WORLD RABBIT SCIENCE 1996, 4(1), 33-36

A REVIEW ON THE ENERGY VALUE OF SUGAR BEET PULP FOR RABBITS

DE BLAS C., CARABAÑO R.

Departamento de Producción Animal, U.P. Madrid, ETS Ingenieros Agrónomos, 28040 MADRID, España

ABSTRACT : Recent information about the energy value of sugar beet pulp (SBP) is reviewed in this paper. According to the results presented, DE content of SBP depends on the type of basal diet and the level of inclusion used. A value of 10.5 MJ/Kg DM is proposed for practical levels of inclusion. Digestible energy can be kept as the unit of expression of energy value of SBP when this ingredient replaces a 15% of cereal grains in the diet. The use of DE overestimates the energy values of SBP when it is included in the diet at levels greater than 30%. However, these levels are not frequent in practical formulation, as intake and performance of rabbits are impaired.

RÉSUMÉ : Le point sur la valeur énergétique pour le lapin de la pulpe de betterave sucrière.
Cet article fait le point sur les informations récentes concernant la valeur énergétique de la pulpe de betterave sucrière (SBP). Les résultats présentés montrent que la teneur en énergie digestible de SBP dépend du type de l'aliment de base et de son taux incorporation dans cet aliment. Le taux optimum d'incorporation proposé est de 10.5 MJ/Kg DM. L'énergie digestible peut être considérée comme l'expression de la valeur énergétique de SBP lorsque ce produit remplace 15% des céréales de l'aliment. L'utilisation de ED majore la valeur énergétique de SBP lorsque celui-ci est inclus dans l'aliment à des taux supérieurs à 30%. Toutefois ces taux ne sont pas fréquents dans les formulations courantes, car la consommation et les performances des lapins sont diminués.

INTRODUCTION

Although sugar beet pulp (SBP) contains approximately 50% of neutral detergent fibre (NDF), its physical and digestion characteristics (high water holding capacity, small proportion of long particles and indigestible fibre, low rate of passage, high caecal retention time), make it of limited value to meet fibre requirements. Consequently, SBP should be considered mainly as an energy concentrate feed in rabbits, because of its content of highly digestible fibre, pectins and sugars (Table 1). Sugar beet pulp has a very low starch concentration, so that its substitution for cereal grains implies major changes in the site of nutrient digestion. Replacing starch with digestible fibre leads to an increase on the fermentative activity in the hindgut, as 40% of the dry matter content of SBP is digested in the caecum (MERINO and CARABAÑO, 1992). Microbial fermentation might imply higher energy losses than enzymatic digestion in the small intestine, as it occurs in pigs (ZHU *et al.*, 1990). Furthermore, the end products of microbial digestion (volatile fatty acids) might be metabolized less efficiently than the glucose arising from starch digestion (LOW, 1985). Consideration of fermentation and metabolic energy losses may be then important in the estimation of the net energy value of SBP with respect to cereal grains.

The aim of this work is to review the information published about the energy value of SBP and to establish its relative value with respect to cereal grains in rabbits.

Table 1 : Average chemical composition of sugar beet pulp (% dry matter basis)

Dry matter	*90.0*
Organic matter	94.8
Crude fibre	20.9
Acid detergent fibre	27.0
Neutral detergent fibre	51.5
Acid detergent lignin	1.9
Pectins	18.0
Starch	1.7
Sugars	7.8
Crude protein	9.3
Ether extract	0.9
Gross energy	17.2

DIGESTIBLE ENERGY CONTENT

Digestible energy values of SBP reported in the literature are shown in Table 2. Method of estimation varies among studies. The value of MARTINEZ and FERNANDEZ (1980) was obtained by giving SBP as the only rabbit feed (direct method), whereas MAERTENS and DE GROOTE (1984), FEKETE and GIPPERT (1986) and DE BLAS and VILLAMIDE (1990) used a substitution method with a level of inclusion of SBP of 40%. Finally, the values of MOTTA (1990) and GARCIA *et al.*, (1992a, 1993) were calculated by difference from diets where alfalfa hay or barley grain, respectively, were substituted with SBP.

The variability of the DE determinations is very high ranging from 9.6 to 14.2 MJ/kg DM. Part of this variation may be explained by the type of basal diet used. DE BLAS and VILLAMIDE (1990) obtained a higher DE value (12.4 *vs* 10.0 MJ/kg DM) and a higher

Table 2 : Digestible energy value (MJ/kg DM) of sugar beet pulp reported in the literature.

Authors	Methods	DE estimation
MARTINEZ and FERNANDEZ, 1980	Direct	14.2
MAERTENS and DE GROOTE, 1984	Substitution Level of inclusion of SBP = 40% Balanced basal diet	12.3
FEKETE and GIPPERT, 1986	Substitution Level of inclusion of SBP = 40% Balanced basal diet	13.0
DE BLAS and VILLAMIDE, 1990	Substitution Level of inclusion of SBP = 40% DE basal diet = 10 MJ/kg DM	10.0
DE BLAS and VILLAMIDE, 1990	Substitution Level of inclusion of SBP = 40% DE basal diet = 12.3 MJ/kg DM	12.4
MOTTA, 1990	Difference, substitution of 30% alfalfa hay with 30% SBP	12.5
GARCIA *et al.*, 1992a	Difference, substitution of barley grain in high fibrous diet - 15 % of SBP - 30 % of SBP	 9.6 10.2
GARCIA *et al.*, 1993	Difference, substitution of barley grain in normal fibrous diets - 15 % of SBP - 35 % of SBP - 50 % of SBP	 10.6 11.2 12.4

ADF digestibility of SBP (71.7 *vs* 38.5), when the basal diet had a lower acid detergent fibre (ADF) content (13.5 *vs* 24.6%, DM basis). Furthermore, the values calculated by GARCIA *et al.* (1993) at a 15% level of inclusion of SBP, were higher (10.6 vs 9.6 MJ/kg DM) than those reported by GARCIA *et al.* (1992a), which could be related again to a lower dietary ADF content (19.9 vs 25.9%, DM basis). These results might be explained by a shorter caecal retention time of potentially digestible fibre, in diets with a higher proportion of long fibre particle and/or a higher content of indigestible fibre. Similar effects were observed when evaluating the DE content of other ingredients by using the same methods. (DE BLAS *et al.*, 1989 ; VILLAMIDE *et al.*, 1991).

Level of inclusion of SBP in the experimental diets (L %) also contributed to explain part (56%) of the variability of DE estimations among studies (see Figure 1). The regression equation obtained between these variables was :

DE (MJ/kg DM) = 9.8 (± 0.6) + 0.047 (±0.014) L; P = 0.008

Figure 1 : Effect of level of inclusion of SBP in the experimental diets on DE estimations using the substitution method.

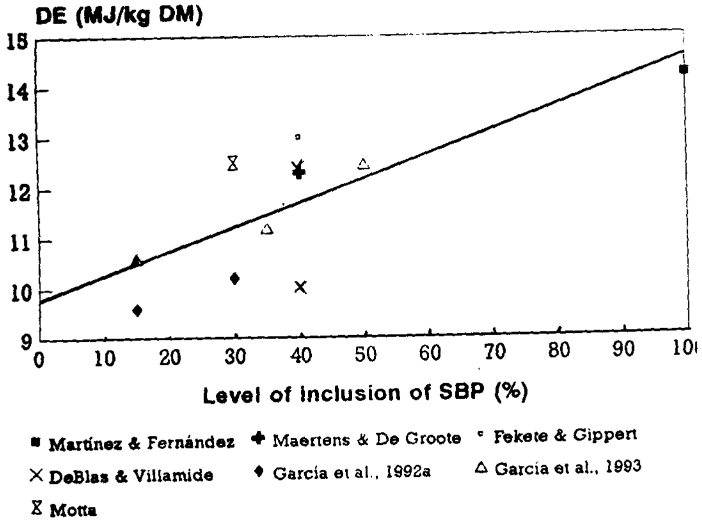

Figure 2 : Effect of level of inclusion of SBP in the diet on the weight of caecum contents.

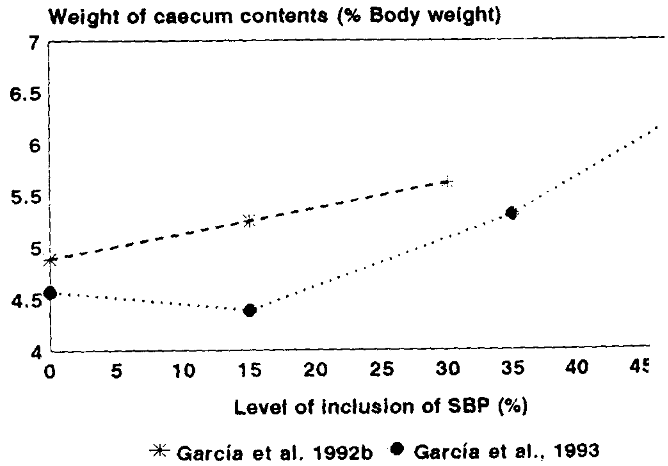

Table 3 : Effect of a substitution of SPB for barley grain on the energy balance of growing rabbits.

	Barley : SBP % [a]				Barley : SBP % [b]			
	50:0	35:15	15:35	0:50	30:10	15:15	0:30	SE
DE, MJ/kg DM	12.48	11.85	11.20	11.27	11.14	10.36	9.75	0.19
DE intake, $MJ.kg^{-0.75}.d^{-1}$	1.04	1.00	0.82	0.73	0.96	0.92	0.89	0.01
Energy retention, $MJ.kg^{-0.75}.d^{-1}$	0.27	0.26	0.20	0.16	0.24	0.21	0.17	0.01
Overall energy efficiency, % [c]	26.0	26.3	24.1	21.1	23.9	23.1	19.1	0.43
Feed conversion rate								
g body weight gain/g DM intake	0.33	0.31	0.29	0.24	0.26	0.25	0.23	0.01
Carcass dressing percentage %	60.4	61.1	59.3	57.0	59.9	58.6	56.6	0.45

[a] : GARCIA *et al.*, 1993 ; [b] : GARCIA *et al.*, 1992[b] ; [c] : (Energy retention/DE intake) x 100.

This effect might be related to a higher retention time of digesta in the caecum of diets containing higher levels of SBP. GARCIA *et al.* (1992b, 1993) observed an increase of caecal contents weight as the level of substitution of SBP for barley grain increased (Figure 2).

According to the previous results, a DE value of approximatively 10.5 MJ/kg DM should assigned to SBP, when this feedstuff is included in the diet to replace a moderate proportion (15%) of cereal grains. This value is lower than the values proposed by INRA (1984) and MAERTENS *et al.* (1990) : 13.5 and 12.5 MJ DE/kg DM, respectively. Levels of substitution of SBP for cereal grains higher than 30% are not of practical interest, because of the decrease in performance observed (GARCIA *et al.*, 1992b, 1993).

NET ENERGY CONTENT

The effect of a substitution of different levels of SPB for barley grain on energy retention has been studied by GARCIA *et al.* (1992a, 1993), using diets with a high or a normal content of indigestible fibre, respectively. The effect of type of diet on the energy balance of growing rabbits is shown in Table 3.

An increase in the proportion of SBP in both studies implied a decrease of DE intake, daily energy retention, feed conversion rate and efficiency of utilization of DE for growth (K = energy retention x 100/total DE intake). The last effect was analyzed using the stepwise regression procedure. The variable that explained better the variation of energy efficiency (K, %) was digestible neutral detergent fibre intake (DNDFI, g/d) :

$$K = 39.2 (\pm 2.13) - 0.895 (\pm 0.119) DNDFI$$

$R^2 = 0.92$; $P<0.001$; $n = 7$

According to this result, the negative influence of dietary SBP inclusion on feed efficiency might be related to an increase of the energy losses associated to caecal digestion (heat of fermentation and methane production) and/or to a decrease of efficiency of utilization of the end products of the digestion (volatile fatty acids *vs* glucose). Increasing dietary SBP level of inclusion led in both studies to an increase of the ratio protein/ether extract retained in the body. This effect might also contribute to explain the lower efficiencies observed, as fat is retained in rabbits with a higher energetic efficiency than protein (DE BLAS *et al.*, 1985).

Substitution of SBP for barley grain elicited an

Table 4 : Relative value of the experimental diets using different criteria of comparison

	Barley : SBP % [a]				Barley : SBP % [b]		
	50:0	35:15	15:35	0:50	30:0	15:15	0:30
Feed conversion rate							
g body weight gain/g DM intake	100	96.0	87.4	72.0	100	96.9	87.2
Feed conversion rate							
g carcass/g DM intake	100	93.8	82.7	65.3	100	91.5	76.6
DE, MJ/kg DM	100	94.7	89.7	90.2	100	92.9	87.4
Overall energy efficiency, K % [c]	100	101.1	92.7	81.1	100	92.3	75.8
Net energy [d]	100	96.0	83.1	73.2	100	89.7	69.7

[a] GARCIA *et al.*, 1993 ; [b] GARCIA *et al.* 1992b ; [c] K = (Energy retention/DE intake) x 100 ; [d] DE (MK/kg DM) x K/100

increase of the weight of the stomach and caecum and their contents. Thus, a parallel decrease of carcass dressing percentage was also observed (see Table 3). Feed conversion rate data should be then corrected to take into account this effect.

The relative value of the experimental diets studied by Garcia et al. (1992[a], 1993) using different criteria of comparison is shown in Table 4. Feed conversion rate values, especially when are expressed as g carcass/g DM intake, can be used as a reference, as they reflect the main practical purpose of the comparison. DE concentration (MJ/kg DM) clearly overestimates the energy value of diets containing SBP levels greater than 30%, because of the decrease of DE efficiency for growth. However, DE content provide useful estimations of energy balance in diets containing a 15% of SBP.

In conclusion, DE content can be kept as the unit of expression of the energy value of SBP if the level of substitution of SBP for cereal grains in the diet is lower than 15%. For levels of inclusion greater than 30% a correction factor should be envisaged to take in account the increase of energy losses associated to caecal digestion.

Received : August 21, 199
Accepted : October 16, 1995

REFERENCES

DE BLAS C, FRAGA M.J., RODRIGUEZ J.M., 1985. Units for feed evaluation and requirements for commercially grown rabbits. *J. Anim. Sci., 60, 1021-1028.*

DE BLAS C., VILLAMIDE M.J., CRABAÑO R., 1989. Nutritive value of cereal by-products for rabbits. *J. Appl. Rabbit Res., 12, 148-151.*

DE BLAS C., VILLAMIDE M.J., 1990. Nutritive value of beet and citrus pulps for rabbits. Anim. *Feed Sci. Technol., 31, 239-246.*

FEKETE S., GIPPERT T., 1986. Digestibility and nutritive value nineteen feedstuffs. *J. Appl. Rabbit Res., 9, 103-108.*

GARCIA G., GALVEZ J.F., DE BLAS C., 1192a. Substitution of barley grain by sugar beet pulp in diets for finishing rabbits. 1 Effect of energy and nitrogen balance. *J. Appl. Rabbit Res., 15, 1008-1016.*

GARCIA G., GALVEZ J.F., DE BLAS C., 1192a. Substitution of barley grain by sugar beet pulp in diets for finishing rabbits. 2. Effect of growth performance. *J. Appl. Rabbit Res., 15, 1017-1024.*

GARCIA G., GALVEZ J.F., DE BLAS C., 1993. Effect of substitution of sugar beet pulp for barley in diets for finishing rabbits on growth performance and on energy and nitrogen efficiency. *J. Anim. Sci., 71, 1823-1830.*

INRA, 1984. L'alimentation des animaux monogastriques : porc, lapin, volailles. *Institut National de la Recherche Agronomique, Versailles, France, 281p.*

LOW A.G., 1985. The role of dietary fibre in digestion, absorption and metabolism. *In : Proc. 3rd International Seminar on Digestive Physiology in the Pig, pp157-159. Copenhagen.*

MAERTENS L., DE GROOTE G., 1984. Digestibility and digestible energy of a number of feedstuffs for rabbits. *In : Proc. 3rd World Rabbit Congress, pp 244-251, Roma.*

MAERTENS L., JANSSEN W.M.N., STEENLAND E., WOLTERS D.F., BRANJE H.E.B., JAGER F., 1990. Tables de composition, de digestibilité et de valeur énergétique des matières premières pour lapins. *In : 5emes Journées de la Recherche Cunicole. Paris.*

MARTINEZ J., FERNANDEZ J., 1980. Composition, digestibility, nutritive value and relations among them of several feeds for rabbits. *In : Proc. 2nd World Rabbit Congress, pp214-223. Barcelona.*

MERINO J., CARABAÑO R., 1992. Effect of type of fibre on ileal and faecal digestibility. *J. Appl. Rabbit Res., 15, 931-937.*

MOTTA W., 1990. Efecto de la sustitución parcial de heno de alfalfa por orujo de uva o pulpa de remolacha sobre la utilización de la dieta y los rendimientos productivos en conejos en crecimiento. *Ph.D Dissertation. Universidad Politécnica de Madrid.*

VILLAMIDE M.J., FRAGA M.J., DE BLAS C., 1991. Effect of basal diet and rate of inclusion on the evaluation of protein concentrates with rabbits. *Anim. Prod., 52, 215-224.*

ZHU J.Q., FOWLER V.R., FULLER, M.F., 1990. Digestion of unmolassed sugar beet pulp in young growing pigs and implications for the growth-supporting values of fermented energy. *Anim. Prod., 50, 531-539.*