9	2.7	17.4	5.6	2.5	15.8	6.8
260.0	13.9	32.0	71.6	103.6	47.1	7.3	485.0	539.4	807.9	383.0	1190.8	1199.3	8.4	0.7	10.9	4.2	3.1	19.6	5.1	2.8	18.0	5.8	2.6	16.4	7.1
270.0	14.4	32.9	74.4	107.2	47.7	7.5	503.7	558.9	836.4	397.3	1233.7	1241.7	8.0	0.6	11.3	4.2	3.2	20.3	5.3	2.9	18.6	6.0	2.7	16.9	7.3
280.0	14.9	33.8	77.1	110.9	48.3	7.7	522.3	578.3	865.0	411.5	1276.5	1284.1	7.6	0.6	11.7	4.2	3.3	21.0	5.5	3.0	19.3	6.2	2.7	17.5	7.6
290.0	15.5	34.7	79.9	114.6	48.9	7.9	541.0	597.8	893.6	425.7	1319.3	1326.5	7.2	0.5	12.1	4.2	3.4	21.7	5.7	3.1	19.9	6.4	2.8	18.1	7.8
300.0	16.0	35.6	82.6	118.2	49.4	8.1	559.7	617.2	922.2	439.9	1362.1	1369.0	6.9	0.5	12.4	4.1	3.5	22.4	5.9	3.2	20.5	6.6	2.9	18.7	8.1
310.0	16.5	36.5	85.4	121.9	49.9	8.3	578.3	636.6	950.8	454.0	1404.8	1411.4	6.6	0.5	12.8	4.1	3.6	23.1	6.0	3.3	21.2	6.8	3.0	19.2	8.3
320.0	17.1	37.4	88.1	125.6	50.4	8.5	597.0	655.9	979.3	468.1	1447.4	1453.8	6.4	0.4	13.2	4.1	3.7	23.8	6.2	3.4	21.8	7.0	3.1	19.8	8.6
330.0	17.6	38.3	90.9	129.2	50.9	8.7	615.6	675.3	1007.9	482.1	1490.1	1496.3	6.2	0.4	13.6	4.1	3.8	24.5	6.4	3.5	22.4	7.2	3.2	20.4	8.8
340.0	18.1	39.2	93.6	132.9	51.4	8.9	634.3	694.6	1036.5	496.2	1532.7	1538.7	6.0	0.4	14.0	4.1	3.9	25.2	6.6	3.6	23.1	7.4	3.3	21.0	9.1
350.0	18.7	40.2	96.4	136.6	51.9	9.1	652.9	713.9	1065.1	510.1	1575.2	1581.1	5.9	0.4	14.4	4.1	4.1	25.9	6.8	3.7	23.7	7.6	3.4	21.6	9.3
360.0	19.2	41.1	99.2	140.2	52.3	9.3	671.6	733.2	1093.7	524.1	1617.8	1623.5	5.8	0.4	14.8	4.1	4.2	26.6	6.9	3.8	24.4	7.8	3.5	22.1	9.6
370.0	19.7	42.0	101.9	143.9	52.8	9.5	690.2	752.5	1122.3	538.0	1660.3	1666.0	5.7	0.3	15.1	4.1	4.3	27.3	7.1	3.9	25.0	8.0	3.6	22.7	9.8
380.0	20.3	42.9	104.7	147.5	53.2	9.7	708.9	771.8	1150.8	552.0	1702.8	1708.4	5.6	0.3	15.5	4.1	4.4	28.0	7.3	4.0	25.6	8.2	3.7	23.3	10.1
390.0	20.8	43.8	107.4	151.2	53.6	9.9	727.5	791.0	1179.4	565.9	1745.3	1750.8	5.6	0.3	15.9	4.1	4.5	28.6	7.5	4.1	26.3	8.4	3.7	23.9	10.3
400.0	21.3	44.7	110.2	154.9	54.0	10.1	746.2	810.3	1208.0	579.7	1787.7	1793.3	5.5	0.3	16.3	4.1	4.6	29.3	7.7	4.2	26.9	8.6	3.8	24.5	10.6
410.0	21.9	45.6	112.9	158.5	54.4	10.3	764.9	829.5	1236.6	593.6	1830.1	1835.7	5.5	0.3	16.7	4.1	4.7	30.0	7.9	4.3	27.5	8.8	3.9	25.0	10.8
420.0	22.4	46.5	115.7	162.2	54.8	10.4	783.5	848.8	1265.2	607.4	1872.6	1878.1	5.6	0.3	17.1	4.1	4.8	30.7	8.0	4.4	28.2	9.0	4.0	25.6	11.1
430.0	22.9	47.4	118.4	165.9	55.2	10.6	802.2	868.0	1293.7	621.2	1914.9	1920.5	5.6	0.3	17.5	4.1	4.9	31.4	8.2	4.5	28.8	9.2	4.1	26.2	11.3
440.0	23.5	48.3	121.2	169.5	55.6	10.8	820.8	887.2	1322.3	635.0	1957.3	1963.0	5.7	0.3	17.8	4.1	5.0	32.1	8.4	4.6	29.4	9.4	4.2	26.8	11.6
450.0	24.0	49.3	123.9	173.2	55.9	11.0	839.5	906.4	1350.9	648.8	1999.7	2005.4	5.7	0.3	18.2	4.1	5.1	32.8	8.6	4.7	30.1	9.7	4.3	27.3	11.8
460.0	24.5	50.2	126.7	176.9	56.3	11.2	858.1	925.6	1379.5	662.5	2042.0	2047.8	5.8	0.3	18.6	4.0	5.3	33.5	8.8	4.8	30.7	9.9	4.4	27.9	12.1
470.0	25.1	51.1	129.5	180.5	56.6	11.4	876.8	944.8	1408.1	676.2	2084.3	2090.3	5.9	0.3	19.0	4.0	5.4	34.2	8.9	4.9	31.4	10.1	4.5	28.5	12.3
480.0	25.6	52.0	132.2	184.2	57.0	11.5	895.4	963.9	1436.7	690.0	2126.6	2132.7	6.1	0.3	19.4	4.0	5.5	34.9	9.1	5.0	32.0	10.3	4.6	29.1	12.5
490.0	26.1	52.9	135.0	187.9	57.3	11.7	914.1	983.1	1465.2	703.7	2168.9	2175.1	6.2	0.3	19.8	4.0	5.6	35.6	9.3	5.1	32.6	10.5	4.7	29.7	12.8
500.0	26.7	53.8	137.7	191.5	57.6	11.9	932.8	1002.3	1493.8	717.4	2211.2	2217.5	6.4	0.3	20.2	4.0	5.7	36.3	9.5	5.2	33.3	10.7	4.7	30.2	13.0
510.0	27.2	54.7	140.5	195.2	57.9	12.1	951.4	1021.4	1522.4	731.0	2253.4	2260.0	6.5	0.3	20.5	4.0	5.8	37.0	9.7	5.3	33.9	10.9	4.8	30.8	13.3
520.0	27.7	55.6	143.2	198.8	58.3	12.3	970.1	1040.6	1551.0	744.7	2295.7	2302.4	6.7	0.3	20.9	4.0	5.9	37.7	9.8	5.4	34.5	11.1	4.9	31.4	13.5
530.0	28.2	56.5	146.0	202.5	58.6	12.4	988.7	1059.7	1579.6	758.4	2337.9	2344.8	6.9	0.3	21.3	4.0	6.0	38.4	10.0	5.5	35.2	11.3	5.0	32.0	13.8
540.0	28.8	57.4	148.7	206.2	58.9	12.6	1007.4	1078.8	1608.1	772.0	2380.1	2387.3	7.1	0.3	21.7	4.0	6.1	39.1	10.2	5.6	35.8	11.5	5.1	32.6	14.0
550.0	29.3	58.4	151.5	209.8	59.2	12.8	1026.0	1098.0	1636.7	785.6	2422.3	2429.7	7.3	0.3	22.1	4.0	6.2	39.8	10.4	5.7	36.4	11.7	5.2	33.1	14.3
560.0	29.8	59.3	154.2	213.5	59.4	13.0	1044.7	1117.1	1665.3	799.2	2464.5	2472.1	7.6	0.3	22.5	4.0	6.3	40.5	10.6	5.8	37.1	11.9	5.3	33.7	14.5
570.0	30.4	60.2	157.0	217.2	59.7	13.1	1063.3	1136.2	1693.9	812.8	2506.7	2514.5	7.8	0.3	22.9	4.0	6.5	41.1	10.8	5.9	37.7	12.1	5.4	34.3	14.8
580.0	30.9	61.1	159.7	220.8	60.0	13.3	1082.0	1155.3	1722.5	826.4	2548.9	2557.0	8.1	0.3	23.2	4.0	6.6	41.8	10.9	6.0	38.4	12.3	5.5	34.9	15.0
590.0	31.4	62.0	162.5	224.5	60.3	13.5	1100.6	1174.4	1751.1	840.0	2591.1	2599.4	8.3	0.3	23.6	4.0	6.7	42.5	11.1	6.1	39.0	12.5	5.6	35.4	15.3
600.0	32.0	62.9	165.3	228.2	60.6	13.6	1119.3	1193.5	1779.6	853.6	2633.2	2641.8	8.6	0.3	24.0	4.0	6.8	43.2	11.3	6.2	39.6	12.7	5.7	36.0	15.5

Table 11. Ration for low milk producing dairy cow (milk yield 3.3% of live weight) without dry roughage

Requirement of ME (MJ/day)					Requirement of CP (g/day)							Allowance of CP			Dry matter		Roughage: Concentrate								
																	60:40			55:45			50:50		
Live weight (kg)	Milk yield (kg)	ME for body maintenance	ME for milk yield	Total ME	Endogenous Protein (EUP)	Dermal Protein (DP)	Milk protein (MP)	Tissue Protein (TP)	RDP	UDP	CP	CP Available (g/d)	CP Surplus (g/d)	CP Allowance (%)	Requirement of DM	DMI (%)	Straw	Grass	Conc.	Straw	Grass	Conc.	Straw	Grass	Conc.
200.0	6.7	26.5	34.4	60.9	42.9	6.0	233.1	282.0	475.1	157.9	633.0	709.7	76.7	12.1	5.9	3.0	0.0	14.2	2.8	0.0	13.0	3.1	0.0	11.8	3.5
210.0	7.0	27.4	36.1	63.5	43.7	6.2	244.8	294.6	495.7	165.6	661.3	802.7	141.4	21.4	6.7	3.2	0.0	16.1	3.1	0.0	14.7	3.5	0.0	13.4	3.9
220.0	7.3	28.3	37.9	66.2	44.4	6.4	256.4	307.3	516.2	173.3	689.5	835.9	146.5	21.2	7.0	3.2	0.0	16.7	3.3	0.0	15.3	3.7	0.0	13.9	4.1
230.0	7.7	29.2	39.6	68.8	45.1	6.6	268.1	319.9	536.7	180.9	717.6	869.2	151.6	21.1	7.2	3.1	0.0	17.4	3.4	0.0	15.9	3.8	0.0	14.5	4.3
240.0	8.0	30.1	41.3	71.4	45.8	6.9	279.7	332.4	557.2	188.4	745.6	902.4	156.8	21.0	7.5	3.1	0.0	18.0	3.5	0.0	16.5	4.0	0.0	15.0	4.4
250.0	8.3	31.1	43.0	74.1	46.5	7.1	291.4	344.9	577.7	195.9	773.6	935.6	162.0	20.9	7.8	3.1	0.0	18.7	3.7	0.0	17.2	4.1	0.0	15.6	4.6
260.0	8.7	32.0	44.7	76.7	47.1	7.3	303.0	357.4	598.3	203.3	801.6	968.8	167.3	20.9	8.1	3.1	0.0	19.4	3.8	0.0	17.8	4.3	0.0	16.1	4.7
270.0	9.0	32.9	46.5	79.3	47.7	7.5	314.7	369.9	618.8	210.7	829.5	1002.1	172.6	20.8	8.4	3.1	0.0	20.0	3.9	0.0	18.4	4.4	0.0	16.7	4.9
280.0	9.3	33.8	48.2	82.0	48.3	7.7	326.3	382.3	639.3	218.0	857.3	1035.3	178.0	20.8	8.6	3.1	0.0	20.7	4.1	0.0	19.0	4.6	0.0	17.3	5.1
290.0	9.7	34.7	49.9	84.6	48.9	7.9	338.0	394.8	659.8	225.3	885.1	1068.5	183.4	20.7	8.9	3.1	0.0	21.4	4.2	0.0	19.6	4.7	0.0	17.8	5.2
300.0	10.0	35.6	51.6	87.2	49.4	8.1	349.7	407.2	680.3	232.6	912.9	1101.8	188.9	20.7	9.2	3.1	0.0	22.0	4.3	0.0	20.2	4.9	0.0	18.4	5.4
310.0	10.3	36.5	53.3	89.9	49.9	8.3	361.3	419.6	700.9	239.8	940.6	1135.0	194.4	20.7	9.5	3.1	0.0	22.7	4.5	0.0	20.8	5.0	0.0	18.9	5.6
320.0	10.7	37.4	55.1	92.5	50.4	8.5	373.0	431.9	721.4	246.9	968.3	1168.2	199.9	20.6	9.7	3.0	0.0	23.4	4.6	0.0	21.4	5.2	0.0	19.5	5.7
330.0	11.0	38.3	56.8	95.1	50.9	8.7	384.6	444.3	741.9	254.1	996.0	1201.5	205.5	20.6	10.0	3.0	0.0	24.0	4.7	0.0	22.0	5.3	0.0	20.0	5.9
340.0	11.3	39.2	58.5	97.7	51.4	8.9	396.3	456.6	762.4	261.2	1023.6	1234.7	211.1	20.6	10.3	3.0	0.0	24.7	4.8	0.0	22.6	5.4	0.0	20.6	6.1
350.0	11.7	40.2	60.2	100.4	51.9	9.1	407.9	468.9	782.9	268.3	1051.2	1267.9	216.7	20.6	10.6	3.0	0.0	25.4	5.0	0.0	23.2	5.6	0.0	21.1	6.2
360.0	12.0	41.1	61.9	103.0	52.3	9.3	419.6	481.2	803.5	275.3	1078.8	1301.2	222.4	20.6	10.8	3.0	0.0	26.0	5.1	0.0	23.9	5.7	0.0	21.7	6.4
370.0	12.3	42.0	63.7	105.6	52.8	9.5	431.2	493.5	824.0	282.4	1106.3	1334.4	228.0	20.6	11.1	3.0	0.0	26.7	5.2	0.0	24.5	5.9	0.0	22.2	6.5
380.0	12.7	42.9	65.4	108.3	53.2	9.7	442.9	505.8	844.5	289.4	1133.9	1367.6	233.8	20.6	11.4	3.0	0.0	27.4	5.4	0.0	25.1	6.0	0.0	22.8	6.7
390.0	13.0	43.8	67.1	110.9	53.6	9.9	454.5	518.0	865.0	296.3	1161.4	1400.9	239.5	20.6	11.7	3.0	0.0	28.0	5.5	0.0	25.7	6.2	0.0	23.3	6.9
400.0	13.3	44.7	68.8	113.5	54.0	10.1	466.2	530.3	885.5	303.3	1188.8	1434.1	245.2	20.6	12.0	3.0	0.0	28.7	5.6	0.0	26.3	6.3	0.0	23.9	7.0
410.0	13.7	45.6	70.6	116.2	54.4	10.3	477.9	542.5	906.1	310.2	1216.3	1467.3	251.0	20.6	12.2	3.0	0.0	29.3	5.8	0.0	26.9	6.5	0.0	24.5	7.2
420.0	14.0	46.5	72.3	118.8	54.8	10.4	489.5	554.8	926.6	317.1	1243.7	1500.5	256.8	20.6	12.5	3.0	0.0	30.0	5.9	0.0	27.5	6.6	0.0	25.0	7.4
430.0	14.3	47.4	74.0	121.4	55.2	10.6	501.2	567.0	947.1	324.0	1271.2	1533.8	262.6	20.7	12.8	3.0	0.0	30.7	6.0	0.0	28.1	6.8	0.0	25.6	7.5
440.0	14.7	48.3	75.7	124.1	55.6	10.8	512.8	579.2	967.6	330.9	1298.5	1567.0	268.5	20.7	13.1	3.0	0.0	31.3	6.1	0.0	28.7	6.9	0.0	26.1	7.7
450.0	15.0	49.3	77.4	126.7	55.9	11.0	524.5	591.4	988.1	337.8	1325.9	1600.2	274.3	20.7	13.3	3.0	0.0	32.0	6.3	0.0	29.3	7.1	0.0	26.7	7.8
460.0	15.3	50.2	79.2	129.3	56.3	11.2	536.1	603.6	1008.7	344.6	1353.3	1633.5	280.2	20.7	13.6	3.0	0.0	32.7	6.4	0.0	29.9	7.2	0.0	27.2	8.0
470.0	15.7	51.1	80.9	131.9	56.6	11.4	547.8	615.8	1029.2	351.4	1380.6	1666.7	286.1	20.7	13.9	3.0	0.0	33.3	6.5	0.0	30.6	7.4	0.0	27.8	8.2
480.0	16.0	52.0	82.6	134.6	57.0	11.5	559.4	627.9	1049.7	358.3	1408.0	1699.9	292.0	20.7	14.2	3.0	0.0	34.0	6.7	0.0	31.2	7.5	0.0	28.3	8.3
490.0	16.3	52.9	84.3	137.2	57.3	11.7	571.1	640.1	1070.2	365.1	1435.3	1733.2	297.9	20.8	14.4	2.9	0.0	34.7	6.8	0.0	31.8	7.6	0.0	28.9	8.5
500.0	16.7	53.8	86.0	139.8	57.6	11.9	582.8	652.3	1090.7	371.8	1462.6	1766.4	303.8	20.8	14.7	2.9	0.0	35.3	6.9	0.0	32.4	7.8	0.0	29.4	8.7
510.0	17.0	54.7	87.8	142.5	57.9	12.1	594.4	664.4	1111.3	378.6	1489.9	1799.6	309.8	20.8	15.0	2.9	0.0	36.0	7.1	0.0	33.0	7.9	0.0	30.0	8.8
520.0	17.3	55.6	89.5	145.1	58.3	12.3	606.1	676.6	1131.8	385.4	1517.1	1832.9	315.7	20.8	15.3	2.9	0.0	36.7	7.2	0.0	33.6	8.1	0.0	30.5	9.0
530.0	17.6	56.5	91.2	147.7	58.6	12.4	617.7	688.7	1152.3	392.1	1544.4	1866.1	321.7	20.8	15.6	2.9	0.0	37.3	7.3	0.0	34.2	8.2	0.0	31.1	9.1
540.0	18.0	57.4	92.9	150.4	58.9	12.6	629.4	700.8	1172.8	398.8	1571.6	1899.3	327.7	20.8	15.8	2.9	0.0	38.0	7.4	0.0	34.8	8.4	0.0	31.7	9.3
550.0	18.3	58.4	94.6	153.0	59.2	12.8	641.0	713.0	1193.4	405.5	1598.9	1932.6	333.7	20.9	16.1	2.9	0.0	38.7	7.6	0.0	35.4	8.5	0.0	32.2	9.5
560.0	18.6	59.3	96.4	155.6	59.4	13.0	652.7	725.1	1213.9	412.2	1626.1	1965.8	339.7	20.9	16.4	2.9	0.0	39.3	7.7	0.0	36.0	8.7	0.0	32.8	9.6
570.0	19.0	60.2	98.1	158.3	59.7	13.1	664.3	737.2	1234.4	418.9	1653.3	1999.0	345.7	20.9	16.7	2.9	0.0	40.0	7.8	0.0	36.6	8.8	0.0	33.3	9.8
580.0	19.3	61.1	99.8	160.9	60.0	13.3	676.0	749.3	1254.9	425.6	1680.5	2032.2	351.7	20.9	16.9	2.9	0.0	40.6	8.0	0.0	37.3	9.0	0.0	33.9	10.0
590.0	19.6	62.0	101.5	163.5	60.3	13.5	687.6	761.4	1275.4	432.3	1707.7	2065.5	357.8	20.9	17.2	2.9	0.0	41.3	8.1	0.0	37.9	9.1	0.0	34.4	10.1
600.0	20.0	62.9	103.2	166.1	60.6	13.6	699.3	773.5	1296.0	438.9	1734.9	2098.7	363.8	21.0	17.5	2.9	0.0	42.0	8.2	0.0	38.5	9.3	0.0	35.0	10.3

Table 12. Ration for the medium milk producing (milk yield 4.0% of live weight) dairy cow without dry roughage

Requirement of ME (MJ/day)					Requirement of CP (g/day)							Allowance of CP			Dry matter		Roughage: Concentrate								
																	60:40			55:45			50:50		
Live weight (kg)	Milk yield (kg)	ME for body maintenance	ME for milk yield	Total ME	Endogenous Protein (EUP)	Dermal Protein (DP)	Milk protein (MP)	Tissue Protein (TP)	RDP	UDP	CP	CP Available (g/d)	CP Surplus (g/d)	CP allowance (%)	Requirement of DM	DMI (%)	Straw	Grass	Conc.	Straw	Grass	Conc.	Straw	Grass	Conc.
200.0	8.0	26.5	41.3	67.8	42.9	6.0	280.0	328.9	529.2	204.2	733.3	749.8	16.5	2.3	7.1	3.6	0.0	17.1	3.4	0.0	15.7	3.8	0.0	14.3	4.2
210.0	8.4	27.4	43.4	70.8	43.7	6.2	294.0	343.9	552.4	214.2	766.6	782.7	16.1	2.1	7.5	3.5	0.0	17.9	3.5	0.0	16.4	3.9	0.0	14.9	4.4
220.0	8.8	28.3	45.5	73.8	44.4	6.4	308.0	358.9	575.6	224.2	799.8	815.6	15.8	2.0	7.8	3.5	0.0	18.6	3.7	0.0	17.1	4.1	0.0	15.5	4.6
230.0	9.2	29.2	47.5	76.8	45.1	6.6	322.0	373.8	598.8	234.1	832.9	848.5	15.6	1.9	8.1	3.5	0.0	19.4	3.8	0.0	17.8	4.3	0.0	16.2	4.8
240.0	9.6	30.1	49.6	79.7	45.8	6.9	336.0	388.7	622.0	244.0	866.0	881.4	15.4	1.8	8.4	3.5	0.0	20.1	4.0	0.0	18.5	4.4	0.0	16.8	4.9
250.0	10.0	31.1	51.7	82.7	46.5	7.1	350.0	403.6	645.3	253.8	899.0	914.3	15.3	1.7	8.7	3.5	0.0	20.9	4.1	0.0	19.2	4.6	0.0	17.4	5.1
260.0	10.4	32.0	53.7	85.7	47.1	7.3	364.0	418.4	668.5	263.5	932.0	947.2	15.3	1.6	9.0	3.5	0.0	21.7	4.2	0.0	19.8	4.8	0.0	18.0	5.3
270.0	10.8	32.9	55.8	88.7	47.7	7.5	378.0	433.2	691.7	273.2	964.9	980.1	15.3	1.6	9.3	3.5	0.0	22.4	4.4	0.0	20.5	4.9	0.0	18.7	5.5
280.0	11.2	33.8	57.9	91.7	48.3	7.7	392.0	448.0	714.9	282.8	997.8	1013.0	15.3	1.5	9.6	3.4	0.0	23.2	4.5	0.0	21.2	5.1	0.0	19.3	5.7
290.0	11.6	34.7	59.9	94.6	48.9	7.9	406.0	462.8	738.1	292.4	1030.6	1045.9	15.4	1.5	10.0	3.4	0.0	23.9	4.7	0.0	21.9	5.3	0.0	19.9	5.9
300.0	12.0	35.6	62.0	97.6	49.4	8.1	420.0	477.5	761.4	302.0	1063.4	1078.9	15.5	1.5	10.3	3.4	0.0	24.7	4.8	0.0	22.6	5.4	0.0	20.5	6.0
310.0	12.4	36.5	64.1	100.6	49.9	8.3	434.0	492.3	784.6	311.5	1096.1	1111.8	15.6	1.4	10.6	3.4	0.0	25.4	5.0	0.0	23.3	5.6	0.0	21.2	6.2
320.0	12.8	37.4	66.1	103.6	50.4	8.5	448.0	507.0	807.8	321.0	1128.8	1144.7	15.8	1.4	10.9	3.4	0.0	26.2	5.1	0.0	24.0	5.8	0.0	21.8	6.4
330.0	13.2	38.3	68.2	106.5	50.9	8.7	462.0	521.7	831.0	330.5	1161.5	1177.6	16.1	1.4	11.2	3.4	0.0	26.9	5.3	0.0	24.7	5.9	0.0	22.4	6.6
340.0	13.6	39.2	70.3	109.5	51.4	8.9	476.0	536.3	854.2	339.9	1194.1	1210.5	16.3	1.4	11.5	3.4	0.0	27.7	5.4	0.0	25.4	6.1	0.0	23.1	6.8
350.0	14.0	40.2	72.3	112.5	51.9	9.1	490.0	551.0	877.5	349.3	1226.8	1243.4	16.6	1.4	11.8	3.4	0.0	28.4	5.6	0.0	26.1	6.3	0.0	23.7	7.0
360.0	14.4	41.1	74.4	115.5	52.3	9.3	504.0	565.6	900.7	358.7	1259.4	1276.3	16.9	1.3	12.2	3.4	0.0	29.2	5.7	0.0	26.7	6.4	0.0	24.3	7.2
370.0	14.8	42.0	76.5	118.4	52.8	9.5	518.0	580.3	923.9	368.0	1291.9	1309.2	17.3	1.3	12.5	3.4	0.0	29.9	5.9	0.0	27.4	6.6	0.0	24.9	7.3
380.0	15.2	42.9	78.5	121.4	53.2	9.7	532.0	594.9	947.1	377.3	1324.5	1342.1	17.6	1.3	12.8	3.4	0.0	30.7	6.0	0.0	28.1	6.8	0.0	25.6	7.5
390.0	15.6	43.8	80.6	124.4	53.6	9.9	546.0	609.5	970.3	386.6	1357.0	1375.0	18.0	1.3	13.1	3.4	0.0	31.4	6.2	0.0	28.8	6.9	0.0	26.2	7.7
400.0	16.0	44.7	82.7	127.4	54.0	10.1	560.0	624.1	993.6	395.9	1389.5	1407.9	18.4	1.3	13.4	3.4	0.0	32.2	6.3	0.0	29.5	7.1	0.0	26.8	7.9
410.0	16.4	45.6	84.7	130.4	54.4	10.3	574.0	638.7	1016.8	405.1	1421.9	1440.8	18.9	1.3	13.7	3.3	0.0	32.9	6.5	0.0	30.2	7.3	0.0	27.4	8.1
420.0	16.8	46.5	86.8	133.3	54.8	10.4	588.0	653.3	1040.0	414.4	1454.4	1473.7	19.3	1.3	14.0	3.3	0.0	33.7	6.6	0.0	30.9	7.4	0.0	28.1	8.3
430.0	17.2	47.4	88.9	136.3	55.2	10.6	602.0	667.8	1063.2	423.6	1486.8	1506.6	19.8	1.3	14.3	3.3	0.0	34.4	6.8	0.0	31.6	7.6	0.0	28.7	8.4
440.0	17.6	48.3	90.9	139.3	55.6	10.8	616.0	682.4	1086.5	432.8	1519.2	1539.5	20.3	1.3	14.7	3.3	0.0	35.2	6.9	0.0	32.3	7.8	0.0	29.3	8.6
450.0	18.0	49.3	93.0	142.3	55.9	11.0	630.0	696.9	1109.7	442.0	1551.6	1572.4	20.8	1.3	15.0	3.3	0.0	35.9	7.0	0.0	32.9	7.9	0.0	30.0	8.8
460.0	18.4	50.2	95.1	145.2	56.3	11.2	644.0	711.5	1132.9	451.1	1584.0	1605.3	21.3	1.3	15.3	3.3	0.0	36.7	7.2	0.0	33.6	8.1	0.0	30.6	9.0
470.0	18.8	51.1	97.1	148.2	56.6	11.4	658.0	726.0	1156.1	460.3	1616.4	1638.2	21.9	1.4	15.6	3.3	0.0	37.4	7.3	0.0	34.3	8.3	0.0	31.2	9.2
480.0	19.2	52.0	99.2	151.2	57.0	11.5	672.0	740.5	1179.3	469.4	1648.7	1671.1	22.4	1.4	15.9	3.3	0.0	38.2	7.5	0.0	35.0	8.4	0.0	31.8	9.4
490.0	19.6	52.9	101.3	154.2	57.3	11.7	686.0	755.0	1202.6	478.5	1681.0	1704.0	23.0	1.4	16.2	3.3	0.0	38.9	7.6	0.0	35.7	8.6	0.0	32.5	9.5
500.0	20.0	53.8	103.4	157.2	57.6	11.9	700.0	769.5	1225.8	487.6	1713.4	1736.9	23.6	1.4	16.5	3.3	0.0	39.7	7.8	0.0	36.4	8.8	0.0	33.1	9.7
510.0	20.4	54.7	105.4	160.1	57.9	12.1	714.0	784.0	1249.0	496.7	1745.7	1769.8	24.2	1.4	16.9	3.3	0.0	40.5	7.9	0.0	37.1	8.9	0.0	33.7	9.9
520.0	20.8	55.6	107.5	163.1	58.3	12.3	728.0	798.5	1272.2	505.7	1778.0	1802.7	24.8	1.4	17.2	3.3	0.0	41.2	8.1	0.0	37.8	9.1	0.0	34.3	10.1
530.0	21.2	56.5	109.6	166.1	58.6	12.4	742.0	813.0	1295.4	514.8	1810.2	1835.6	25.4	1.4	17.5	3.3	0.0	42.0	8.2	0.0	38.5	9.3	0.0	35.0	10.3
540.0	21.6	57.4	111.6	169.1	58.9	12.6	756.0	827.5	1318.7	523.8	1842.5	1868.5	26.1	1.4	17.8	3.3	0.0	42.7	8.4	0.0	39.2	9.4	0.0	35.6	10.5
550.0	22.0	58.4	113.7	172.0	59.2	12.8	770.0	841.9	1341.9	532.9	1874.7	1901.5	26.7	1.4	18.1	3.3	0.0	43.5	8.5	0.0	39.8	9.6	0.0	36.2	10.7
560.0	22.4	59.3	115.8	175.0	59.4	13.0	784.0	856.4	1365.1	541.9	1907.0	1934.4	27.4	1.4	18.4	3.3	0.0	44.2	8.7	0.0	40.5	9.8	0.0	36.8	10.8
570.0	22.8	60.2	117.8	178.0	59.7	13.1	798.0	870.9	1388.3	550.9	1939.2	1967.3	28.0	1.4	18.7	3.3	0.0	45.0	8.8	0.0	41.2	9.9	0.0	37.5	11.0
580.0	23.2	61.1	119.9	181.0	60.0	13.3	812.0	885.3	1411.5	559.9	1971.4	2000.2	28.7	1.5	19.0	3.3	0.0	45.7	9.0	0.0	41.9	10.1	0.0	38.1	11.2
590.0	23.6	62.0	122.0	183.9	60.3	13.5	826.0	899.7	1434.8	568.9	2003.6	2033.1	29.4	1.5	19.4	3.3	0.0	46.5	9.1	0.0	42.6	10.3	0.0	38.7	11.4
600.0	24.0	62.9	124.0	186.9	60.6	13.6	840.0	914.2	1458.0	577.8	2035.8	2066.0	30.1	1.5	19.7	3.3	0.0	47.2	9.3	0.0	43.3	10.4	0.0	39.4	11.6

Table 13. Ration for the moderate milk producing (milk yield 4.7% of live weight) dairy cow without dry roughage

Requirement of ME (MJ/day)					Requirement of CP (g/day)							Allowance of CP			Dry matter		Roughage: Concentrate								
																	60:40			55:45			50:50		
Live weight (kg)	Milk yield (kg)	ME for body maintenance	ME for milk yield	Total ME	Endogenous Protein (EUP)	Dermal Protein (DP)	Milk protein (MP)	Tissue Protein (TP)	RDP	UDP	CP	CP Available (g/d)	CP Surplus (g/d)	CP allowance (%)	Requirement of DM (Kg/d)	DMI (%)	Straw	Grass	Conc.	Straw	Grass	Conc.	Straw	Grass	Conc.
200.0	9.3	26.5	48.3	74.8	42.9	6.0	326.9	375.8	583.2	250.5	833.6	865.7	32.1	3.8	7.9	3.9	0.0	18.9	3.7	0.0	17.3	4.2	0.0	15.7	4.6
210.0	9.8	27.4	50.7	78.1	43.7	6.2	343.2	393.1	609.1	262.8	871.9	904.2	32.3	3.7	8.2	3.9	0.0	19.7	3.9	0.0	18.1	4.4	0.0	16.4	4.8
220.0	10.3	28.3	53.1	81.4	44.4	6.4	359.6	410.4	635.0	275.1	910.1	942.7	32.5	3.6	8.6	3.9	0.0	20.6	4.0	0.0	18.9	4.5	0.0	17.1	5.0
230.0	10.7	29.2	55.5	84.7	45.1	6.6	375.9	427.7	660.9	287.4	948.3	981.1	32.8	3.5	8.9	3.9	0.0	21.4	4.2	0.0	19.6	4.7	0.0	17.8	5.2
240.0	11.2	30.1	57.9	88.1	45.8	6.9	392.3	445.0	686.9	299.5	986.4	1019.6	33.2	3.4	9.3	3.9	0.0	22.2	4.4	0.0	20.4	4.9	0.0	18.5	5.5
250.0	11.7	31.1	60.3	91.4	46.5	7.1	408.6	462.2	712.8	311.6	1024.4	1058.1	33.7	3.3	9.6	3.8	0.0	23.1	4.5	0.0	21.2	5.1	0.0	19.2	5.7
260.0	12.1	32.0	62.7	94.7	47.1	7.3	425.0	479.4	738.7	323.7	1062.4	1096.6	34.2	3.2	10.0	3.8	0.0	23.9	4.7	0.0	21.9	5.3	0.0	19.9	5.9
270.0	12.6	32.9	65.2	98.0	47.7	7.5	441.3	496.5	764.6	335.7	1100.3	1135.1	34.7	3.2	10.3	3.8	0.0	24.8	4.9	0.0	22.7	5.5	0.0	20.6	6.1
280.0	13.1	33.8	67.6	101.4	48.3	7.7	457.7	513.7	790.5	347.7	1138.2	1173.5	35.3	3.1	10.7	3.8	0.0	25.6	5.0	0.0	23.5	5.6	0.0	21.3	6.3
290.0	13.5	34.7	70.0	104.7	48.9	7.9	474.0	530.8	816.5	359.6	1176.0	1212.0	36.0	3.1	11.0	3.8	0.0	26.4	5.2	0.0	24.2	5.8	0.0	22.0	6.5
300.0	14.0	35.6	72.4	108.0	49.4	8.1	490.4	547.9	842.4	371.5	1213.8	1250.5	36.7	3.0	11.4	3.8	0.0	27.3	5.3	0.0	25.0	6.0	0.0	22.7	6.7
310.0	14.5	36.5	74.8	111.3	49.9	8.3	506.7	564.9	868.3	383.3	1251.6	1289.0	37.4	3.0	11.7	3.8	0.0	28.1	5.5	0.0	25.8	6.2	0.0	23.4	6.9
320.0	14.9	37.4	77.2	114.6	50.4	8.5	523.0	582.0	894.2	395.1	1289.3	1327.5	38.1	3.0	12.1	3.8	0.0	29.0	5.7	0.0	26.5	6.4	0.0	24.1	7.1
330.0	15.4	38.3	79.6	118.0	50.9	8.7	539.4	599.0	920.1	406.9	1327.0	1365.9	38.9	2.9	12.4	3.8	0.0	29.8	5.8	0.0	27.3	6.6	0.0	24.8	7.3
340.0	15.9	39.2	82.1	121.3	51.4	8.9	555.7	616.1	946.1	418.6	1364.7	1404.4	39.7	2.9	12.8	3.8	0.0	30.6	6.0	0.0	28.1	6.8	0.0	25.5	7.5
350.0	16.3	40.2	84.5	124.6	51.9	9.1	572.1	633.1	972.0	430.3	1402.3	1442.9	40.6	2.9	13.1	3.7	0.0	31.5	6.2	0.0	28.9	6.9	0.0	26.2	7.7
360.0	16.8	41.1	86.9	127.9	52.3	9.3	588.4	650.1	997.9	442.0	1439.9	1481.4	41.5	2.9	13.5	3.7	0.0	32.3	6.3	0.0	29.6	7.1	0.0	26.9	7.9
370.0	17.3	42.0	89.3	131.3	52.8	9.5	604.8	667.0	1023.8	453.7	1477.5	1519.9	42.4	2.9	13.8	3.7	0.0	33.2	6.5	0.0	30.4	7.3	0.0	27.6	8.1
380.0	17.7	42.9	91.7	134.6	53.2	9.7	621.1	684.0	1049.7	465.3	1515.1	1558.3	43.3	2.9	14.2	3.7	0.0	34.0	6.7	0.0	31.2	7.5	0.0	28.3	8.3
390.0	18.2	43.8	94.1	137.9	53.6	9.9	637.5	701.0	1075.7	476.9	1552.6	1596.8	44.2	2.8	14.5	3.7	0.0	34.8	6.8	0.0	31.9	7.7	0.0	29.0	8.5
400.0	18.7	44.7	96.5	141.2	54.0	10.1	653.8	717.9	1101.6	488.5	1590.1	1635.3	45.2	2.8	14.9	3.7	0.0	35.7	7.0	0.0	32.7	7.9	0.0	29.7	8.7
410.0	19.1	45.6	98.9	144.6	54.4	10.3	670.1	734.8	1127.5	500.1	1627.6	1673.8	46.2	2.8	15.2	3.7	0.0	36.5	7.2	0.0	33.5	8.1	0.0	30.4	9.0
420.0	19.6	46.5	101.4	147.9	54.8	10.4	686.5	751.7	1153.4	511.6	1665.0	1712.3	47.2	2.8	15.6	3.7	0.0	37.4	7.3	0.0	34.2	8.2	0.0	31.1	9.2
430.0	20.1	47.4	103.8	151.2	55.2	10.6	702.8	768.7	1179.4	523.1	1702.5	1750.7	48.2	2.8	15.9	3.7	0.0	38.2	7.5	0.0	35.0	8.4	0.0	31.8	9.4
440.0	20.5	48.3	106.2	154.5	55.6	10.8	719.2	785.6	1205.3	534.6	1739.9	1789.2	49.3	2.8	16.3	3.7	0.0	39.0	7.7	0.0	35.8	8.6	0.0	32.5	9.6
450.0	21.0	49.3	108.6	157.8	55.9	11.0	735.5	802.4	1231.2	546.1	1777.3	1827.7	50.4	2.8	16.6	3.7	0.0	39.9	7.8	0.0	36.6	8.8	0.0	33.2	9.8
460.0	21.5	50.2	111.0	161.2	56.3	11.2	751.9	819.3	1257.1	557.6	1814.7	1866.2	51.4	2.8	17.0	3.7	0.0	40.7	8.0	0.0	37.3	9.0	0.0	33.9	10.0
470.0	21.9	51.1	113.4	164.5	56.6	11.4	768.2	836.2	1283.0	569.1	1852.1	1904.6	52.5	2.8	17.3	3.7	0.0	41.6	8.1	0.0	38.1	9.2	0.0	34.6	10.2
480.0	22.4	52.0	115.8	167.8	57.0	11.5	784.6	853.1	1309.0	580.5	1889.5	1943.1	53.7	2.8	17.7	3.7	0.0	42.4	8.3	0.0	38.9	9.4	0.0	35.3	10.4
490.0	22.9	52.9	118.2	171.1	57.3	11.7	800.9	869.9	1334.9	591.9	1926.8	1981.6	54.8	2.8	18.0	3.7	0.0	43.2	8.5	0.0	39.6	9.5	0.0	36.0	10.6
500.0	23.4	53.8	120.7	174.5	57.6	11.9	817.3	886.8	1360.8	603.3	1964.1	2020.1	55.9	2.8	18.4	3.7	0.0	44.1	8.6	0.0	40.4	9.7	0.0	36.7	10.8
510.0	23.8	54.7	123.1	177.8	57.9	12.1	833.6	903.6	1386.7	614.7	2001.5	2058.6	57.1	2.9	18.7	3.7	0.0	44.9	8.8	0.0	41.2	9.9	0.0	37.4	11.0
520.0	24.3	55.6	125.5	181.1	58.3	12.3	849.9	920.4	1412.6	626.1	2038.8	2097.0	58.3	2.9	19.1	3.7	0.0	45.8	9.0	0.0	41.9	10.1	0.0	38.1	11.2
530.0	24.8	56.5	127.9	184.4	58.6	12.4	866.3	937.3	1438.6	637.5	2076.1	2135.5	59.5	2.9	19.4	3.7	0.0	46.6	9.1	0.0	42.7	10.3	0.0	38.8	11.4
540.0	25.2	57.4	130.3	187.8	58.9	12.6	882.6	954.1	1464.5	648.8	2113.3	2174.0	60.7	2.9	19.8	3.7	0.0	47.4	9.3	0.0	43.5	10.5	0.0	39.5	11.6
550.0	25.7	58.4	132.7	191.1	59.2	12.8	899.0	970.9	1490.4	660.2	2150.6	2212.5	61.9	2.9	20.1	3.7	0.0	48.3	9.5	0.0	44.2	10.6	0.0	40.2	11.8
560.0	26.2	59.3	135.1	194.4	59.4	13.0	915.3	987.7	1516.3	671.5	2187.9	2251.0	63.1	2.9	20.5	3.7	0.0	49.1	9.6	0.0	45.0	10.8	0.0	40.9	12.0
570.0	26.6	60.2	137.6	197.7	59.7	13.1	931.7	1004.5	1542.3	682.8	2225.1	2289.4	64.3	2.9	20.8	3.7	0.0	50.0	9.8	0.0	45.8	11.0	0.0	41.6	12.2
580.0	27.1	61.1	140.0	201.0	60.0	13.3	948.0	1021.3	1568.2	694.2	2262.3	2327.9	65.6	2.9	21.2	3.6	0.0	50.8	10.0	0.0	46.6	11.2	0.0	42.3	12.4
590.0	27.6	62.0	142.4	204.4	60.3	13.5	964.4	1038.1	1594.1	705.5	2299.6	2366.4	66.9	2.9	21.5	3.6	0.0	51.6	10.1	0.0	47.3	11.4	0.0	43.0	12.7
600.0	28.0	62.9	144.8	207.7	60.6	13.6	980.7	1054.9	1620.0	716.7	2336.8	2404.9	68.1	2.9	21.9	3.6	0.0	52.5	10.3	0.0	48.1	11.6	0.0	43.7	12.9

Table 14. Ration for the high milk producing dairy cow (milk yield 5.3% of live weight) without dry roughage

Requirement of ME (MJ/day)					Requirement of CP (g/day)							Allowance of CP			Dry matter		Roughage: Concentrate								
																	60:40			55:45			50:50		
Live weight (kg)	Milk yield (kg)	ME for body maintenance	ME for milk yield	Total ME	Endogenous Protein (EUP)	Dermal Protein (DP)	Milk protein (MP)	Tissue Protein (TP)	RDP	UDP	CP	CP Available (g/d)	CP Surplus (g/d)	CP Allowance (%)	Requirement of DM (Kg/d)	DMI (%)	Straw	Grass	Conc.	Straw	Grass	Conc.	Straw	Grass	Conc.
200.0	10.7	26.5	55.1	81.6	42.9	6.0	373.1	422.0	636.4	296.1	932.4	944.7	12.2	1.3	8.6	4.3	0.0	20.6	4.0	0.0	18.9	4.5	0.0	17.2	5.1
210.0	11.2	27.4	57.8	85.3	43.7	6.2	391.8	441.6	665.0	310.7	975.7	987.1	11.4	1.2	9.0	4.3	0.0	21.5	4.2	0.0	19.7	4.8	0.0	17.9	5.3
220.0	11.7	28.3	60.6	88.9	44.4	6.4	410.4	461.3	693.5	325.3	1018.8	1029.5	10.7	1.1	9.4	4.3	0.0	22.5	4.4	0.0	20.6	5.0	0.0	18.7	5.5
230.0	12.3	29.2	63.3	92.6	45.1	6.6	429.1	480.9	722.1	339.8	1061.9	1072.0	10.0	0.9	9.7	4.2	0.0	23.4	4.6	0.0	21.4	5.2	0.0	19.5	5.7
240.0	12.8	30.1	66.1	96.2	45.8	6.9	447.7	500.4	750.7	354.3	1105.0	1114.4	9.4	0.9	10.1	4.2	0.0	24.3	4.8	0.0	22.3	5.4	0.0	20.3	6.0
250.0	13.3	31.1	68.9	99.9	46.5	7.1	466.4	519.9	779.3	368.6	1147.9	1156.8	8.9	0.8	10.5	4.2	0.0	25.2	4.9	0.0	23.1	5.6	0.0	21.0	6.2
260.0	13.9	32.0	71.6	103.6	47.1	7.3	485.0	539.4	807.9	383.0	1190.8	1199.3	8.4	0.7	10.9	4.2	0.0	26.2	5.1	0.0	24.0	5.8	0.0	21.8	6.4
270.0	14.4	32.9	74.4	107.2	47.7	7.5	503.7	558.9	836.4	397.3	1233.7	1241.7	8.0	0.6	11.3	4.2	0.0	27.1	5.3	0.0	24.8	6.0	0.0	22.6	6.6
280.0	14.9	33.8	77.1	110.9	48.3	7.7	522.3	578.3	865.0	411.5	1276.5	1284.1	7.6	0.6	11.7	4.2	0.0	28.0	5.5	0.0	25.7	6.2	0.0	23.3	6.9
290.0	15.5	34.7	79.9	114.6	48.9	7.9	541.0	597.8	893.6	425.7	1319.3	1326.5	7.2	0.5	12.1	4.2	0.0	28.9	5.7	0.0	26.5	6.4	0.0	24.1	7.1
300.0	16.0	35.6	82.6	118.2	49.4	8.1	559.7	617.2	922.2	439.9	1362.1	1369.0	6.9	0.5	12.4	4.1	0.0	29.9	5.9	0.0	27.4	6.6	0.0	24.9	7.3
310.0	16.5	36.5	85.4	121.9	49.9	8.3	578.3	636.6	950.8	454.0	1404.8	1411.4	6.6	0.5	12.8	4.1	0.0	30.8	6.0	0.0	28.2	6.8	0.0	25.7	7.5
320.0	17.1	37.4	88.1	125.6	50.4	8.5	597.0	655.9	979.3	468.1	1447.4	1453.8	6.4	0.4	13.2	4.1	0.0	31.7	6.2	0.0	29.1	7.0	0.0	26.4	7.8
330.0	17.6	38.3	90.9	129.2	50.9	8.7	615.6	675.3	1007.9	482.1	1490.1	1496.3	6.2	0.4	13.6	4.1	0.0	32.6	6.4	0.0	29.9	7.2	0.0	27.2	8.0
340.0	18.1	39.2	93.6	132.9	51.4	8.9	634.3	694.6	1036.5	496.2	1532.7	1538.7	6.0	0.4	14.0	4.1	0.0	33.6	6.6	0.0	30.8	7.4	0.0	28.0	8.2
350.0	18.7	40.2	96.4	136.6	51.9	9.1	652.9	713.9	1065.1	510.1	1575.2	1581.1	5.9	0.4	14.4	4.1	0.0	34.5	6.8	0.0	31.6	7.6	0.0	28.7	8.5
360.0	19.2	41.1	99.2	140.2	52.3	9.3	671.6	733.2	1093.7	524.1	1617.8	1623.5	5.8	0.4	14.8	4.1	0.0	35.4	6.9	0.0	32.5	7.8	0.0	29.5	8.7
370.0	19.7	42.0	101.9	143.9	52.8	9.5	690.2	752.5	1122.3	538.0	1660.3	1666.0	5.7	0.3	15.1	4.1	0.0	36.3	7.1	0.0	33.3	8.0	0.0	30.3	8.9
380.0	20.3	42.9	104.7	147.5	53.2	9.7	708.9	771.8	1150.8	552.0	1702.8	1708.4	5.6	0.3	15.5	4.1	0.0	37.3	7.3	0.0	34.2	8.2	0.0	31.1	9.1
390.0	20.8	43.8	107.4	151.2	53.6	9.9	727.5	791.0	1179.4	565.9	1745.3	1750.8	5.6	0.3	15.9	4.1	0.0	38.2	7.5	0.0	35.0	8.4	0.0	31.8	9.4
400.0	21.3	44.7	110.2	154.9	54.0	10.1	746.2	810.3	1208.0	579.7	1787.7	1793.3	5.5	0.3	16.3	4.1	0.0	39.1	7.7	0.0	35.9	8.6	0.0	32.6	9.6
410.0	21.9	45.6	112.9	158.5	54.4	10.3	764.9	829.5	1236.6	593.6	1830.1	1835.7	5.5	0.3	16.7	4.1	0.0	40.1	7.9	0.0	36.7	8.8	0.0	33.4	9.8
420.0	22.4	46.5	115.7	162.2	54.8	10.4	783.5	848.8	1265.2	607.4	1872.6	1878.1	5.6	0.3	17.1	4.1	0.0	41.0	8.0	0.0	37.6	9.0	0.0	34.1	10.0
430.0	22.9	47.4	118.4	165.9	55.2	10.6	802.2	868.0	1293.7	621.2	1914.9	1920.5	5.6	0.3	17.5	4.1	0.0	41.9	8.2	0.0	38.4	9.2	0.0	34.9	10.3
440.0	23.5	48.3	121.2	169.5	55.6	10.8	820.8	887.2	1322.3	635.0	1957.3	1963.0	5.7	0.3	17.8	4.1	0.0	42.8	8.4	0.0	39.3	9.4	0.0	35.7	10.5
450.0	24.0	49.3	123.9	173.2	55.9	11.0	839.5	906.4	1350.9	648.8	1999.7	2005.4	5.7	0.3	18.2	4.1	0.0	43.8	8.6	0.0	40.1	9.7	0.0	36.5	10.7
460.0	24.5	50.2	126.7	176.9	56.3	11.2	858.1	925.6	1379.5	662.5	2042.0	2047.8	5.8	0.3	18.6	4.0	0.0	44.7	8.8	0.0	41.0	9.9	0.0	37.2	11.0
470.0	25.1	51.1	129.5	180.5	56.6	11.4	876.8	944.8	1408.1	676.2	2084.3	2090.3	5.9	0.3	19.0	4.0	0.0	45.6	8.9	0.0	41.8	10.1	0.0	38.0	11.2
480.0	25.6	52.0	132.2	184.2	57.0	11.5	895.4	963.9	1436.7	690.0	2126.6	2132.7	6.1	0.3	19.4	4.0	0.0	46.5	9.1	0.0	42.7	10.3	0.0	38.8	11.4
490.0	26.1	52.9	135.0	187.9	57.3	11.7	914.1	983.1	1465.2	703.7	2168.9	2175.1	6.2	0.3	19.8	4.0	0.0	47.5	9.3	0.0	43.5	10.5	0.0	39.5	11.6
500.0	26.7	53.8	137.7	191.5	57.6	11.9	932.8	1002.3	1493.8	717.4	2211.2	2217.5	6.4	0.3	20.2	4.0	0.0	48.4	9.5	0.0	44.4	10.7	0.0	40.3	11.9
510.0	27.2	54.7	140.5	195.2	57.9	12.1	951.4	1021.4	1522.4	731.0	2253.4	2260.0	6.5	0.3	20.5	4.0	0.0	49.3	9.7	0.0	45.2	10.9	0.0	41.1	12.1
520.0	27.7	55.6	143.2	198.8	58.3	12.3	970.1	1040.6	1551.0	744.7	2295.7	2302.4	6.7	0.3	20.9	4.0	0.0	50.2	9.8	0.0	46.0	11.1	0.0	41.9	12.3
530.0	28.2	56.5	146.0	202.5	58.6	12.4	988.7	1059.7	1579.6	758.4	2337.9	2344.8	6.9	0.3	21.3	4.0	0.0	51.2	10.0	0.0	46.9	11.3	0.0	42.6	12.5
540.0	28.8	57.4	148.7	206.2	58.9	12.6	1007.4	1078.8	1608.1	772.0	2380.1	2387.3	7.1	0.3	21.7	4.0	0.0	52.1	10.2	0.0	47.7	11.5	0.0	43.4	12.8
550.0	29.3	58.4	151.5	209.8	59.2	12.8	1026.0	1098.0	1636.7	785.6	2422.3	2429.7	7.3	0.3	22.1	4.0	0.0	53.0	10.4	0.0	48.6	11.7	0.0	44.2	13.0
560.0	29.8	59.3	154.2	213.5	59.4	13.0	1044.7	1117.1	1665.3	799.2	2464.5	2472.1	7.6	0.3	22.5	4.0	0.0	53.9	10.6	0.0	49.4	11.9	0.0	44.9	13.2
570.0	30.4	60.2	157.0	217.2	59.7	13.1	1063.3	1136.2	1693.9	812.8	2506.7	2514.5	7.8	0.3	22.9	4.0	0.0	54.9	10.8	0.0	50.3	12.1	0.0	45.7	13.4
580.0	30.9	61.1	159.7	220.8	60.0	13.3	1082.0	1155.3	1722.5	826.4	2548.9	2557.0	8.1	0.3	23.2	4.0	0.0	55.8	10.9	0.0	51.1	12.3	0.0	46.5	13.7
590.0	31.4	62.0	162.5	224.5	60.3	13.5	1100.6	1174.4	1751.1	840.0	2591.1	2599.4	8.3	0.3	23.6	4.0	0.0	56.7	11.1	0.0	52.0	12.5	0.0	47.3	13.9
600.0	32.0	62.9	165.3	228.2	60.6	13.6	1119.3	1193.5	1779.6	853.6	2633.2	2641.8	8.6	0.3	24.0	4.0	0.0	57.6	11.3	0.0	52.8	12.7	0.0	48.0	14.1

Increasing concentrate to forage ratio occasionally enhances milk production (Hansen et al., 1991; Llamas-Lamas and Combs, 1991; Sanh, 2001; Machado et al., 2014; Menajovsky et al., 2018; Jaakamo et al., 2019), improves milk protein content (Macleod et al., 1983; Llamas-Lamas and Combs, 1991; Sanh, 2001; Bargo et al., 2002) and changes milk fatty acid profile (De Campeneere et al., 2002; Soita et al., 2005; Sterk et al., 2011), however, the percentage of milk fat decreases (Aguerre et al., 2011; Sterk et al., 2011). An increase in the proportion of concentrate to forage ratio may enhance intake of dry matter and digestible carbohydrate, milk yield and alter volatile fatty acid (VFA) profile, but reduces fiber digestibility and chewing activity, hence, ruminal pH decreases due to low saliva production which may cause subclinical ruminal acidosis (De Campeneere et al., 2002; Maekawa et al., 2002; Zebeli et al., 2007; Jiang et al., 2017).

In another study, two high-forage complete feeds, 95% forage: 5% concentrate and 80% forage: 20% concentrate were fed *ad libitum* to 32 cows from 28 days pre-partum to 4 days postpartum. Total concentration of volatile fatty acids was higher and pH was lower on 60% concentrate than on 40% (Hernandez-Urdaneta et al., 1976). Therefore, long term benefit is questionable.

Effects of forage-to-concentrate ratio on apparent ruminal synthesis of thiamine, riboflavin, niacin, vitamin B_6, folates and vitamin B_{12} were evaluated. Increasing dietary forage concentration reduced apparent ruminal degradation of thiamine and apparent ruminal synthesis of riboflavin, niacin, and folates and increased ruminal degradation of vitamin B_6, but had no effect on ruminal synthesis of vitamin B_{12}. As a consequence, increasing the forage-to-concentrate ratio had no effect on the amounts of thiamine, riboflavin, and vitamin B_{12} reaching the small intestine but decreased the amounts of niacin, vitamin B_6, and folates available for absorption. Apparent ruminal syntheses of riboflavin, niacin, folates, and vitamin B_{12} were correlated positively with the amount of starch digested in the rumen and duodenal flow of microbial N (Seck et al., 2017). Therefore, overall 60:40 forage to concentrate ratio is suggested.

Traditional forage based diets are dominant in cellulose and hemicellulose which raise the acetic acid, while concentrate rich diets accentuate level of propionic acid over acetic acid (McDonald et al., 2002). Thus, increased concentration of propionic acid in the rumen due to high levels of dietary concentrate ultimately turns the partition of energy towards synthesis of body fat instead of milk fat resulting in a linear decrease in milk fat content.

The higher the fibre content, the lower the nutritive value of feeds, but the end products of fibre fermentation in rumen is mostly volatile fatty acids that the host animal utilizes for biosynthesis of milk fat. The more the dietary fibre, the richer the lipid profile of milk. It was reported that, changing the ratio of roughage to concentrate from 62:38 to 50:50 increased both fat corrected milk yield and live weight gain in milking cows.

Therefore, inclusion of sufficient green forage materials is a prerequisite of a good TMR. The influence of concentrate-to-roughage ratio on the fatty acid profile of milk fat was investigated in dairy cows. The ratio of total unsaturated fatty acids in milk fat to its daily intake was substantially lower for forage based diet compared with concentrate rich, suggesting that the high proportion of roughage resulted in a high rate of bio-hydrogenation in the rumen (Han et al., 2014).

5. CONCLUSION

No single system is absolute. Each and every system has its own drawbacks. The TMR is one of the most effective systems in terms of productivity, reproductive efficiency and profitability. However, taking into consideration the perspective of herd size, animal groupings and degree of mechanization, TMR is not above controversy. Efficient bunk management, appropriate grouping of the animal, optimum particle size and uniform mixing of feed may provide desirable benefit from TMR in commercial dairy farms.

LIMITATIONS

For preparation of TMR, baled hay need to be chopped before blended with grain. Mixer wagons are required for thorough mixing of ingredients. Mixing devices used for blending require small to moderate expenditures for maintenance. It is important to follow the manufacturer's recommendations for mixing. Over mixing may cause problems due to grinding and pulverizing the feed. Under mixing can result in less effective feed utilization by the cows. Production specific sub-group of animals needs to be allocated. Limited experimental data are available regarding number of cows per group. TMR is less applicable for grazing systems. More mathematical calculations are necessary. Again, the idea that each bite is identical is not entirely true. Sorting of ingredients is minimized in TMR but not completely prevented. Existing buildings, feed alleys, and mangers may create a TMR system nearly impossible to use and some housing and feeding facilities also may not be well suited. Overall, A TMR system may not be economical for small herds or for those using pasture feeding over an extended period of time.

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