Estimation of energy Balance Curve in dairy cows using Wood function

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ABSTRACT

This study was conducted to investigate whether Wood function can adequately explained the energy balance of dairy cows during lactation and if so, how accurate could energy balance (EB) be predicted using the wood function. Data for the study were collected from 13 primiparous cows and 18 multiparous (F_1) Friesian x Bunaji cows at National Animal Production Research Institute (NAPRI), Zaria. The results revealed that the Wood function fitted the EB curve adequately, it explained over 73.57% of the variation in EB of the dairy cows with a very low residual error (0.50592). The EB curve parameters; initial EB of the dairy cows after calving (a), the ascending slope parameter up to peak EB (b) and descending slope parameter (c) of the curve models and their standard error (SE) were -1.411±0.56, 3.239±0.406 and -0.293±0.034, respectively. The model for prediction of EB over a period of time t was developed as $Y_t = -1.411t^{3.239}e^{-0.293.}$ The EB curve pattern shows that the animals had negative energy balance (NEB) at the initial lactation (within the first 2 weeks of lactation) and recovered to positive energy balance (PEB) and rose faster to the peak at approximately 9 to 10 weeks and then maintain some persistency and thereafter decline at a slower rate to negative EB (during the advanced pregnancy). Based on the foregoing, it is concluded that the Wood function adequately explained the variation in EB of Friesian x Bunaji dairy cows during lactation.

Key words: energy balance, lactation, Friesian –Bunaji crosses, wood function

INTRODUCTION

The term energy balance (EB) is used to describe the relationship between dietary energy intake and energy utilization. It is the difference between net energy intake (NE_I) and net energy required (NE_R) for maintenance, milk production, growth and other physiological activities (Lucy et al., 1991; Tamminga et al., 2006). When the energy needs of the animal exceed the energy input, the cow is in negative energy balance. Furthermore, modeling and predicting the EB of a cow during its lifetime could become a useful management tool on-farm. This would assist in culling decisions, reproductive management, and other related practices (Banos *et al.,* 2005).

Therefore, frequent estimation of EB in dairy cows is useful for the dairy herd management (Lovendahl et al.,2006). Given the central role of EB in health and reproductive complex (Friggens et al., 2003; Ingvartsen et al., 2003), being able to predict EB of dairy cows, especially during the early lactation is of great economic benefit to the dairy farmer and health benefit to the animal as well. However, the traditional method of measuring EB by classical input-output method is not feasible under current economic condition, because it requires the measurement of all energetic inputs feed intake and output (milk, fetus, growth). More over, in commercial farms, individual feed intake is not measured except under experimental condition. Therefore the purpose of this study was to investigate whether Wood function can adequately explained the energy balance of dairy cows during lactation and if so, how accurate could EB be predicted using the wood function.

MATERIALS AND METHODS

Experimental site:

The study was conducted on the dairy herd of National Animal Production Research Institute (NAPRI) Shika, Nigeria, located between latitude 11^0 and 12^0N at an altitude of 640 m above sea level, and lies within the Northern Guinea Savannah Zone of Nigeria (Oni *et al.*, 2001). The mean annual rainfall in this zone is 1,100mm, which commenced from May and last till October, with 90% falling between June and September. (Malau–Aduli and Abubakar, 1992).

Animal's managements and Data collection

Data for this study were collected from 13 primiparous SRW cows and 18 multiparous (F_1) Friesian x Bunaji cows from 2011 to 2013. The cows were raised during the rainy season on both natural and paddock–sown pasture, while hay or silage supplemented with concentrate of undelinted cotton seed cake, were offered during the dry season. They had access to water and salt lick *ad-libitum*. Unrestricted grazing was allowed under the supervision of herdsmen for about 7 – 9 hours per day.

The cows were milked twice daily, proportional milk samples for determination of fat, protein and lactose were taken weekly and analysed from first week postpartum to 31st week of lactation. The body weight of the cows were measured monthly in kilogram using weigh bridge

Calculation of Energy Balance (EB)

The energy balance (EB) was calculated weekly from parturition to 31st week post-partum using milk production, milk fat, and protein and lactose content data, body weight (BW) and dry matter intake (DMI).
The model for the calculation of energy balance was as follows

$EB= NE_I- NE_R$

Where EB = Energy balance

NE_I (mj/d) = net energy intake, determine by multiplying dry matter intake (DMI) with the calculated mean net energy for lactation (NE_L) using the following equation of NRC (2001)

i.e $NE_I = DMI\ (kg/d) \times NE_L(mj/d)$

$NE_L= 4\%\ FCM \times 0.749$

$=0.4 \times \text{milk yield (kg/d)} + 15 \times MFC \times 0.749$

Where FCM= fat corrected milk

0.749Mcal/kg is net energy of lactation concentration of milk when milk contains 4% fat

The DMI was theoretically estimated using the following formula by NRC (2001)

$DMI\ (kg/d)= (0.372 \times 4\%FCM + 0.0968 \times BW^{0.75}) \times 1\text{-}e^{(-0.192\ x(wol+3.67)}$

Where $BW^{0.75}$ = metabolic body weight

e= 2.71828

WOL =week of lactation

The net energy requirement (NE_R) = $(0.9 \times NE_M)+ N_G +NE_L$

Where $NE_M = (0.359824 \times (0.96 \times BW)^{0.75}$

$NE_G = SBW=0.96 \times BW$

NE_G required for target Shrunk weight gain during first lactation values were calculated applying equation from Van Amburgh *et al*.(1998)

Statistical Analysis

From the data collected, the EB curve of Friesian x Bunaji dairy cows was estimated using incomplete gamma function (Wood, 1967) and predicted model for estimation of EB was as follows

$Y_t = at^be\text{-}^{ct}$

Where Y_t is the estimated EB on the t^{th} week of lactation, a is the initial EB after calving, b is the ascending slope parameter up to peak yield, c is the descending slope parameter after peak EB and e is the exponential. The incomplete gama function was log-linear transformed and then the weekly EB estimate was set as independent variable. The model was analyzed to obtained the model parameter a, b and c, using SAS, (2000). Along with the model parameters were other goodness of fit statistics; coefficient of determination adjusted (R^2 adj), Durbin-Watson (DW) statistics and root mean square error (RMSE) of prediction

Results and Discussion

The Wood function fitted the EB curve adequately, it explained over 73.57% of the variation in EB of the dairy cows with a very low residual error (0.50592). A further indication of the goodness of fit was represented by the absence of serial correlations among the residuals. The visual inspection of the plot of residuals against time showed no definite trend in the regression pattern (Fig. 1). Such impression was confirmed by the Durbin-Watson statistics (DW). As a rule, if the value of DW = < 1.5 shows positive correlation, whereas value >2.5 shows the existence of a negative autocorrelation. Taking a look at the present study, the DW statistics value was 1.853; this showed the absence of autocorrelation. The EB curve pattern (Fig 2) shows that the animals had negative energy balance (NEB) at the initial lactation (within the first 2 weeks of lactation) and recovered to positive energy balance (PEB) and rose faster to the peak at approximately 9 to 10 weeks and then maintain some persistency and thereafter decline at a slower rate to negative EB (during the advanced pregnancy).

The EB curve parameters, that is initial EB of the dairy cows after calving (a), the ascending slope parameter up to peak EB (b) and descending slope parameter (c) of the curve models and their standard error (SE) were -1.411±0.56, 3.239±0.406 and -0.293±0.034, respectively (Table 1) and the model for prediction of EB over a period of time t was developed as $Yt = -1.411t^{3.239}e^{-0.293}$

The curve parameter estimates showed that the initial EB after calving (a) was negative, this confirm the earlier report of Buttler, (2005) that negative EB in dairy cows usually begin about one week before calving as a results of reduced feed intake and that it becomes visible during early lactation as a loss in body condition and reaches its nadir about two months postpartum. During this period of NEB in the early lactation, milk yield usually increases more rapidly than the dry matter intake. The demand for energy is therefore higher than the amount of energy consumed, thus the cows mobilizes its body reserve to offset the deficit energy and as a consequence loses weight. A study by Block et al.(2001) estimated that the mobilization of endogenous lipids meets approximately 33% of the cow energy requirements between parturition and third week of lactation. During this period it is advisable to improve the quality of the ration rather than the quantity in other to maximize microbial yield and to meet requirements for ruminal undegraded amino acid. The rate of increase to the peak (b) was higher than the rate of decline (c) after peak (Fig.2)

Conclusion

The EB curve pattern of Friesian x Bunaji dairy cows was characterized by negative energy balance (NEB) at initial lactation (within the first 2 weeks of lactation) and recovered to positive energy balance (PEB) and rose faster to the peak at approximately 9 to 10 weeks of lactation and then maintain some persistency and thereafter decline at a slower rate to negative EB (during the advanced pregnancy).

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Table 1: means and standard error of lactation curve parameter estimate from Gama type model and measures of goodness of fit

Statistics	Energy balance curve parameters			Goodness of fit		
	a	B	C	R^2	RMSE	DW
Average	-1.411	3.239	-0.293	73.57%	0.5059	1.853
SE	0.563	0.406	0.034			
P –value	0.0189	<0.001	<0.001			

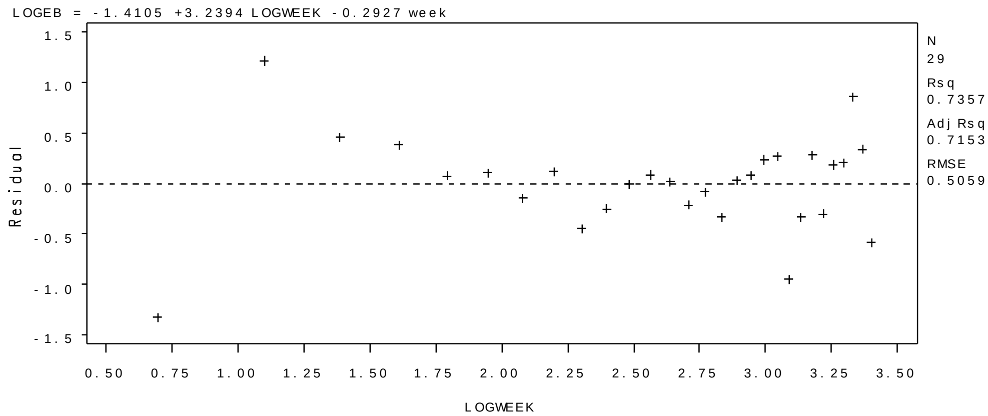

Figure 1: Plot of residuals for energy balance curve of Friesian x Bunaji cows

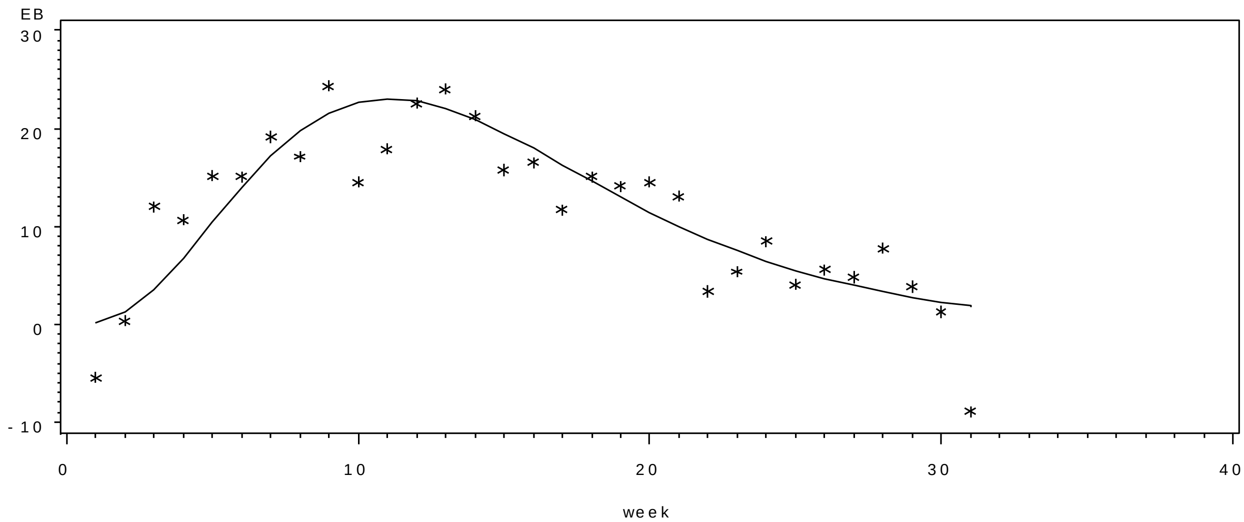

Figure 2: Actual (*) and estimated (-) average energy balance curve of Friesian x Bunaji cows