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Characteristics of Spanish carob pods and nutritive value of carob kibbles

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SUMMARY - The Carob pods of 182 common carob trees from different areas of Spain were evaluated to obtain estimates of their nutritive value as animal feeds and for industrial use. The mean of the main descriptive morphological values of pods were: weight (14.88 g), length (15.83cm), width (2.11cm) and kernel yield (12.11%). The mean values of chemical composition of carob kibbles were as follows (g/kg dry matter): Crude Protein (43.2), Crude Fibre (80.1), Ether Extract (4.4), Ash (32.7), NFE (839.5), Neutral and Acid Detergent Fibres (346.7 and 338.0), Lignin (227.3), Total and Reducing Sugars (469.5 and 127.5), Sucrose (342.0) and Gross Energy (18.8 MJ/kg dry matter). Theoretical degradation of Crude Protein in sheep rumen *in sacco* conditions was 28%, with an initial value of 22.5%. Most of the parameters measured showed significant differences ($P<0.05$ to $P<0.001$); geographical origin being taken as the source of variation.

RESUME - "Valeur nutritive des caroubes et des pulpes de caroubes". Les caroubes de 182 caroubiers des différentes régions de l'Espagne ont été évaluées pour estimer leur valeur nutritive pour l'alimentation animale et l'utilisation industrielle. Les moyennes des mesures morphologiques descriptives des caroubes ont été: Poids (14.88g), Longueur (15.83cm), Largeur (2.11cm) et Rendement en graine (12.11%). Les valeurs moyennes de composition chimique de la Pulpe de Caroube ont été (g/kg matiére sèche): Matières Azotées Totales (43.2), Cellulose brute (80.1), Extrait Ethéré (4.4), Cendres (32.7), Extractif Non Azoté (839.5), Fibres Acide et Neutre Détérgentes (346.7 et 338.0), Lignine (227.3), Sucres Totals et Réducteurs (469.5 et 127.5), Sucrose (342.0) et Energie Brute (18.8 MJ/kg matière sèche). La dégradation théorique des Matières Azotées dans un rumen ovin en conditions in sacco a été de 28%, en prenant une valeur initiale de 22.5%. La plupart des paramètres mesurés ont montré des différences significatives ($P<0.05$ à $P<0.001$) selon la source de variation due à l'origine géografique.

Introduction

Carob (*Ceratonia siliqua* L.) is an evergreen tree of the Caesalpiniaceae, cultivated mainly in the Mediterranean area: its fruit has traditionally been used as an animal feed. Spain is the most important producer of carob pods in the world, with an average production of 150.000 Tns/year (40% of total world production).

Carob pods provide two important products: a) "Carob Kernels" or seeds from which Carob or Locust Bean Gum (LBG) is extracted, and b) "Carob Kibbles" or the remaining pulp obtained after the removal of the seeds. This can be used directly in animal and human nutrition or as a raw material for industrial processing. The purpose of this work is to evaluate some of the principal characteristics of Spanish carob pods in relation to their nutritive value and industrial uses.

Material and methods

A total of 182 samples (50 pods/tree) were taken from various carob producing regions in Spain: Baleares (54), Catalunya (26), C. Valenciana (93), Andalucía y Murcia (9). The carobs were first evaluated morphologically by measuring weight, length, width, thickness, number of normal and aborted kernels, number of carpelar holes and cutting hardness. For chemical analysis the carob seeds were manually separated and the pulp ground (Cyclone, 1 mmø). A total of 60 random triple samples of pulp were used. Proximate analysis and detergent fibre contents were determined according to AOAC (1984) methods, sugars by the method of Somogyi (1952) and energy was estimated using an adiabatic calorimeter (IKA 4000). From these samples Near Infrared Analysis equipment (Infraalyzer 450, Technicon) was calibrated to analyze

the remaining samples. The kinetics of ruminal degradation of 10 samples of pulp were estimated according to Michalet-Doreau *et al.* (1987), using 3 fistulated sheep. Variance analysis was applied to the data (SPSSx, 1985).

Results and discussion

Data for morphological characteristics (Table 1) and break-down according to weight (Table 2) show variations in the Spanish carob pods, with significant differences (P<0.05 to P<0.001) due to geographical location of cultivation, except in thickness and number of carpelar holes. The number and weight of kernels (ks) were correlated (r=0.59 and r=0.49, P<0.001) with carob pod length (0.63 ks/cm) and weight (12.1 g/100g), respectively. Average kernel weight was 0.188 g.

The chemical composition of carob kibbles is given in Table 3. The carob kibbles have high Dry Matter and Nitrogen Free Extract contents. The other constituents in proximate analysis showed lower values, especially in Crude Protein and Crude Fibre contents. Neutral and Acid Detergent Fibres contents showed a high proportion of cell wall content. Lignin Acid Detergent was also high. Carob kibbles are especially rich in Total and Non Reducing Sugars (Sucrose) and in Gross Energy, making carob kibbles a high-energy food for animal nutrition. Theoretical degradation *in sacco* conditions of Dry Matter (65.4%) and Crude Protein (28.0%), is in accordance with the chemical composition discussed above, and shows high initial values (62.1 and 22.5 %). Results also indicate that Crude Protein in the rumen residues is non digestible in HCl-Pepsin.

Table 1: Morphological characteristics of Spanish carob pods and variation between geographical zones

Parameter	Variation Interval	Mean ± SE	Sign.level
Dimensions (cm):			
Length	7.71-27.28	15.83 ± 0.21	***
Width	1.44- 2.68	2.11 ± 0.02	***
Thickness	0.54- 1.32	0.85 ± 0.01	NS
Internal thickness	0.40- 0.98	0.60 ± 0.01	***
Nº kernels	2.88-14.76	10.00 ± 0.17	***
Nº ks. aborted	0.75- 9.60	3.76 ± 0.13	***
Nº carpelar holes	8.20-20.00	13.77 ± 0.16	NS
Cutting hardness[1] (Kg/cm^2)	4.33-24.13	11.18 ± 0.31	***

[1]= Warner-Bratzler; SE= Standard Error; ***= P<0.001; NS= non significant.

Table 2: Break-down according to weight and kernel yield of Spanish carob pods and variation between geographical zones

Weight (g/pod)	Variation Interval	Mean ± SE	Sign.level
Carob Pod	5.09-29.84	14.88 ± 0.28	**
Carob Kibbles	3.74-27.43	13.00 ± 0.27	*
Carob Kernels	0.35- 3.13	1.88 ± 0.04	***
K. Yield (%)	3.55-29.41	12.11 ± 0.28	***

***= P<0.001, **= P<0.01, *= P<0.05

Table 3: Chemical composition and variation of Spanish carob pods between geographical zones

Parameter[1]	Variation Interval	Mean ± SE	Sign.level
PROXIMATE ANALYSIS:			
Dry Matter	735.7-941.2	873.1 ± 2.1	***
Protein (Nx6.25)	19.0- 72.1	43.2 ± 0.8	***
Crude Fibre	57.0-141.1	80.1 ± 0.8	***
Ether Extract	1.4- 15.7	4.4 ± 0.1	***
Ash	22.5- 50.1	32.7 ± 0.3	NS
Nitrogen Free Extract	762.2-872.6	839.5 ± 1.1	NS
DETERGENT FIBRES:			
Neutral Detergent	274.3-501.0	346.7 ± 2.7	***
Acid Detergent	241.3-494.7	338.0 ± 3.0	***
Lignin AD	100.3-430.3	227.3 ± 2.9	**
SUGARS:			
Total	257.0-550.0	469.5 ± 3.0	*
Reducing	65.8-288.3	127.5 ± 2.8	***
Sucrose	108.7-467.9	342.0 ± 4.5	***
Gross Energy (MJ/kg)	17.94-19.89	18.8 ± 0.03	***

[1]= g/kg dry matter; ***= P<0.001, **= P<0.01, *= P<0.05, NS= non significant)

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