Supplementation of palm kernel expeller to grazing dairy farms in New Zealand

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Abstract

This thesis is composed of a series of studies to assess the nutritional value and characteristics of palm kernel expeller (PKE) for grazing ruminants. The chemical composition of PKE has shown high concentrations of neutral detergent fibre (NDF) (70.1±0.39 g/100g DM) and fat (9.0±0.37 g/100g DM), and a moderate content of crude protein (16.2±0.42 g/100g DM), with very low concentrations of starch and sugar (0.3%) and reasonable gross energy content (18.6±0.33MJ/kg DM). *In sacco* digestion kinetics of PKE and pasture showed that PKE presented lower values for the soluble fractions in dry matter (DM), crude protein (CP) (25-27% and 37-38%, respectively) than pasture (41 and 52%), and the majority of the NDF in PKE was also present in the slowly degradable fraction (58-59%). The values for mixtures of pasture plus PKE were generally intermediate to those of the two feeds alone and the rate of degradation (k) for DM and fibre fractions did not differ significantly between feeds. But the rate of degradation for CP in PKE was about three to four times lower than that in pasture (6.7-9.8%/h and 33.8-48.4%/h, respectively), and the addition of PKE with pasture reduced the rate of protein degradation for the mixture to a rate similar to that of PKE alone (around 10%/h). *In vitro* net ammonia (NH_3) production decreased as the amount of PKE increased in the mixture with pasture, while PKE was only able to maintain a surplus of NH_3 for a short period of time; in contrast volatile fatty acids (VFA) yields were increased, with butyrate percentage being higher at the expense of acetate. In the *in vivo* trial with lambs, daily pasture DM intake was reduced as the amount of PKE plus molasses (PKEM) was increased in both periods, but total DM intake was not increased with the addition of PKE, except when the values were converted to DM intake per kg of metabolic liveweight. Independent of the pasture quality offered, there was a linear decrease in the apparent digestibility of DM and CP with the addition of PKEM in the diet; however NDF digestibility of the diet was only decreased when PKEM was fed with good quality pasture (period 1). The apparent digestibilities of PKEM of DM, CP, and NDF for PKEM were around 63.0%, 52.0% and 68.5%, respectively, with the estimated concentration of digestible energy (DE) of PKEM being approximately 12.8 MJ /kg DM. Addition of PKEM caused a decrease in the diet's DE concentration with high quality pasture (period 1), but an increase with low quality pasture (period 2). Faecal nitrogen (N) increased and urine N decreased when increasing

amounts of PKEM were fed in the diet, however, N retention and VFA concentrations were only increased by the addition of PKEM to the low quality pasture (period 2). The supplementation of either 3 or 6 kg of PKE to cows in late lactation grazing a restricted pasture allowance (20 kg DM/cow/day) decreased pasture intake, but overall total DM intake increased. Cows actually consumed only 2.7 and 3.6 kg PKE/cow of the 3 and 6 kg PKE offered/cow and presented substitution rates of 0.30 kg/kg and 0.54 kg/kg, respectively. Supplemented cows produced 0.86 to 0.94 kg milksolids/cow daily, respectively, while cows offered restricted pasture allowance only produced 0.76 kg milksolids/day. Supplemented cows had higher concentrations of milk fat than cows offered pasture only, and marginal returns of 42 and 53 g of milksolids/kg of PKE to cows offered 3 and 6 kg of PKE, respectively.

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List of Abbreviations

A	soluble fraction
ADF	acid detergent fibre
AFRC	Agricultural and Food Research Council
AIC	Akaike information criteria
B	slowly degradable fraction
BCS	body condition score
BIC	Bayesian information criteria
BW	body weight
C.V	coefficient of variation
CHO	carbohydrates
CLA	conjugated linoleic acids
CNCPS	Cornell Net Carbohydrate and Protein System
CP	crude protein
dL	decilitre
DM	dry matter
DMD	dry matter digestibility
ED	effective degradability
EE	ether extract
eNDF	effective fibre
ERDP	effective rumen degradable protein
FA	fatty acids
FCM	fat-corrected milk
g	grams
GE	gross energy
GIT	gastro-intestinal tract
HA	herbage allowance
HG0P	*ad libitum* pasture allowance and no PKE
k	rate of digestion of the slowly degradable fraction
kg	kilograms
kp	fractional outflow rate
L	litre

LSmeans	least square means
LW	liveweight
$LW^{0.75}$	metabolic liveweight
m^2	square metre
MAF	Ministry of Agriculture & Forestry, New Zealand
ME	metabolizable energy
mg	milligram
mL	millilitre
MP	metabolizable protein
MPOC	Malaysian Palm Oil Council
MR	meter readings
MS	milk solids
MUN	milk urea nitrogen
N	nitrogen
NDF	neutral detergent fibre
NH_3	ammonia
NIRS	near infrared reflectance spectroscopy
ns	not significant
NZ	New Zealand
OMD	organic matter digestibility
P + PKE	pasture plus PKE
PD	potential degradability
PK	palm kernel
PKE	palm kernel expeller
PKEM	palm kernel expeller plus molasses
PKM	palm kernel meal
QDP	quickly degradable protein
R^2	coefficient of determination
RDP	rumen degradable protein
RG0P	restricted pasture allowance and no PKE
RGHP	restricted pasture allowance plus 3kg of fresh PKE
RGLP	restricted pasture allowance plus 6kg of fresh PKE
RMSPE	root mean square prediction error
RSMPE	root square mean prediction error

RUP	rumen undegradable protein
RW	ryegrass and white clover
Ryegrass	ryegrass-only
s.d	standard deviation
SBM	soybean meal
SDP	slowly degradable protein
SE	standard error
SR	substitution rate
SSS	soluble sugars and starch
t	time
TMR	total mixed ration
U	undegradable fraction
UK	United Kingdom
US	United States
VFA	volatile fatty acids
vs.	versus
Y	herbage mass