Raw, extruded and expanded pea (Pisum sativum) in dairy cows diets

Francesco Masoero¹, Maurizio Moschini¹, Giorgio Fusconi², Gianfranco Piva¹

¹Istituto di Scienze degli Alimenti e della Nutrizione. Università Cattolica del Sacro Cuore, Piacenza, Italy
²Centro Ricerche per la Zootecnica e l’Ambiente. Piacenza, Italy

Corresponding author: Prof. Francesco Masoero. Istituto di Scienze degli Alimenti e della Nutrizione. Facoltà di Agraria, Università Cattolica del Sacro Cuore. Via Emilia Parmense 84, 29100 Piacenza, Italy - Tel. +39 0523 599258 - Fax: +39 0523 599259 - Email: francesco.masoero@unicatt.it

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ABSTRACT

The objective of the study was to evaluate the nutritive value of raw, extruded or expanded peas relative to soybean meal in lactating dairy cows feeding. Twenty four Italian Holstein cows (8 primiparous and 16 pluriparous), 604 ± 109 kg body weight, 34.5 ± 2.5 kg/d milk yield, were randomly assigned to four dietary treatments in a 4x4 Latin square arrangement with periods of four weeks and washout period of seven days. Diets were fed ad libitum (5% orts). The bulk of the base diet on a dry matter basis was corn silage (31.2%), alfalfa hay (16.7%), grass hay (4.1%), protein supplement (10.3%), whole cotton seed (8.5%), corn and barley mix (24.9%), soybean meal (3.4%) and calcium soap (0.9%). The pea (2.5 kg/cow/day) partially replaced the soybean meal and totally replaced the barley meal of the base diet. The unprocessed or differently processed pea did not affect the dry matter intake. The extruded pea group had a 3.2% increase (P < 0.05) of the milk yield compared to the control group. When estimated as contrast analysis, the technological treatment (extruded or expanded) on peas did not modify the milk yield and composition. Among pea diets, animal fed the extruded pea had the higher (P < 0.05) milk protein content, although not different than that of the control group. The rumen acetate was reduced (P < 0.05) and the butyrate and valerate were increased (P < 0.05) in animals fed extruded pea compared to the control. No differences were observed among feeding groups on blood parameters except for the cholesterol level higher (P < 0.05) in animals fed the expanded pea diet. There were no effects of diets on milk rennet coagulation characteristics. Results support the partial substitution of soybean meal and the total substitution of barley meal with peas in diets for lactating cows with no negative effects on milk yield and composition.

Key words: Pea, Extrusion, Expansion, Dairy cow.

RIASSUNTO

PISELLO (PISUM SATIVUM) CRUDO, ESTRUSO ED ESPANSO IN DIETE PER VACCHE DA LATTE

Lo studio ha valutato la possibilità dell’utilizzo di pisello (Pisum sativum) crudo, estruso od espanso in alternativa alla farina di estrazione di soia in dieti per vacche da latte. Venti quattro vacche da latte Holstein (8 primipare e 16 pluripare), del peso di 604 ± 109 kg e con una produzione di latte di 34,5 ± 2,5 kg/d, sono state divise in quattro gruppi (6 animali/gruppo) ed assegnate casualmente a quattro diete sperimentali secondo uno schema a quadrato latino 4x4, con periodi di quattro settimane intervallate da un periodo di
Introduction

The soybean meal (SBM), sunflower meal and canola meal are considered the main protein sources used in dairy cow diets. The starch sources are from corn and barley meals and cereals by-products. The European ban on meat and bone meal (European Commission, 1991, 1999) and on genetically modified organisms (GMO) containing feeds from entering animal diets, along with regulations for producing typical products considerably narrow the protein sources that can be used in animal feeding. Lupin (Ragni et al., 2001; Vicenti et al., 2001), peas and faba beans, widely grown in the Mediterranean regions, are valuable alternative GMO free protein sources for non ruminants and ruminants (Masoero et al., 2005; Moschini et al., 2005a). Peas and faba beans have lower protein (NRC, 2001) and higher starch (Valentine and Bartsch, 1990) contents than soybean meal, and are similar to barley (Masoero et al., 1997) in terms of starch rumen fermentability. The methionine and lysine contents are 21.5 g/kg and 154.2 g/kg of essential amino acids (EAA) for peas and 31.9 g/kg and 138.2 g/kg of EAA for SBM (NRC, 2001). Thus, by adding corn either as corn silage (48.1 and 76.9 g/kg of EAA, respectively, for methionine and lysine contents) or corn meal (47.8 and 62.4 g/kg of EAA, respectively, for methionine and lysine contents) it should restore the amino acids balance of the diet when using peas.

The pea protein seems to have higher rumen degradability compared to the SBM (78% vs. 65%) (Michalet-Doreau and Cerneau, 1991; Aufrere et al., 1994; Masoero et al., 2005). Similar values were obtained by Khorasani et al. (2001) (84.5 vs. 67.2%) observing a higher degradation rate (11.4 vs. 9.6 % h⁻¹) and soluble protein fractions (59.3 vs. 20.9%). These feeds are being blamed for containing antinutritional factors (ANF) (Marquardt and Ward, 1979; Cansfield et al., 1980; Olaboro et al., 1981). Protease inhibitors (trypsin, chymotrypsin), alpha-amylase and lectins are abolished at high temperature treatments (Khalil and Mansour, 1995; Alonso et al., 2000), whereas tannins and phytic acid (Alonso et al., 2000), vicine and convicine in Faba beans (Marquardt et al., 1983) could end up in the diet independently of the processing treatment applied. The extrusion process reduces some of the ANF content (Alonso et al., 2000), however, no economical benefit of feeding extruded peas or faba beans, originally low in ANF contents, were observed in piglets and broilers (Masoero et al., 2003; Moschini et al., 2005b). The heat-based processing treatments, extrusion and expansion, increased the insoluble protein fraction and reduced the amount of the
Table 1. Ingredients and composition of experimental diets.

| Item                      | Control (%) | PESP (%) | PEST (%) | RP (%) |
|---------------------------|-------------|----------|----------|--------|
| **Ingredient composition**|             |          |          |        |
| Corn silage               | 31.20       | 31.00    | 31.00    | 31.00  |
| Alfalfa hay, dehydrate    | 16.70       | 16.60    | 16.60    | 16.60  |
| Grass hay                 | 4.10        | 4.10     | 4.10     | 4.10   |
| Cotton seed, whole with lint | 8.50   | 8.50     | 8.50     | 8.50   |
| Corn meal                 | 18.30       | 18.30    | 18.30    | 18.30  |
| Barley meal               | 6.60        | -        | -        | -      |
| Protein supplement        | 10.30       | 10.30    | 10.30    | 10.30  |
| Calcium soap              | 0.90        | 0.90     | 0.90     | 0.90   |
| Soybean meal              | 3.40        | -        | -        | -      |
| Pea, expanded             | -           | 10.30    | -        | -      |
| Pea, extruded             | -           | -        | 10.30    | -      |
| Pea, raw                  | -           | -        | -        | 10.30  |
| **Chemical composition**  |             |          |          |        |
| Crude protein             | 15.86       | 15.91    | 15.93    | 15.91  |
| Degradable protein, % CP  | 63.19       | 63.00    | 63.12    | 66.10  |
| Soluble protein, % CP     | 27.65       | 29.25    | 28.00    | 35.70  |
| Crude lipids              | 4.86        | 4.68     | 4.70     | 4.69   |
| ADF                       | 20.40       | 19.84    | 20.95    | 20.37  |
| NDF                       | 34.00       | 33.98    | 33.65    | 34.27  |
| Calculated:               |             |          |          |        |
| PeNDF                     | 26.68       | 26.46    | 27.41    | 26.54  |
| NSC                       | 41.18       | 41.32    | 41.62    | 41.03  |
| Forage                    | 52.20       | 51.76    | 51.84    | 51.81  |
| Net energy lactation, Mcal/day | 39.73  | 40.32    | 40.13    | 39.95  |

*Control: base diet; PESP: base diet with expanded pea; PEST: base diet with extruded pea; RP: base diet with raw pea.

*Contains per kg of premix: Soybean meal 600 g, Sunflower meal 300 g, mineral and vitamin supplement 100 g.; 120,000 IU of Vitamin A; 9,000 IU of Vitamin D3; 90 mg of Vitamin E; 3.6 mg of Co; 19.2 mg of I; 1.44 mg of Se; 600 mg of Mn; 62.4 mg of Cu; 2,240 mg of Zn; 1.92 mg of Mo; 360 mg of Fe.

*Megalac.

*Expressed without residual ash.

*according to Van Soest et al. (1991) without sodium sulfite and with alpha-amylase; expressed without residual ash;

*PeNDF: Physical effective neutral detergent fibre (Mertens, 1997), calculated according to the contribution of the single feed present into the diet (concentrates were considered with PeNDF=0; whole cotton seeds PeNDF=70);

*according to NRC, 2001.
protein being degraded into the rumen with no changes on in vitro digestibility (Masoero et al., 2005). The extrusion cooking reduced the starch and non-starch polysaccharides (NSP) contents in pea and kidney bean seed meals (Alonso et al., 2001), whereas the rumen starch degradability was increased in extruded peas with no effect on milk yield (Petit et al., 1997) and the in vitro starch degradability (amyloglucosidase) was considerably increased in extruded peas and faba beans (Masoero et al., 2005). Thus, according to the latest guidelines for dairy cow requirements (NRC, 2001), heat processed peas or similar legumes could be used in the formulation of diets for high producing dairy cows: the performance could be enhanced by maximising the microbial protein synthesis when feeding on feeds with larger amounts of undegradable rumen proteins and higher carbohydrate rumen digestibility.

The objective of the study was to evaluate the effect on milk production and quality of processed (extruded or expanded) or unprocessed pea meal relative to the SBM and barley (to balance the starch content) in lactating dairy cow diets.

### Material and methods

**Technological treatments of feeds**

Three batches of commercially available peas from the same lot were ground (1 mm sieve), extruded (Anderson single-screw wet extruder, 300-350 Kg h⁻¹ capacity, 120A power absorption - Cortal Extrasoy, Vicenza, Italy) or expanded (Buhler expander, 70°C conditioning temperature, 130°C internal temperature, 30 atmosphere head pressure, 180-200A power absorption - Consorzio Agrario, Cremona, Italy).

**Animals and diets**

The experimental trial was carried out at the CERZOO (Zootecnic and Environmental Research Center) research and experimental centre (San Bonico, Italy). Twenty-four Italian Holstein cows (8 primiparous and 16 pluriparous) averaging (mean ± SD) 604 ± 109 kg of body weight were used as experimental animals. The treatments were arranged according to a randomised block design with four animals per treatment. The cows were maintained on a total mixed ration of grass silage, hay, and concentrates, with 5% of the total feeding allowance provided as a concentrate supplement (22% DM) with the different tested diets. The experimental period consisted of a 3-month period of adaptation before the milk yield measurements were performed. The trial was carried out from February to May 2006.

### Results

Table 2. Dry matter intake (DMI), milk yield, milk composition and 4% fat corrected milk (FCM) as influenced by different diets fed to animals.

| Items                      | Control | PESP  | PEST  | RP    | SEM  |
|----------------------------|---------|-------|-------|-------|------|
| DMI (kg)                   | 22.34   | 22.71 | 22.54 | 22.59 | 0.124|
| Milk yield (%)             | 34.37a  | 34.36a| 35.47a| 34.20a| 0.270|
| Fat (%)                    | 3.67    | 3.60  | 3.52  | 3.64  | 0.063|
| Protein (%)                | 3.40    | 3.32  | 3.38  | 3.36  | 0.024|
| Lactose (%)                | 5.13ab  | 5.12a | 5.14ab| 5.15a | 0.008|
| Fat (kg)                   | 1.25    | 1.22  | 1.24  | 1.23  | 0.030|
| Protein (%)                | 1.16ab  | 1.13a | 1.19a | 1.14a | 0.010|
| Milk yield/DMI             | 1.55ab  | 1.53a | 1.58b | 1.52b | 0.014|
| 4% FCM (%)                 | 32.45   | 32.11 | 32.72 | 32.16 | 0.527|
| 4% FCM/DMI                 | 1.46    | 1.43  | 1.46  | 1.43  | 0.025|

1 Control: base diet; PESP: base diet with expanded pea; PEST: base diet with extruded pea; RP: base diet with raw pea; Contrast comparing PESP and PEST diets vs. the RP diet for items in table were not significant.

Least square means in the same row without common letters differ significantly (P < 0.05).
ALTERNATIVE PROTEIN IN DAIRY COWS DIETS

Cows with negative milk coagulation parameters (Salvadori del Prato, 1998) were prevented from entering the trial. Cows were housed in a free stall and had free access to water. Diets were formulated according to the NRC requirements (NRC, 2001) for an average cow weight of 600 kg, 140 days in milk and average daily milk yield of 35 Kg (3.8% fat and 3.35% protein). Cows were fed ad libitum (5% expected orts) a total mixed ration (TMR) (Table 1) once a day at 9 a.m.. Diets were control (base diet), base diet with expanded pea (PESP), base diet with extruded pea (PEST) and base diet with raw pea (RP). The differently processed pea partially replaced the SBM and completely replaced the barley meal of the base diet. The barley meal was replaced to balance for the starch content.

The experimental periods lasted four weeks with a washout of seven days between periods. The pen feed intake was recorded daily. Orts were collected daily and weighed weekly during the last week of each period. Animals were milked twice a day at 1.30 a.m. and 2.30 p.m. and individual milk yield was recorded at every milking (Afimilk system, Afikim, Israel).

Sample collection and analytical procedures

Individual milk samples were collected weekly (twice a week in two consecutive days), pooled by day, during the last three weeks of each period and analysed for fat, protein and lactose contents (infrared analysis, Milkoscan Model FT120 Foss Electric, Denmark). The rennet coagulation characteristics (tromboelastographic method; Formawin 32, Foss Electric, Denmark) of bulk milk for each group were measured at the end of each period according to the regulation adopted by the Parmesan Cheese Consortium (Salvadori del Prato, 1998) and were expressed as: clotting time (r), curd firming time (k20) and curd firmness measured 30 min after rennet addition (a30).

Blood (all animals) and rumen fluid samples (3 animals per pen, randomly selected) were collect-

Table 3. Ammonia (mg/l), lactic acid (mol/100 mol) and volatile fatty acids (mol/100 mol) in rumen fluid collected three hours from morning meal.

| Parameter               | Control | PESP | PEST | RP    | SEM  |
|-------------------------|---------|------|------|-------|------|
| Ammonia                 | 143.75  | 138.17 | 136.33 | 178.00 | 6.973 |
| Lactic acid             | 0.62    | 1.09  | 1.21  | 0.12  | 0.783 |
| Acetate                 | 64.27a  | 64.06a | 61.93a | 62.62ab | 0.503 |
| Propionate              | 22.92   | 22.17 | 23.05 | 24.10 | 0.969 |
| Butyrate                | 9.99a   | 10.67ab | 11.65a | 10.89ab | 0.295 |
| Isobutyrate             | 0.59    | 0.54  | 0.48  | 0.58  | 0.030 |
| Valerate                | 1.20ab  | 1.10a  | 1.36c  | 1.25sc | 0.040 |
| Isovalerate             | 0.42ab  | 0.38ab | 0.35a  | 0.44c  | 0.016 |
| Acetate/propionate ratio| 2.89    | 2.98  | 2.75  | 2.68  | 0.132 |

1 Control: base diet; PESP: base diet with expanded pea; PEST: base diet with extruded pea; RP: base diet with raw pea;
Least square means in the same row without common letters differ significantly (P < 0.05)
2 P of the model not significant
ed during the last week of each experimental period. The blood samples were obtained before the morning meal by venipuncture of the jugular vein and collected into Li-Heparinized (17 U of heparin/ml of blood) Vacutainer (Vacutainer systems, Belliver industrial estate, Plymouth, UK). Then, plasma was obtained by centrifugation (3000 rpm for 20 minutes) and stored at -20°C until it was analysed for total protein, albumin, globulin, urea, nonesterified fatty acids (NEFA), glucose, cholesterol, triglycerides, aspartate aminotransferase, gamma-glutamyl transferase, bilirubin, creatinine, calcium, phosphorous, magnesium and beta-hydroxybutyrate concentrations (A.S.P.A, 1999).

The rumen fluid samples were obtained through the esophagus at 3 hours after the morning meal. Samples were kept under ice, centrifuged at 3000 rpm for 20 minutes, and then supernatant was collected and analysed for ammonia, lactic acid and volatile fatty acids (VFA) contents (Khorasani et al., 1996).

Diet and orts were sampled once a week, monitored for structure with the Penn State Particle Separator (PSPS) (Kononoff et al., 2003) and frozen (diet samples only) for chemical analysis after thawing.

Thawed samples were dried in a ventilated oven at 65°C for 48 hours, ground with a 1mm sieve (Thomas-Wiley Laboratory Mill, model 4, Arthur H. Thomas Co., Philadelphia, PA), then

Table 4. Blood parameters as influenced by different diets fed to animals.

| Parameter                      | Diet¹ | SEM  |
|--------------------------------|-------|------|
|                                | Control | PESP | PEST | RP |
| Total protein g/l              | 79.25  | 76.67| 78.25| 77.33| 1.032|
| Albumin mmol/l                 | 38.42  | 37.92| 38.00| 38.92| 0.573|
| Globulin mmol/l                | 40.83  | 38.75| 40.25| 38.42| 1.058|
| A/G²                           | 1.00   | 1.01 | 0.98 | 1.04 | 0.027|
| Urea mmol/l                    | 6.66   | 6.02 | 6.15 | 6.42 | 0.250|
| NEFA³                          | 0.27   | 0.28 | 0.28 | 0.31 | 0.020|
| Glucose mmol/l                 | 3.63   | 3.62 | 3.66 | 3.60 | 0.054|
| Cholesterol U/l                | 7.13   | 7.51 | 7.40 | 6.87 | 0.160|
| Triglycerides U/l              | 0.11   | 0.13 | 0.12 | 0.11 | 0.004|
| Aspartate aminotransferase U/l | 60.25  | 57.00| 58.50| 62.17| 1.502|
| Gamma-glutamyl transferase     | 27.83  | 27.50| 29.58| 28.58| 0.942|
| Bilirubin µmol/l               | 5.63   | 4.68 | 4.70 | 4.46 | 0.654|
| Creatinine mmol/l              | 152.09 | 117.75| 140.17| 128.17| 18.375|
| Ca mmol/l                      | 2.41   | 2.41 | 2.39 | 2.40 | 0.031|
| P µmol/l                       | 1.97   | 1.98 | 1.95 | 2.03 | 0.081|
| Mg µmol/l                      | 1.15   | 1.14 | 1.14 | 1.16 | 0.022|
| Beta-hydroxybutyrate mmol/l    | 0.38   | 0.40 | 0.38 | 0.38 | 0.027|

¹Control: base diet; PESP: base diet with expanded pea; PEST: base diet with extruded pea; RP: base diet with raw pea;
²Albumin to globulin ratio;
³Non esterified Fatty Acids;
Least square means in the same row without common letters differ significantly (P < 0.05).
analysed for dry matter, crude protein, ash in
according to AOAC (1990), soluble protein (Licitra
et al., 1996), neutral detergent fibre (NDF) and
acid detergent fibre (ADF) (Van Soest et al., 1991)
and ether extract (Martillotti et al., 1987) con-
tents.

The faecal score was recorded weekly using the
following scale (Skidmore et al., 1996): 1 = very liq-
uid faeces; 2 = faeces are runny and does not form
a nice pile; 3 = porridge-like consistency; 4 = mod-
erate thickening of the faeces; 5 = firm faecal balls.

Statistical methods
Data were analysed by ANOVA using the gen-
eral linear model procedure of SAS (2001) as a
Latin square design. The effect of technological
treatments on peas was determined by contrasts
between the processed-pea containing diet and
unprocessed-pea containing diets. Contrasts were
estimated for dry matter intake (DMI), milk yield
and composition, fat and protein yields and 4% fat
corrected milk (FCM). Statements of statistical
significance were based on P< 0.05.

Results and discussion

Feeds were not selected within the TMR as con-
irmed by the modest variation (within 10%) of the
lower pan fraction of the PSPS on samples diets col-
lected eight hours from meal (data not shown).

No health problems that could be attributed to
the diet being fed were observed in animals during
the entire experimental period. The observed fae-
cal scores (mean ± SD) were 2.38 ± 0.20, 2.30 ±
0.19, 2.34 ± 0.13, 2.33 ± 0.16, respectively, for the
control, PESP, PEST and RP group fed diets.

The unprocessed or differently processed pea
did not affect the DMI (Table 2) compared to the
control suggesting no effects on palatability as
previously reported on peas (Khorasani et al.,
2001) or on differently processed canola meal and
SBM (Rule et al., 1994). Early lactating cows fed
diets containing extruded peas tended to have
higher DMI than cows fed the diet containing
SBM, with NDF as the major constrictor for the
DMI (Petit et al., 1997). Authors suggested a par-
titioning of the fibre toward a more soluble frac-
tion when extruding peas, as previously reported
(Walhain et al., 1992). In our trials the NDF con-
tents of diets were similar and no differences were
observed in DMI among groups.

The technological treatments (extruded and
expanded) on peas as estimated by the contrast
analysis did not have any benefit on milk yield
and composition, however, the milk yield was
increased (P< 0.05) in the PEST group compared
to the control group (35.47 vs. 34.37 kg/d) (Table
2). This is contradictory to a previous work on mid-
producing (80% primiparous) lactating cows
(Hoden et al., 1992). According to Corbett et al.

Table 5. Rennet coagulation characteristics.

| Parameter | Control | PESP | PEST | RP |
|-----------|---------|------|------|----|
| \( r^2 \)  | min     | 17.48| 17.15| 17.19| 16.73|
| \( k_{20} \) | "      | 3.61 | 3.26 | 3.44 | 3.19 |
| \( a_{30} \) | mm     | 35.83| 37.86| 35.58| 38.83|

1Control: base diet; PESP: base diet with expanded pea; PEST: base diet with extruded pea; RP: base diet with raw pea;
2clotting time;
3curd firming time;
4curd firmness (a) measured 30 min after rennet addition.
(1995) and Petit et al. (1997) early lactating cows fed pea-based concentrate had higher 4% FCM yield and higher milk fat content compared to cows fed a diet with SBM and canola meal as protein sources. However, no differences were reported in mid late-lactating cows feeding on diets with increasing levels of pea (Khorasani et al., 2001). In our trial no differences among treatment groups were observed on 4% FCM yield (Table 2).

No differences were observed in milk protein content. However, when feeding on peas, the milk protein yield was higher (P< 0.05) for the PEST group, although not different from the control group (Table 2). Khorasani et al. (2001) reported a quadratic response of the milk protein content in mid late-lactating cows when the SBM protein was replaced by the pea protein. Only a tendency toward higher milk protein content was observed by Petit et al. (1997) when replacing the SBM with extruded peas. Authors conclusions were a higher nitrogen digestibility which could have increased the amount of nitrogen available for the milk protein synthesis.

It was reported substituting SBM and barley grain with peas may alter the site and end products of digestion in lactating cows with no effects on milk yield (Khorasani et al., 2001). The extrusion of peas increased the starch rumen degradability (Petit et al., 1997; Masoero et al., 2005) leaving unchanged (Petit et al., 1997) or decreasing (Masoero et al., 2005) the amount of ruminal degradable proteins. Khorasani et al. (2001) obtained a linear and cubic response of rumen ammonia-N to increasing levels of pea into the diet; the reported rumen ammonia-N when SBM was completely replaced by the pea was 159 mg/L, close to 178 mg/L measured in the rumen liquor collected from the RP diet fed animals in our trial (Table 3). Thus, the observed pattern of the rumen ammonia-N (Table 3) when feeding differently processed peas might be due to the reported differences in nitrogen solubility (Masoero et al., 2005). The increased rate of rumen starch disappearance (Walhain et al., 1992) and digestibility (Masoero et al., 2005) on extruded peas compared with the less marked effect of expansion on pea starch digestibility (Masoero et al., 2005) might have been a key factor for higher microbial protein synthesis and nitrogen available for milk protein synthesis in the PEST group (Table 2). However, the reported ruminal ammonia-N required to maximise the in vitro growth of rumen bacteria is 50mg/L (Satter and Slyter, 1974), a value considerably lower compared to what was measured in our trial.

The rumen volatile fatty acids (VFA) molar percentages were modified by the treatment diets (Table 3). The acetate was reduced (P< 0.05) and the butyrate and valerate were increased (P< 0.05) in the PEST group compared to the control. Although no differences were observed in the propionate content, the observed pattern of VFA when feeding the PEST containing diet suggests an effect on the fermentation activity. The rate of fermentation of the non-structural carbohydrates (NSC) is important for the rumen pH stability and the acetate:propionate ratio. The rate of rumen degradation was lower in peas than in SBM (Corbett et al., 1995). The rumen pH was decreased and the VFA precursors for mammary gland fat synthesis were increased linearly with increasing levels of pea into the diet (Khorasani et al., 2001); authors found a cubical response on the total VFA. Considering the amount of pea inclusion in our study (2.5 kg/d), as expected, there were no effects on milk fat content and yield compared to the control group (Table 2), as a result of the similar acetate:propionate ratio and ruminal fermentation pattern (Table 3). The different ratio of corn and barley in the concentrate proportion of the diet when the pea diets were used in our trial compared to what was reported by Khorasani et al. (2001) (27:11 vs. 20:17) might explain discrepancies of results on rumen VFA contents.

No differences were observed among feeding groups on blood parameters except for the higher cholesterol level (P< 0.05) in the PESP fed group (Table 4). Petit et al. (1997) reported higher serum urea concentration in raw pea compared to SBM fed animals, with an increase after feeding greater for cows fed the SBM than for those fed the extruded peas, whereas no difference was reported between raw and extruded peas. There is a close relationship (Song and Kennelly, 1989) and interaction with time of sampling between
the blood urea nitrogen and the ammonia-N in the rumen (Petit et al., 1997). The rumen sampling in our trial was at three hours post meal, where the maximum of the fermentation activity was expected to take place. The blood urea levels observed in our trial (Table 4) are in agreement with results from Petit et al. (1997) suggesting either a slightly high protein intake or an inadequate ratio between NSC and the rumen degradable protein fraction. The extruded pea used in the current trial had a lower soluble nitrogen and higher starch digestibility compared to the raw pea (Masoero et al., 2005). Also, the level of the pea inclusion in the diet (103 g/kg DM TMR; 2.5kg/cow/day) was probably below the threshold to allow changes for carbohydrates and protein degradability into the rumen. The NEFA concentration in blood is considered an index of body fat mobilisation (Roberts, 1981). Animals in our trial had normal blood NEFA levels (Table 4), similar to previously reported data in dairy cows fed growing levels of extruded or raw pea (Petit et al., 1997), suggesting an adequate level of energy available to the animal.

There were no differences in rennet coagulation characteristics of milks collected among feeding groups (Table 5). The considered parameters are good indicators of the cheese-making property, which is of paramount relevance for typical cheese production. The experiment was carried out on cows screened for good cheese-making properties. The absence of negative results observed in milk from animals fed a diet containing peas could be considered a positive results when approaching the problem of an alternative protein source to the SBM in diet formulation for dairy cows raised in a typical productive area.

Conclusions

The inclusion of peas, either processed or unprocessed, in diets for lactating dairy cows did not produce negative effects on milk yield, composition and cheese-making properties. The increased milk yield when feeding extruded pea might justify the cost effort of the technological treatment put into the processed feed.

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