Italian Journal of Animal Science

ISSN: (Print) 1828-051X (Online) Journal homepage: http://www.tandfonline.com/loi/tjas20

In vitro digestibility of field pea as influenced by processing methods

Paolo Bani, Andrea Minuti, Valentina Ficuciello, Matteo Guerreschi, Giorgia Astorri & Gianluca Galassi

To cite this article: Paolo Bani, Andrea Minuti, Valentina Ficuciello, Matteo Guerreschi, Giorgia Astorri & Gianluca Galassi (2009) In vitro digestibility of field pea as influenced by processing methods, Italian Journal of Animal Science, 8:sup2, 259-261, DOI: 10.4081/ijas.2009.s2.259

To link to this article: https://doi.org/10.4081/ijas.2009.s2.259

In vitro digestibility of field pea as influenced by processing methods

Paolo Bani[1], Andrea Minuti[1], Valentina Ficuciello[1], Matteo Guerreschi[1], Giorgia Astorri[1], Gianluca Galassi [2]

[1]Istituto di Zootecnica, Università Cattolica del Sacro Cuore, Piacenza, Italy

[2]Dipartimento di Scienze Animali, Università di Milano, Italy

Corresponding author: Paolo Bani. Istituto di Zootecnica, Facoltà di Agraria, Università Cattolica del Sacro Cuore. Via Emilia Parmense 84, 29100 Piacenza, Italy – Tel. +39 0523 599279 – Fax: +39 0523 599276 – Email: paolo.bani@unicatt.it

ABSTRACT - Field pea meals exposed to different treatments (flaking, extrusion, expansion, dry heating at 150°C/15' or 30', dry heating at 150°C/30' after addition of 1% of xylose, 4% NaOH addition, microwave irradiation at 800 W for 6' or 9') were controlled for their 6 and 24 hours *in vitro* fermentability by the gas production (GP) technique. Flaking and extrusion accelerated initial fermentation but tended to reduce 24h GP, whereas dry heating and microwaves mainly improved final gas volume, but NaOH had the opposite effect. Apparent dry matter digestion at 6h was lowered by dry heating, NaOH addition and the shorter microwave irradiation. Xylose addition did not substantially change the effects of dry heating, but lowered the initial disappearance. Ammonia concentration was in general lowered by the treatments, suggesting a reduction in protein degradability but also a possible higher microbial uptake for protein synthesis. Microwave irradiation had limited effects on all the parameters. Dry heating, with or without xylose addition, seems interesting to increase rumen escaping protein fraction without accelerating starch fermentation that could expose to higher risks of rumen acidosis.

Key words: Peas, Technological treatments, Gas production, *In vitro* digestibility.

Introduction - The interest on legume seeds as feeds for livestock, and in particular for ruminants, has grown during the last years mainly as a possible source of protein alternative to soybean. Field pea (*Pisum sativum* L.) is a cool-season legume crop that was among the first crops cultivated by man and still is grown on over 10 million hectares worldwide. Peas crude protein content, ranging from 20 to 25% D.M. (Arvalis, 2005), has a favourable aminoacidic profile, characterized by a high lysine and arginine content though low in sulphur aminoacids. On the other hand, the nutritive value for ruminants is compromised by the high solubility (over 70% of CP) and rumen degradability with a consequent low bypass protein value (Christensen *et al.*, 2000). Peas have also a relevant but quite variable starch content (from 40 to over 54% D.M.), approximately half of which is soluble (Christensen *et al.*, 2000). Starch rumen digestibility is intermediate between barley and corn (Cerneau and Michalet-Doreau, 1991). Heat treatments lower protein degradability increasing the protein escape fraction but, if excessive, further intestinal digestibility can be impaired. Heating, and other technological treatments, modify also starch digestibility, but with less consistent effects. Combinations of heat and chemical application has also been used and proved to be effective in reducing soybean meal protein degradability (Cleale *et al.*, 1987), but no data are available on the effects on rumen starch digestibility of starchy feeds. Aim of the present work was to evaluate the effects of different technological treatment of pea seeds on the rumen fermentability evaluated *in vitro* by the gas production technique.

Material and methods - Pea seeds underwent different technological treatments, in part performed by industrial equipments [flaking (FLAKED), expansion (EXPANDED) and extrusion (EXTRUDED)] and in part at the laboratory of the Istituto di Zootecnica di Piacenza. These latter ones were: heat treatment at 150°C for 15' (H 150/15) or for 30' (H 150/30); heating at 150°C for 30' after addition of xylose (1% w/w, air dry basis)

(H 150/30-X); microwave irradiation (800W equipment) for 6' (MW-6) or for 9' (MW-9); sodium idroxide addition (4% w/w, air dry basis) (NaOH-4). For these lab treatments, the same raw product also used for expansion was used. Gas test (for 6 and 24h) was performed, for all the treated samples and the corresponding untreated samples, by the pressure transducer technique, as modified in our laboratory: in 100 ml glass bottles kept at 39°C in a water bath, 0.5 g of air dry sample was incubated with 40ml of medium (Menke and Steingass, 1988) and 10 ml of filtrated rumen liquor. Rumen liquor was taken, 6 hours after the morning meal, from two non lactating dairy cows fed 8 kg/d of grass hay and 1 kg/d of a commercial concentrate plus minerals and vitamins. Pressures were measured seven times during the 24h of the incubation. At 6 and 24 hours the bottles content (3 replicates for each time) was filtrated on a tissue non tissue filter (P2 equivalent porosity) and residual dry matter was measured drying overnight at 105°C. Ammonia nitrogen was measured on the filtrate after 6 and 24 hours, and pH at 24h only. Gas volumes were calculated by a pre-established pressure/volume calibration curve and corrected for gas production recorded in blanks. Cumulated gas production (GP) recorded at 6h was considered an index of short term fermentation, whereas that measured after 24h as an index of potential fermentability for lactating cows. Partitioning factor was calculated as mg of apparently degraded/ml of gas produced (Blummel *et al.*, 1999). The results were statistically evaluated by the GLM procedure of SAS using a monofactorial model. The effects of the treatments were evaluated as differences between each treated product and its corresponding untreated one, assuming $P<0.05$ as minimum level of significance.

Results and discussion - The main results of the *in vitro* fermentation trials are presented in table 1. The effects of most technological processes on the fermentative patterns were significant but very different depending on the kind of treatment. Among the industrial treatments, flaking had a minor impact on GP, whereas expansion and extrusion greatly increased, by more than 60%, the initial GP. All the industrially treated samples produced less gas at 24h, though the reduction vs. the corresponding untreated meal was significant only for extrusion. The lab dry heat treatments did not influence to a large extent the initial (6h) GP, but the final (24h) one was increased, without major differences between the two levels of heating. Masoero *et al.* (2005) found a similar behaviour for GP in extruded, expanded and toasted peas though for toasting they reported also an improvement in the enzymatic starch availability. Xylose addition, vs. HEAT 150/30, only slightly lowered the 6h GP with minor influence at 24h. No data are available in literature for the effect on starch fermentability of such a treatment, that lowers rumen protein degradability in soybean meal (Cleale *et al.*, 1987).

The NaOH treatment did not affect the initial GP but reduced GP at 24h. Microwave irradiation acted similarly to heat treatments, with limited effects at 6 but enhancing 24h GP. These effects were more marked with the heavier irradiation (MW-9). Sadeghi e Shawrang (2008) in microwave irradiated barley grain measured a slight decrease of in situ starch effective degradability. Initial (6h) dry matter apparent digestion was in general lowered by the treatments, in particular by dry heat treatments. At 24h the effects were more limited but expansion, extrusion and heat/xylose reduced this parameter whereas NaOH and microwave increased it. The partitioning factor was on average 6.15 at 6h and 3.16 mg/ml at 24h. According to Blummel *et al.* (1999), PF is related to the efficiency of microbial protein synthesis (higher the PF, higher the efficiency). The PF values at 6h are above the theoretical range (2.74 – 4.41). At 24h the values were within the expected range and were enhanced, though to different degrees, by all the treatments. The concentration of ammonia at 6h and 24h was in general lowered by the treatments, more consistely by extrusion, heat/xylose and NaOH. Flaking, HEAT 150/15 and MW treatments had no effects on this parameter. These data are likely index of a reduction in protein degradability due to the treatments as the general increase of fermentability (GP) should have promoted the microbial ammonia uptake for protein syntheses. Final pH (data not shown) was not affected by any treatment.

These results confirmed the possibility to enhance the rate of fermentation of pea meal by the industrial treatments of extrusion and expansion whereas flaking, more easily carried out also at low temperature and pressure, does not seem always to guarantee relevant effects in this respect. Moreover, some of these treatments appear to lower, though to different extents, the final rumen digestibility at least when evalu-

Table 1. Gas production, dry matter digested and NH_3 recorded during the *in vitro* fermentation of field pea meals differently treated. Values are expressed as average of raw meals and difference between the treated pea and the corresponding untreated raw meal.

	Gas production		degraded		Partitioning factor		NH_3	
	6h	24h	6h	24h	6h	24h	6h	24h
	(ml)	(ml)	(%)	(%)	(mg/ml)	(mg/ml)	(mMol/l)	(mMol/l)
RAW (#)	35.93	132.99	61.99	91.97	7.63	3.03	17.22	36.73
FLAKED	0.63	-1.75	-13.37*	0.31	-1.71*	0.09	-0.48	-1.42*
EXPANDED	21.82*	-3.36	4.34	-1.47*	-2.05*	0.07	-2.59*	-3.19*
EXTRUDED	28.26*	-7.92*	-3.69	-1.35*	-3.86*	0.17*	-1.91*	-0.27
H 150/15	2.68*	8.18*	-11.16*	0.10	-0.98	0.19*	-0.31	-0.12
H 150/30	-0.99	12.50*	-19.85*	-0.22	-1.52*	0.08	-0.82*	-0.29
H 150/30-X	-3.42*	9.35*	-27.94*	-2.18*	-2.33*	0.07	-1.34*	-3.37*
NaOH-4	2.37	-6.69*	-4.50	1.18*	-0.42	0.47*	-1.90*	-2.73*
MW-6	0.82	10.24*	-5.51	1.03*	-0.21	0.07	0.07	0.71
MW-9	2.72*	14.63*	2.94	1.31*	0.61	0.06	0.09	0.69
s.e.m.	0.892	1.538	2.838	0.375	0.411	0.034	0.172	0.431

(#) means of the untreated raw meals used for the technological treatments.
**significant difference (P<0.05) between the treated pea and the corresponding untreated meal.*

ated *in vitro* at 24h of incubation. Results available in literature for dry heating are less and more erratic, likely depending on the different conditions of treatment, but it seems interesting, also associated to xylose addition, as it seems able to reduce protein degradability without accelerating, or even reducing, the starch fermentability and the risks of rumen acidosis. NaOH addition, that is also demonstrated to reduce protein degradability, appeared to act similarly, likely favouring starch bypass, but which following intestinal digestibility should be further evaluated. Microwave irradiation is a relatively new technique that needs to be better investigated for its effects on protein and carbohydrate digestibility in the rumen and in the gut.

The research was supported by project: "Azioni di innovazione e ricerca a supporto del piano Proteine Vegetali" (L. 499/1999 e D.M. n. S/25279/2003).

REFERENCES - Arvalis Institut du vegetal, 2005 – Qualité pois, recolte 2005. www.arvalisinstitutduvegetal.fr/fr/fichier/communique/247_qualite-pois-2005.pdf. **Blummel** M., Mgomezulu R., Chen X.B., Makkar H.P.S., Becker K., Orskov E.R., 1999. The modification of an *in vitro* gas production test to detect roughage related differences in vivo microbial protein synthesis as estimated by the excretion of purine derivatives. J. Agric. Sci. 133: 335-340. **Cleale** R. M., Klopfenstein T. J., Britton R. A., Satterlee L. D., and Lowry S. R., 1987. Induced non-enzymatic browning of soybean meal effects of factors controlling non-enzymatic browning on *in vitro* ammonia release. J. Anim. Sci., 65: 1312-1318. **Cerneau** P., Michalet-Doreau B., 1991. In situ starch degradation of different feeds in the rumen. Repr. Nutr. Dev., 3165-72. **Christensen** D. A., Mustafa A., 2000. The use of peas in dairy rations West. Can. Dairy Sem.. www.wcds.afns.ualberta.ca/ Proceedings/2000/Chapter24.htm. **Masoero** F., Pulimeno A.M., Rossi F., 2005. Effect of extrusion, espansion and toasting on the nutritional value of peas, faba beans and lupins. It. J. Anim. Sci. 4: 177-189. **Menke** K.H., Steingass H., 1988. Estimation of the energetic feed value obtained from chemical analysis and *in vitro* gas production using rumen fluid. Anim. Res. Dev. 28: 7-55. **Sadeghi** A.A., Shawrang P., 2008. Effects of microwave irradiation on ruminal dry matter, protein and starch degradation characteristics of barley grain. Anim. Feed Sci. Techn. 141: 184-194.