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NUTRITIVE VALUE OF RAW MATERIALS FOR RABBITS: EGRAN TABLES 2002.

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ABSTRACT: Feedstuff tables are presented including the composition and the nutritive value of 53 raw materials used in compound diets for intensively reared rabbits. Each raw material is characterised by 23 analytical data and its digestible protein and energy values. Because of the importance of the fibre fractions in the nutrition of the rabbit, special efforts have been done to characterise the carbohydrate complex. The digestibility data were selected after a compilation of original literature data and a discussion between the authors. The methodology used, in the different *in vivo* assays, was evaluated accurately in order to judge the reliability of the data. Besides digestible and metabolisable energy values are also presented because they lead to a better mutual comparison between raw materials for formulation purposes. Finally, attention has been drawn that the presented nutritive values fit well with the proposed nutrient composition and show coherence in each category of feedstuffs.

Key words: Nutritive value, Feedstuffs, Rabbit.

INTRODUCTION

In rabbits, as for other livestock productions, feeding costs represent at least 60% of the total production costs. The challenge for the feed formulator is to obtain least cost diets that fully match animal requirements. Furthermore, he has to avoid an excess of some nutrients in order to minimise the environmental pollution (e.g. N and P). An accurate knowledge of the composition and nutritive value of the available raw materials is of fundamental importance. Up-to-date feedstuff tables are considered as basis information and great efforts are done for different species to implement new research data in the regularly updated versions. Feedstuff tables are also very helpful for scientists to calculate their experimental diets and to predict animal performance.

One of the main goals of the ERAFE project (Gidenne, 1999) was to establish common feedstuff tables for rabbits based on a critical literature survey and taking into account the methodology used. A first proposal for common European tables has been published in 1998 (Perez *et al.*, 1998b; Villamide *et al.*, 1998).

These initial tables have been updated and critically judged both the nutrient compositions as the nutritive value. Because of the sensitivity of rabbits for digestive disorders, efforts have been done to enlarge the nutritive value with more data concerning the carbohydrate concentration. We hope that this could contribute to the formulation of diets with increased safety in terms of lower mortality and morbidity (Gidenne, 2003).

On the other hand, the information concerning protein (amino acid) availability is actually too limited to introduce in the tables although significant efforts are been executed (Carabaño *et al.*, 2000). However, research funds for rabbits are limited and in most countries the evaluation of the nutritive value of raw

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materials is no longer a priority. The development of more accurate nutritive criteria as e.g. net energy or ileal digestible amino acids is widely recognised but can only be achieved with a concerted action among the Countries most involved in rabbit production.

We have limited our efforts in the actualization of the most currently available dry raw materials available in feed plants in Europe. For roughages, green plants and tropical plants, only scarce new information became available and is also of minor interest for commercial rabbit production under actual European conditions. Compilations of this literature can be found in the books of CHEEKE (1987) and SCHLOLAUT *et al.* (1995).

Although the composition and nutritive value of raw materials is variable and depends of a lot of factors, feedstuff tables intend to present as accurate as possible an estimate of the nutritive value. Their accuracy can be increased with on-line analyses.

Nevertheless, the current tables intend to contribute to a more accurate formulation and harmonisation. Thus avoiding that different tables for rabbits are developed which complicates comparison between labs or countries.

Development of the tables

Initially, a literature compilation was done to collect all available data of digestibility assays for each raw material. For most of the raw materials only limited information was available or very divergent nutritive values were found according to the different experiments. The initial proposed method to calculate an average value for each raw material did not lead to reliable values and a good coherence between the chemical and nutritive characteristics. Two main reasons for the discrepancies found in the literature are:

1). The divergent methodology used in the different experiments and

2). The fact that, in contrast with poultry and pigs, most raw materials can not directly be tested but have to be incorporated in compound diets.

That is why efforts have been done to standardise the methodology of nutritional evaluation of ingredients for rabbits (PEREZ *et al.*, 1995; VILLAMIDE *et al.*, 2000; VILLAMIDE *et al.*, 2003).

In order to judge critically the available data for each raw material, an EGRAN (European Group on Rabbit Nutrition) workgroup was constituted. The following criteria were taken into consideration: the methodology used in the digestibility trial, the number of rabbits considered, the incorporation level of the raw material in the experimental diets and the accuracy of the determination. Finally, the proposed common nutritive value was adjusted to the average chemical composition retained in the first version of the table (PEREZ *et al.*, 1998b; VILLAMIDE *et al.*, 1998).

Originally, the chemical composition was mainly based on those of the Dutch (CVB, 1997), Spanish (FEDNA, 1997) and French (INRA-AFZ, 2002) feedstuff tables. Special attention was drawn to present coherent values of the different chemical parameters for sub-qualities of the same raw material. Because of the importance of the fibre complex in the prevention of digestive disorders (LEBAS *et al.*, 1998; DE BLAS 1999; GIDENNE, 2000; GIDENNE 2003), much attention has been drawn to the data of the crude fibre and fibre fractions (NDF, ADF and ADL).

Updates

In this updated version of the preliminary tables (PEREZ *et al.*, 1998b; VILLAMIDE *et al.*, 1998), limited adjustments have been performed concerning the chemical composition. All initial proposed chemical values were critically judged taking into account the last version of FEDNA and CVB tables and the INRA-AFZ database of raw materials. However, only if a significant discrepancy was observed with the preliminary table, new values have been proposed. With the increasing concern to minimise the environmental pollution, special attention has been drawn to the level of P and K.

Although incomplete, but in view of trying to increase the dietary safety in terms of minimal digestive disorders, some additional criteria have been introduced. Recently, it has been shown that different fibre and starch requirements have to be respected (GIDENNE, 2000; PEREZ *et al.*, 2000). With the introduction of hemicellulose and water insoluble pectins (WIP) in the tables, we intend a further optimisation of the nutritional role of fibre in rabbit diets (GIDENNE, 2003). Values of water insoluble pectins were obtained from analysis of uronic acids and associated neutral sugars belonging to pectins, and previously published (CARRÉ and BRILLOUET, 1986; GIDENNE, 1992; BRILLOUET *et al.*, 1988; BACH-KNUDSEN, 1997; COLONNA *et al.*, 1995;).

Since our first common approach (PEREZ *et al.*, 1998b, VILLAMIDE *et al.*, 1998), only few new digestibility data were published (BLAS *et al.*, 2000: VILLAMIDE *et al.*, 2000; MAERTENS and VAN HERCK, 2001; LEBAS and DJAGO, 2001; VILLAMIDE *et al.*, 2002). They have been taken into consideration together with some unpublished data obtained in the labs of the authors, to update the former tables. But again, only if the discrepancies observed were judged as significant by the workgroup, the proposed nutritive value was changed.

Description of the tables

In the tables, the chemical composition and nutritive value of 53 raw materials useful for the formulation of rabbit diets are presented. The raw materials have been classified in 7 main categories: cereals, cereal by-products and other energy concentrates (Table 1), legume, oil seeds, oil seed meals, oils and fats (Table 2) and fibrous feedstuffs (Table 3).

For an optimal practical implementation, we have chosen to present the data on air-dry basis. Moreover, in order to facilitate the mutual comparison between raw materials of the same category, values are expressed on the same air-dry basis. The retained chemical components were limited to those of major importance in rabbit diets. For additional information, general feedstuff tables for livestock species have to be consulted. Besides dry matter (DM), the chemical composition includes values for crude protein (CP = N x 6.25), ether extract (EE), crude fibre (CF), neutral detergent fibre (NDF), acid detergent fibre (ADF), lignin (ADL), hemicellulose (HEM = NDF – ADF), water insoluble pectins (WIP), starch (ST), sugar (SU), lysine (Lys), methionine (Met), methionine + cystine (SAA), threonine (Thr), tryptophan (Trp), calcium (Ca), phosphorus (P), sodium (Na), chloride (Cl), magnesium (Mg) and potassium (K).

For the nutritive value only the apparent fecal crude protein digestibility (CPd), the digestible energy (ED) and metabolisable energy (ME) values were considered. Digestibility of the crude fibre was not retained because of the difficulty to present reliable and coherent values. Moreover, the presented composition of the different fibre fractions can fully replace the constrain of indigestible fibre in rabbit diets formulation (GIDENNE, 2003).

Although the joule is already long-time accepted as the official expression unit of energy, in a lot of countries the calorie is still used in diet formulation. For practical usefulness the energy values are still presented in both expressions. Values referring to kcal and MJ were rounded off till 10 kcal or 0.05 MJ, respectively.

Utilisation of the tables

The composition presented in the tables is an average composition for a given DM content. If the DM content is different from the mentioned, corrections both for the chemical composition as the nutritive values have to be executed.

Many raw materials used to a large extent in rabbit diets (e.g. alfalfa meal, cereal by-products, fibrous oil-seed meals and fibrous feedstuffs) have a very divergent chemical composition according to the batch or the country of origin. For some of these raw materials, we have introduced different qualities in the tables to help to overcome this problem. However, a more accurate method to adapt the nutritive value to the actual composition should be a correction based on one or more chemical parameters.

The following published prediction equation is proposed:

Alfalfa meal:

DE (MJ/kg DM) = 13.932 – 0.196 CF (% DM)
r= -0.94; SE= 0.30
(PEREZ, 1994; PEREZ *et al.*, 1998a).

Differences in protein digestibility according to the quality of alfalfa meal can be adjusted using the following equation:

CPd of dehydrated alfalfa = 78.7 – 0.69 CF (% DM)
(PEREZ, 2002).

Because dehydrated grass meal is a quite similar product, the proposed equations for alfalfa meal are considered to be useful also for this raw material.

For protein concentrates, the equations proposed by WISEMAN and AL. (1992) can be used although the accuracy has not been validated for individual raw materials.

Another method proposed by MAERTENS *et al.* (1990), predicts the energy value based on the energy providing nutrients. If the digestibility coefficients (ADC) are determined, an accurate (<2%) estimation of the actual batch is obtained. When the digestible nutrients are calculated using the proposed ADC, the accuracy is depending of the reliability of the ADC's. However, due to methodology problems the ADC of many raw materials is questioned.

Although the most commonly used unit for expressing energy value in rabbit **diets** is digestible energy, this system has several disadvantages when used for **raw materials** in least cost diet formulation. DE overestimates the energy content of protein concentrates, as it does not take into account either the energy losses in urine. For this reason, the DE system favours the formulation of protein rich (excess) diets leading both to an increased risk of incidence of digestive disorders (DE BLAS *et al.*, 1981; GIDENNE *et al.*, 2001) or to increased environmental pollution (MAERTENS *et al.*, 1997). Therefore in the tables, values of ME are calculated based on the DE and protein content.

Losses of energy in urine (mainly urea) are depending of the protein content and quality. Consequently they are largely depending of the digestibility of the dietary protein. In order to avoid interferences with the use of the dietary N in the animal, the correction is done for N equilibrium as proposed by MAERTENS *et al.* (1990) and as it is widespread in poultry nutrition.

Because experimental ME data of raw materials are not available, ME is calculated based on the DE value presented in the tables. Under the conditions of N equilibrium, 1 g of digestible protein corresponds to a loss of 0.16 g of urinary N. The energy value of 1 g urinary N is according to JENTSCH *et al.* (1963) 0.030 MJ (7.16 kcal) or 0.0048 MJ (1.15 kcal)/g digestible protein. Losses due to gasses are small in rabbits and lower on average than 0.5% of the DE content. Based on these data the following equations have been used to calculate the ME content for N equilibrium:

ME (MJ/kg) = DE (MJ/kg) x ME/DE

With

ME/DE = 0.995 – 0.0048 x DP (g/kg)/DE (MJ/kg)

Example: Soybean 44 contains 43.2 CP with a digestibility of 82% and a DE value of 13.35 MJ/kg (see Table 2)

DP (g) = 430 x 0.82 = 352.6

ME/DE = 0.995 – 0.0048 x 352.6/13.35 = 0.868

ME (MJ/kg) = 13.35 x 0.868 = 11.58 or rounded off to 11.60 MJ/kg

All ME values presented in the tables are calculated using these equations. Compared to DE values, protein rich feedstuffs are much lower evaluated as energy source. A better hierarchy with especially carbohydrate rich raw materials is intended. Consequently, raw materials are more optimally chosen for their nutritional characteristics when using the ME system in the formulation of compound diets for rabbits.

Further concerted efforts are necessary to predict the energy value of raw materials with a very divergent composition. Actually, we are still lacking a practical (based on e.g. a limited number of chemical parameters) and accurate method to adapt the nutritive value of several important by-products (e.g. wheat bran, sunflower meal) to the actual available batch. Because of the limited research possibilities for rabbits in different countries and the low priority for feed evaluation experiments, only with collaborative studies this goal could be achieved in the near future. The teams involved in the ERAFE project (GIDENNE, 1999), have expressed their willingness to collaborate and to update in the future the presented tables.

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REFERENCES

CARABAÑO R., DE BLAS J.C., GARCIA A.I., 2000. Recent advances in nitrogen nutrition in rabbits. *Proc. 7th World Rabbit Congres, vol.**C**,15-28.*

BLAS E., FERNANDEZ-CARMONA J., CERVERA C., PASCUAL J.J., 2000. Digestible energy of different wheat brans for rabbits. *Proc. 7th World Rabbit Congres, vol.**C**,139-144.*

BACH KNUDSEN K.E., 1997. Carbohydrate and lignin contents of plant materials used in animal feeding. *Anim. Feed Sci. Tech., **67**, 319-338.*

BRILLOUET J.M., ROUAU X., HOEBLER C., BARRY J.L., CARRÉ B., LORTA E., 1988. A new method for determination of insoluble cell-walls and soluble non-starchy polysaccharides from plant materials. *J. Agric. Food Chem, **36**, 969-979.*

CARRÉ B., BRILLOUET J.M., 1986. Yield and composition of cell wall residues isolated from various feedstuffs used for non-ruminants farm animals. *Journal of the Science of Food and Agriculture, 37, 341-351.*

CHEEKE P.R., 1987. Rabbit feeding and nutrition. *Academic Press, Orlando, Florida. 376p.*

COLONNA P., BULÉON A., LELOUP V., THIBAULT J.F., RENARD C., LAHAYE M., VIROBEN G., 1995. Constituants des céréales, des graines, des fruits et de leurs sous-produits. *In: Nutrition des ruminants domestiques. Ruckebusch Y. Jarrige R., Demarquilly C., Farce M-H., Journet M. Eds, , INRA Ed. chap. **3**: 83-121.*

CVB, 1997. VEEVOEDERTABEL 1997. Gegevens over chemische samenstelling, verteerbaarheid en voederwaarde van voedermiddelen. *CVB (Ed), Runderweg 6, 8219 PK Lelystad, The Netherlands.*

DE BLAS J.C., PEREZ E., FRAGA J.M., RODRIGUEZ J.M., GALVEZ J.F., 1981. Effect of diet on feed intake and growth of rabbits from weaning to slaughter at different ages and weights. *J. Anim. Sci., **52** : 1225-1232.*

DE BLAS C., WISEMAN J., 1998. The Nutrition of the rabbit. *CABI Publishing, CAB International, Wallingford Oxon (UK), 344p.*

DE BLAS C., GARCIA J., CARABAÑO R., 1999. Role of fiber in rabbit diets. A review. *Ann. Zootech., **48**, 3-13.*

FEDNA, 1997. Normas FEDNA para la formulación de piensos compuestos. *C. De Blas, G.G. Mateos & P.G. Rebollar (eds). FEDNA, Elanco*

GIDENNE T., 1992. Effect of fibre level, particle size and adaptation period on digestibility and rate of passage as measured at the ileum and in the faeces in the adult rabbit. *Br. J. Nutr., 67, 133-146.*

GIDENNE T., 1999. EGRAN: a European group for rabbit nutrition. Presentation and activity. *World Rabbit Sci., 7, 101-106.*

GIDENNE T., 2000. Recent advances in rabbit nutrition: emphasis on fibre requirements. A review. *World Rabbit Sci., **8**, 23-32.*

GIDENNE T., 2003. Fibre in rabbit feeding for digestive troubles prevention: respective role of low-digested and digestible fibre. *Livest. Prod. Sci., (in press)*

GIDENNE T., KERDILES V., JEHL N., ARVEUX P., BRIENS C., ECKENFELDER B., FORTUNE H., MONTESSUY S., MURAZ G., STEPHAN S., 2001. Effet d'une hausse du ratio fibres digestibles/protéines sur les performances zootechniques et l'état sanitaire du lapin en croissance: résultats préliminaires d'une étude multi-site. *9èmes Journ. Recch. Cunicole Fr., Paris, 65-68.*

INRA - AFZ, 2002. Tables de composition et de valeur nutritive des matières premières destinées aux animaux d'élevage. *INRA Editions, Paris, 304p.*

JENTSCH W., SCHIEMANN L., HOFMANN L., NEHRING K., 1963. Die energetische Verwertung der Futterstoffe. 2. Die energetische Verwertung der Kraftfutterstoffe durch Kaninchen. *Arch. Tierernähr., **13**, 133-145.*

LEBAS F., DJAGO A.Y., 2001. Valorisation alimentaire de la paille par le lapin en croissance. *9èmes Journ. Rech. Cunicole Fr., Paris, 77-80.*

LEBAS F., GIDENNE T., PEREZ J.M., LICOIS D., 1998. Nutrition and pathology. *In: The nutrition of the rabbit. De Blas C. and Wiseman L (Eds), CABI Publishing, Wallingford, IK, 197-213.*

MAERTENS L., VAN HERCK A., 2001. La digestibilité de quelques matières premières couramment utilisées dans l'alimentation du lapin. *9èmes Journ. Rech. Cunicole, Paris 28-29 novembre 2001, 81-84.*

MAERTENS L., JANSSEN W.M.M.A., STEENLAND E.M., WOLTERS D.F., BRANJE H. E. B., JAGER F., 1990. Tables de composition, de digestibilité et de valeur énergétique des matiéres premiéres pour lapins. *5èmes Journées de la Recherche Cunicole, Paris 12-13 Décembre, 1990. Ed. ITAVI, communication 57 (9p).*

MAERTENS L., LUZI F., DE GROOTE G., 1997. Effect of dietary protein and amino acids on the performance, carcass composition and N-excretion of growing rabbits. *Ann. Zootech., **46**, 255-268.*

PEREZ J.M., 1994. Digestibilité et valeur énergétique des luzernes déshydratées pour le lapin: influence de leur composition chimique et de leur technologie de préparation. *6èmes Journ. Rech. Cunicole Fr.*, La Rochelle, 6-7/12/1994, 355-364. ITAVI Ed., Paris.

PEREZ J.M., 2002. Valeurs nutritives pour les lapins. *In : D. Sauvant, J.M. Perez, G. Tran (eds) Tables de composition et de valeur nutritive des matières premières destinées aux animaux d'élevage. INRA Editions, Paris, 51-54.*

PEREZ J.M., LEBAS F., GIDENNE T., MAERTENS L., XICCATO G., PARIGI BINI R., DALLE ZOTTE A., COSSU M.E., CARAZZOLO A., VILLAMIDE M.J., CARA-BANO R., FRAGA M.J., RAMOS M.A., CERVERA C., BLAS E., FERNANDEZ J., FALCAO E CUNHA L., BENGALA FREIRE J., 1995. European reference method for in vivo determination of diet digestibility in rabbits. *World Rabbit Sci., 3, 41-43.*

PEREZ J.M., LAMBOLEY B., BERANGER C., 1998A. Valeur nutritive de différentes luzernes déshydratées utilisées seules ou en mélange dans le régime du lapin en croissance. *7èmes Journ. Rech. Cunicole Fr., Lyon, 13-14/05/1998, pp. 129-132. ITAVI Ed., Paris.*

PEREZ J.M., MAERTENS L., VILLAMIDE M.J., DE BLAS C., 1998B. Tables de composition et de valeur nutritive des aliments destinés au lapin: conclusions d'un groupe de travail européen. *7èmes Journ. Rech. Cunicole Fr., Lyon. Ed. INRA-ITAVI, 141-146.*

PEREZ J.M., GIDENNE T., BOUVAREL I., ARVEUX P., BOURDILLON A ., MESSAGER B., BRIENS C., LE NAOUR J., MIRABITO L., 2000. Replacement of digestible fibre by starch in the diet of the growing rabbit. II. Effects on performances and mortality by diarrhoea. *Annales de Zootechnie **49**, 369-377.*

SCHLOLAUT W., 1995. Das große Buch vom Kaninchen. *DLG-Verlag, Frankfurt am Main, 396p.*

VILLAMIDE M.J., MAERTENS L., DE BLAS C., PEREZ J.M., 1998. Feed evaluation. *In: De Blas C., Wiseman J. (eds), The Nutrition of the rabbit. CABI Publishing, CAB International, Wallingford Oxon (UK), 89-102.*

VILLAMIDE M.J., GARCIA J., BLAS E ., CERVERA C., 2000. Comparison among methods of nutritional evaluation of fibrous ingredients. *Proc. 7th World Rabbit Congress, Vol. C, 475-482.*

VILLAMIDE M.J., MAERTENS L., CERVERA C., PEREZ J.M., XICCATO G., 2001. A critical approach of the calculation procedures to be used in digestibility determination of feed ingredients for rabbits. *World Rabbit. Sci., **9**, 19-25.*

VILLAMIDE M.J., GARCIA J., CERVERA C., BLAS E., MAERTENS L., PEREZ J.M., 2003. Comparison of methods of nutritional evaluation of dietary ingredients for rabbits. *Anim. Feed Sci Technol.,*

(submitted)
WISEMAN J., VILLAMIDE M.J., DE BLAS C., CARABAÑO R., 1992. Prediction of the digestible energy and digestibility of gross energy of feeds for rabbits. 1. Individual classes of feeds. *Anim. Feed Sci. Technol.*, ***39***, *27-28.*

Table 1: Composition and nutritive value for rabbits of some commonly used cereals, cereal by products and other energy concentrates (data as % of as-fed basis)

	DM	ash	CP	EE	CF	NDF	ADF	ADL	HEM[1]	WIP[2]	ST	Sugar	Lys	Met	SAA	Thr	Trp	Ca	P	Na	Cl	Mg	K	CPd[3]	DE[4]		ME[5]	
																								%	kcal/kg	MJ/kg	kcal/kg	MJ/kg
Cereals																												
Barley	88	2.2	10.3	2.0	4.6	17.5	5.5	0.9	12.0	0.6	51	25	0.39	0.17	0.42	0.36	0.13	0.06	0.36	0.02	0.14	0.13	0.51	67	3080	12.90	2980	12.50
Corn	88	1.2	8.2	3.5	1.9	9.5	2.5	0.5	6.5	0.6	64	1.5	0.23	0.17	0.35	0.29	0.05	0.02	0.25	0.01	0.05	0.11	0.32	65	3130	13.10	3050	12.75
Oats	88	2.6	10.6	5.1	11.1	28.0	13.5	2.2	14.5	1.1	37	1.5	0.44	0.19	0.53	0.37	0.13	0.10	0.30	0.02	0.07	0.13	0.40	73	2600	10.90	2500	10.45
Triticale	88	1.8	11.0	1.6	2.3	12.5	3.1	0.9	9.4	0.6	57	3.0	0.39	0.19	0.46	0.36	0.14	0.05	0.34	0.01	0.05	0.12	0.42	75	3080	12.90	2970	12.40
Wheat	88	1.6	10.8	1.8	2.2	11.0	3.1	0.9	7.9	0.5	60	2.5	0.33	0.18	0.45	0.34	0.14	0.04	0.35	0.02	0.06	0.12	0.41	77	3130	13.10	3020	12.65
Cereal by-products																												
Corn gluten feed	90	6.7	21.5	4.3	7.8	31.2	9.4	1.2	21.8	5.0	18	2.0	0.71	0.41	0.90	0.80	0.16	0.17	0.86	0.22	0.22	0.38	0.97	70	2730	11.40	2540	10.65
DDGS	90	6.0	25.3	9.0	8.1	31.6	8.9	1.2	22.7	5.0	10.5	1.0	0.66	0.51	0.89	0.89	0.19	0.14	0.73	0.05	0.20	0.29	0.97	70	3030	12.70	2810	11.75
Malt sprouts	90	6.1	23.2	1.9	12.6	37.8	13.9	1.8	23.9	5.5	11	7.0	1.08	0.31	0.60	0.81	0.23	0.21	0.66	0.06	0.40	0.15	1.10	75	2580	10.80	2370	9.90
Rice bran	90	9.0	13.5	15.3	8.1	21.1	10.1	3.6	11,0	1.5	27	3.0	0.59	0.21	0.44	0.53	0.14	0.12	1.60	0.06	0.08	1,00	1.60	65	2970	12.45	2850	11.95
Wheat bran	88	5.0	15.0	3.4	9.5	40.5	11.8	3.5	28.7	2.9	19	5.0	0.59	0.24	0.55	0.48	0.19	0.15	1.09	0.03	0.08	0.44	1.10	74	2460	10.30	2330	9.75
Wheat feed	88	4.0	14.0	4.0	5.0	27.1	7.7	2.4	19.4	1.5	27	9.0	0.50	0.25	0.70	0.50	0.20	0.10	0.9	0.02	0.09	0.40	1.02	79	2950	12.35	2810	11.75
Wheat shorts	88	3.6	15.8	3.6	7.0	32.6	10.0	2.7	22.6	2.3	24	5.0	0.63	0.26	0.57	0.50	0.21	0.14	1.05	0.03	0.08	0.42	1.30	77	2680	11.20	2520	10.55
Other energy concentrates																												
Beet molasses	75	8.6	10.5	0	0	0	0	0	0	0	0	45.0	0.04	0.05	0.10	0.06	0.10	0.22	0.02	0.80	1.08	0.05	3.91	70	2550	10.65	2450	10.25
Cane molasses	75	9.8	4.5	0	0	0	0	0	0	0	0	47.0	0.02	0.02	0.04	0.05	-	0.74	0.09	0.20	2.00	0.42	4.50	60	2410	10.10	2370	9.90
Cassava 60	88	5.7	2.6	0.7	4.8	12.4	7.7	2.1	4.7	1.9	60	1.8	0.10	0.03	0.07	0.08	0.03	0.30	0.12	0.04	0.11	0.14	1.20	50	2880	12.05	2850	11.95
Cassava 65	88	5.7	2.6	0.7	4.4	9.5	6.8	2.0	2.7	1.5	65	2.1	0.10	0.03	0.07	0.08	0.03	0.25	0.11	0.03	0.07	0.11	0.75	50	2990	12.50	2960	12.40
Cassava 70	88	3.5	2.6	0.7	3.1	8.0	5.0	1.4	3	1.2	70	2.5	0.10	0.03	0.07	0.08	0.03	0.20	0.10	0.03	0.07	0.09	0.44	50	3130	13.10	3100	12.95

[1]HEM: hemicellulose: NDF-ADF
[2]WIP: water insolluble pectins (Gidenne, 2003)
[3]CPd: apparent fecal crude protein digestibility (as %)
[4]DE: digestible energy
[5]ME : metabolisable energy, corrected for zero N retention
- : no sufficient data available

Table 2: Composition and nutritive value for rabbits of fats, oils, oil seeds, oil meals and legumes (data as % of as-fed basis)

	DM	ash	CP	EE	CF	NDF	ADF	ADL	HEM[1]	WIP[2]	ST	Sugar	Lys	Met	SAA	Thr	Trp	Ca	P	Na	Cl	Mg	K	CPd[3]	DE[4]		ME[5]	
																								%	kcal/kg	MJ/kg	kcal/kg	MJ/kg
Legume and oil seeds																												
Faba bean	88	3.3	25.7	1.3	7.7	12.3	8.9	0.8	3.4	2.1	39.0	3.5	1.68	0.18	0.50	0.92	0.24	0.12	0.53	0.02	0.07	0.15	1.24	80	3120	13.05	2870	12.00
Lupin	88	3.5	32.6	7.0	12.8	21.0	15.5	1.5	5.5	10.5	0	6.0	1.59	0.25	0.73	1.16	0.26	0.23	0.32	0.05	0.04	0.17	0.85	80	3040	12.70	2720	11.40
Peas	88	3.0	22.0	1.2	5.7	12.0	7.0	0.4	5.0	4.6	43.5	4.5	1.63	0.22	0.54	0.84	0.18	0.10	0.4	0.02	0.04	0.12	1.05	83	3150	13.20	2920	12.25
Rapeseed	90	4.1	18.9	39.6	8.1	18.1	12.4	4.9	5.7	6.4	0	5.0	1.15	0.42	0.92	0.87	0.24	0.40	0.6	0.03	0.06	0.24	0.79	80	5000	20.90	4800	20.10
Soya bean	90	4.7	36.9	19.3	5.6	11.7	7.3	0.8	4.4	6.0	0	7.5	2.33	0.52	1.14	1.44	0.48	0.25	0.56	0.01	0.03	0.30	1.7	83	4150	17.35	3780	15.80
Oil meals																												
Coconut cake	90	6.0	20.2	7.4	12.5	44.7	23.5	5.5	21.2	4.0	0	9.3	0.5	0.3	0.61	0.66	0.16	0.14	0.54	0.06	0.63	0.30	1.81	65	2900	12.15	2740	11.45
Palm cake	90	4.0	14.7	8.4	17.8	60.5	37.2	11.0	23.3	2.7	0	2.0	0.48	0.28	0.50	0.46	0.11	0.21	0.58	0.02	0.16	0.26	0.62	60	2500	10.45	2390	10.00
Rapeseed meal	90	6.8	36.1	2.5	12.1	27.7	18.9	8.6	8.8	10.0	0	9.0	1.94	0.76	1.62	1.57	0.43	0.70	1.00	0.07	0.03	0.45	1.25	76	2710	11.35	2380	9.95
Soybean meal 44	90	6.8	43.2	1.8	7.7	16.1	10.0	0.8	6.1	8.5	0	8.0	2.72	0.60	1.25	1.68	0.59	0.29	0.60	0.02	0.04	0.25	1.80	82	3190	13.35	2770	11.60
Soybean meal 46	90	6.3	45.0	1.8	6.3	13.2	8.2	0.6	5.0	6.9	0	8.0	2.84	0.63	1.31	1.76	0.60	0.29	0.61	0.02	0.04	0.27	1.95	83	3330	13.95	2880	12.05
Soybean meal 48	90	6.1	46.8	1.8	5.0	12.4	6.5	0.5	5.9	6.6	0	8.0	2.95	0.66	1.36	1.83	0.63	0.29	0.64	0.02	0.04	0.28	2.05	84	3510	14.70	3040	12.70
Sunflower meal 28	90	6.8	27.9	2.7	25.2	42.8	30.2	10.1	12.6	7.2	0	5.0	1.00	0.67	1.20	1.03	0.36	0.35	1.00	0.03	0.15	0.50	1.10	77	2300	9.60	2040	8.55
Sunflower meal 32	90	6.8	30.6	2.3	22.5	38.3	27.0	9.0	11.3	6.5	0	5.0	1.12	0.74	1.31	1.13	0.40	0.30	0.95	0.03	0.15	0.50	1.10	80	2450	10.25	2160	9.00
Sunflower meal 36	90	6.8	34.2	1.9	18.0	30.6	21.6	7.2	9.0	5.2	0	5.0	1.25	0.82	1.47	1.27	0.44	0.25	0.90	0.03	0.16	0.50	1.10	83	2650	11.10	2310	9.65
Oils and fats																												
Animal fat	99.5	0	0	99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8000	33.45	8000	33.45
Olein	99.5	0	0	99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7500	31.40	7500	31.40
Rapeseed oil	99.5	0	0	99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8400	35.15	8400	35.15
Soybean oil	99.5	0	0	99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8500	35.55	8500	35.55
Sunflower oil	99.5	0	0	99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8500	35.55	8500	35.55

[1]HEM: hemicellulose: NDF-ADF

[2]WIP: water insolluble pectins (Gidenne, 2003)

[3]CPd: apparent fecal crude protein digestibility (as %)

[4]DE: digestible energy

[5]ME : metabolisable energy, corrected for zero N retention

- : no sufficient data available

Table 3: Composition and nutritive value of fibrous feedstuffs used in rabbit diets (data as % of as-fed basis)

	DM	ash	CP	EE	CF	NDF	ADF	ADL	HEM[1]	WIP[2]	ST	Sugar	Lys	Met	SAA	Thr	Trp	Ca	P	Na	Cl	Mg	K	CPd[3]	DE[4]		ME[5]	
																								%	kcal/kg	MJ/kg	kcal/kg	MJ/kg
Fibrous feedstuffs																												
Alfalfa meal 12	90.0	9.0	12.6	2.3	29.7	47.5	37.1	8.3	10.4	7.7	0.0	3.0	0.54	0.19	0.34	0.52	0.21	1.40	0.26	0.06	0.35	0.20	1.90	56	1610	6.75	1520	6.35
Alfalfa meal 15	90.0	9.9	15.3	3.2	26.1	41.8	32.6	7.3	9.2	6.8	0.0	3.0	0.66	0.23	0.41	0.63	0.25	1.50	0.26	0.07	0.48	0.27	2.10	59	1770	7.40	1660	6.95
Alfalfa meal 18	90.0	9.9	18.0	3.6	21.6	34.6	27.0	6.0	7.6	5.6	0.0	3.0	0.77	0.27	0.49	0.74	0.30	1.60	0.27	0.08	0.49	0.30	2.50	62	1980	8.30	1840	7.70
Beet pulp	90.0	7.2	9.0	1.0	18.0	42.8	21.2	1.8	21.6	25.0	0.0	6.0	0.53	0.19	0.31	0.44	0.09	0.76	0.10	0.20	0.10	0.23	0.49	50	2480	10.40	2420	10.10
Cacao hulls	90.0	8.0	16.4	5.0	18.3	39.0	30.0	14.0	9.0	3.0	0.0	-	0.75	0.15	0.35	0.60	0.10	0.30	0.35	0.08	0.15	0.40	2.50	25	1300	5.45	1250	5.20
Carob meal	90.0	3.2	4.7	0.5	7.8	28.9	24.8	13.8	4.1	-	0.7	42.4	0.16	0.09	0.15	0.17	0.08	0.45	0.10	0.02	0.15	0.05	0.90	20	2150	9.00	2130	8.90
Citus pulp	90.0	6.7	5.9	2.7	13.3	22.0	15.5	1.6	6.5	12.0	0.0	23.0	0.20	0.07	0.15	0.20	0.06	1.59	0.12	0.10	0.06	0.14	0.71	60	2700	11.30	2650	11.05
Flax chaff	90.0	7.6	10.2	3.5	31.5	45.5	31.0	11.0	14.5	-	0.0	-	0.30	0.05	0.10	0.15	-	1.80	0.30	0.06	0.09	0.10	0.90	40	1050	4.40	1000	4.15
Grape pomace	90.0	8.1	11.7	5.4	28.0	56.0	48.0	30.0	8.0	7.0	0.0	2.0	0.49	0.17	0.35	0.37	0.07	0.70	0.20	0.01	0.01	0.12	1.60	0	1200	5.00	1190	5.00
Grape seed meal	90.0	3.6	9.9	1.4	44.1	73.0	65.0	55.0	8.0	2.0	0.0	-	0.40	0.15	0.35	0.20	0.09	0.60	0.12	0.01	0.01	0.10	0.60	0	800	3.35	800	3.35
Grass meal	90.0	8.0	15.0	3.0	22.5	46.0	26.0	5.0	20.0	4.5	0.0	8.0	0.60	0.20	0.35	0.55	0.15	0.70	0.40	0.10	0.08	0.20	2.50	61	1940	8.10	1830	7.65
Olive leaves	90.0	7.2	9.0	4.0	20.0	45.5	31.8	17.7	13.7	-	0.0	9.0	-	-	-	-	-	1.10	0.08	0.17	0.45	0.19	0.86	5	1280	5.35	1270	5.30
Rice straw	90.0	16.2	6.0	0.5	29.5	58.5	34.0	2.2	24.5	1.6	0.0	-	-	-	-	-	-	-	-	-	-	-	-	60	600	2.50	560	2.30
Soybean hulls	90.0	4.6	12.2	2.0	35.5	58.8	42.6	2.1	16.2	9.2	0.0	1.0	0.70	0.14	0.34	0.46	0.15	0.50	0.16	0.02	0.03	0.20	1.26	50	1720	7.20	1640	6.85
Sunflower hulls	90.0	3.4	5.4	4.0	46.8	69.3	56.2	20.2	13.1	10.0	0.0	1.0	0.23	0.12	0.25	0.23	0.07	0.40	0.20	0.10	0.10	0.17	1.05	15	1030	4.30	1020	4.25
Wheat straw	90.0	6.1	3.6	1.2	39.5	75.0	47.4	8.0	27.6	2.2	0.5	-	-	-	-	-	-	0.38	0.08	0.16	0.46	0.09	0.95	10	650	2.70	640	2.70
Wheat straw treated	90.0	7.3	3.2	0.8	36.5	69.4	44.4	7.5	25.0	2.0	0.5	-	-	-	-	-	-	0.43	0.06	0.86	0.43	0.07	0.89	15	880	3.70	870	3.65

[1]HEM: hemicellulose: NDF-ADF

[2]WIP: water insoluble pectins (Gidenne, 2003)

[3]CPd: apparent fecal crude protein digestibility (as %)

[4]DE: digestible energy

[5]ME : metabolisable energy, corrected for zero N retention