NUTRITIVE VALUE OF CARROT (WHOLE PLANT), DRIED AT LOW TEMPERATURE, FOR THE GROWING RABBIT

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ABSTRACT

The nutritive value of carrot (whole plant) dried at low temperature (35°C max) was studied in the growing rabbit, by comparing 4 diets (regression method) containing an increasing incorporation rate of carrot: 10-20-30% in substitution to the control diet (0%). The faecal digestibility of the diets were measured between 42 and 46 days of age on four groups of 12 young rabbits fed *ad libitum* since weaning (35 d). The ash level of the carrot, analysed here, was high (21%), probably originating from soil residues on the root or top of the plant. The crude protein level reached almost 13%, while ADF was almost 14%. This data classed the whole carrot as a balanced source of protein and fibres. The digestible energy (DE) concentration of the carrot was estimated to 2160 kcal/kg (±82.7 kcal, as fed basis) for an incorporation rate up to 20%. The mean digestibility of crude protein was estimated to 66.5%, corresponding to a digestible crude protein concentration of 64 g/kg (±2 g, as fed basis). Even at a high incorporation rate in the feed (30%) carrot did not produce adverse effects on the animal growth (mean 39.0 g/d), intake (mean 155 g/d) or health. However, further experiment is necessary to compare growth performances on more numerous rabbits fed with balanced diets containing an increasing level of whole carrot.

Key words: Carrot (whole plant), Nutritive value, Growing rabbit, Regression method.

INTRODUCTION

Since the rabbit is a monogastric and herbivorous animal, it is relevant to use plants or vegetable sources in rabbit rearing, especially by products non concurrent of the human feeding. However, one main restriction to the use of plants or vegetable by products is to store them in good conditions, especially in a dried form. Drying is also necessary to prepare pelleted feeds. Classically, for plants rich in water the drying is done by heating in oven, and sometime at a high temperature such during the dehydration of lucerne meal or beet pulp (600-800°C). Recently, a new strategy was developed to dry products at a low temperature (30-35°C), using a cold air-flow system (Process CFT technick, Gumlingen, Switzerland). It was applied with success to dry salad, that is very rich in water (about 90-95%), to be incorporated in pelleted feed for rabbits (Goby *et al.*, 2001). Furthermore, as shown by Lebas (1987) dehydration at a low temperature or lyophilisation particularly preserve the quality of the proteins, and allow a higher nutritive value, as demonstrated for lucerne (Lebas and Goby, 2005).

The carrot, as whole plant, is readily available in area producing carrots for human consumption, because over the half of the carrot production is not calibrated for canning factory and is considered as wastes. In France, to reject these wastes, producers must follow a specific rule, and must pay taxes. Hence, discarded whole carrots constituted a potential feed resource for animal rearing, and particularly for herbivorous animal such the rabbit. In addition, introducing carrot in the feed may brought a positive "symbol" for rabbit rearing.

Therefore, we aimed to measure the nutritive value for the growing rabbit of whole carrots, freshly collected from production wastes, cold-dried and incorporated at increasing levels in 4 pelleted feeds.

MATERIALS AND METHODS

Feeding, animals and experimental design

The whole carrot was daily collected in fresh form from production wastes of one farm (area of Perpignan, France), and immediately dehydrated at low temperature (30-35°C) in a specific oven (CFT technick process, Gumlingen, Swiss) located at IUT Perpignan.

The nutritive value of the carrot (whole plant) dehydrated at low temperature was studied by measuring the faecal digestibility of four pelleted feeds (C0-C10-C20-C30) corresponding to a control diet (CO) and to three diets with an increasing incorporation rate of whole carrot (Table 1 and 2) in CO. The control diet met the nutritional requirements of the growing rabbit. Diets were formulated and prepared at Tandem mill experimental unit (INRA Toulouse).

At weaning (35 d), 4 groups of 12 rabbits were assigned to the four pelleted diets, and placed in individual cages till 60 d of age. Animals were chosen among the heaviest of a group of 300 weaned rabbits, and their genotype was a hybrid among Californian and New Zealand White INRA lines. Animals had a free access to feed and water. Faecal collections were achieved after a 7-d adaptation period, from 42 to 46 d of age, according the standardised European procedure of the EGRAN group (European Group on Rabbit nutrition**:** http://www.dcam.upv.es/egran/; Perez *et al.*, 1995).

Chemical Analyses

The following analyses were performed on feeds and whole carrot, according to EGRAN harmonised procedures (EGRAN, 2001): humidity, crude ash, crude protein (N x 6.25, Dumas method, Leco apparatus), energy (adiabatic calorimeter Parr), and fibres (NDF, ADF and ADL) according to the sequential procedure of Van Soest.

Statistical Analysis

Results were submitted to a mono-factorial variance analysis (diet effect), combined if necessary with a multiple comparison of means (Scheffe test), using SAS Software. The nutritive value of the whole carrot was calculated using the regression method and according to Villamide *et al*. (2001).

Table 1: Ingredients of the basal mixture, and formulation of experimental diets

Basal mixture	%	Vitamins and minerals	%
Wheat	18.0	Salt	0.45
Soybean meal	8.0		
Sunflower meal	14.0	DL Methionin (99%)	0.15
Alfalfa meal	25.0	Premix + Salinomycin	0.80
Wheat bran	17.0	Digeston®	0.20
Wheat straw	5.0		
Dried beet pulp	11.4		
Total	98.4		1.60

Experimental diets	C0	C10	C20	C30
Basal mixture	98.4%	88.4%	78.4%	68.4%
Carrot (dehydrated, whole plant)	0%	10%	20%	30%
Vitamins and minerals	1.6%	1.6%	1.6%	1.6%

RESULTS AND DISCUSSION

References about the use of whole carrot in animal nutrition are not available in tables of ingredients (INRA or FEDNA) or in recent reviews (Lebas, 2004). Only the chemical composition of carrot root is available because it is used for human nutrition. Thus, studying the nutritive value of the carrot, as a whole plant, was original. The whole carrot analysed here (Table 2) presented a relatively high level of ash, probably originating from soil residues on the root or top of the plant, although the raw material was washed before the drying process. Accordingly, the crude ash level of the diets was increasing from 10 to 17.7% for C30. The crude protein level of the whole carrot reached almost 13%, while that of ADF was almost 14%. This classed the whole carrot as a balanced source of protein and fibres.

Table 2: Chemical composition (g/kg, raw basis) of the carrot* (whole plant, dehydrated form) and of the experimental diets

	Carrot* (whole plant)	Experimental diets			
		C0	C10	C20	C30
Moisture	107	48	58	56	58
Crude ash	212	100	118	146	177
Crude protein (N x 6.25)	129	188	177	164	165
NDF	195	375	357	340	323
ADF	138	208	198	189	184
ADL	26	53	49	49	51
Crude energy (kcal/kg)	3255	4176	4057	3854	3645

*analytical value of a sample from the material incorporated in the pelleted feeds (C0, C10, C20, C30)

Throughout the experiment, no mortality occurred, except one rabbit that died between 35 and 38 d of age.

The level of the growth performances ranged within usual standard, either for growth or intake. No significant effect of the carrot incorporation rate was detected on the performances (Table 3), however the number of rabbits was here limited. A further experiment is thus necessary to compare growth performances of rabbits, fed with balanced diets containing an increasing level of whole carrot, to evaluate any adverse effect of the whole carrot on performances and digestive health of the young rabbit.

Table 3: Growth performances

Diets	C0	C10	C20	C30	RMSE	Pr > F
Weight at 35 d (g)	1199	1180	1188	1192	33.5	NS
Weight at 42 d* (g)	1478	1481	1474	1455	52.3	NS
Weight at 46 d* (g)	1667	1668	1654	1636	69.2	NS
Weight at 60 d* (g)	2170	2198	2192	2134	118.5	NS
Weight gain from 42-60 d (g/d)	38.4	39.8	39.9	37.7	5.3	NS
Feed intake from 42-46 d (g/d)	109.4	114.5	113.1	114.0	12.5	NS
Feed intake from 42-60 d (g/d)	152.9	157.7	160.4	148.7	18.6	NS
Feed conversion ratio 42-60 d	4.00	3.98	4.03	3.98	0.37	NS

* 42 d, 46 d, 60 d: resp. start and end of the faecal sampling period, and end of experiment
RMSE: Root mean square error. NS: P>0.20

The digestibility of the experimental diets was significantly modulated by the incorporation level of the whole carrot (Table 4). The digestibility coefficient for energy tended to increase with carrot incorporation, but this effect was counterbalanced by a sharp decrease in dietary energy content. Accordingly, digestible energy content of the diets decreased with carrot level (Figure 1). When extrapolated to 100% (using a linear regression), the digestible energy content of the whole carrot was estimated to 1790 kcal/kg (raw basis). The standard deviation of this energetic value was 70.0 kcal (calculated according to Villamide *et al*., 2001), thus corresponding to a mean value ranging between 1720 kcal and 1860 kcal/kg. This estimation placed the whole carrot at a level similar to that of lucerne meal or sunflower hulls (EGRAN Tables, Maertens *et al*., 2002).

However, if looking more carefully to the curve fitting DE and carrot level (Figure 1), we cannot exclude a curvilinear response, instead of a linear one, since the DE content of the C30 diet seemed to decrease sharply compare to previous level. This lower energetic value for the highest level of carrot incorporation may originated in the high concentration in minerals (almost 18%), that could impaired the digestive processes in the rabbit. Accordingly, when calculating the energetic value for moderate levels of carrot incorporation (with three levels only: 0-10-20%), the DE content of the whole carrot reached 2160 kcal/kg, but was less precisely estimated (±82.7 kcal; equation: y=2767-6.0x, r^2=0.494).

Table 4: Digestibility coefficient and nutritive value of the diets

Diets	C0	C10	C20	C30	RMSE	Pr > F
Digestibility coefficient (%)						
Organic matter	66.0a	67.4a	69.2b	69.3b	1.3	<0.01
Crude protein	78.9a	77.6ab	76.7b	76.0b	1.6	<0.01
Energy	66.0b	67.4ab	68.5a	67.7ab	1.3	<0.01
NDF	36.9b	39.0ab	40.4a	39.8ab	2.4	0.014
ADF	27.3c	30.1bc	33.1ab	35.2a	3.1	<0.01
Nutritive value						
Digestible energy (kcal/kg, raw basis)	2754	2732	2640	2466		
Digestible protein (g/kg, raw basis)	149	138	126	125		

*42 d, 46 d, 60 d: resp. start and end of the faecal sampling period, and end of experiment
RMSE: Root mean square error. NS: P > 0.20

The digestibility coefficient for crude protein decreased linearly and significantly with carrot incorporation (Table 4). Therefore, the digestible protein content of the diets decreased relatively sharply with the carrot level (Figure 2). When extrapolated to 100% (using a linear regression), the digestible protein content of the whole carrot was estimated to 64 g/kg (raw basis) with a quite good precision (see equation on the Figure 2). The standard deviation of this proteic value was 2.0 g (calculated according to Villamide *et al.*, 2001), thus corresponding to a mean value ranging between 62 and 66 g/kg. This estimation corresponded to a protein digestibility estimated at 66.5% for the carrot.

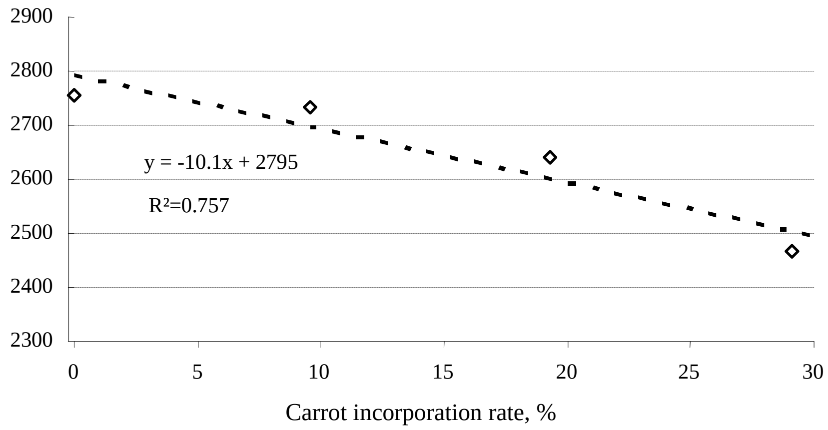

Figure 1: Digestible energy content (kcal/kg) of diets according to the carrot incorporation rate

The digestibility of fibre increased slightly but significantly for NDF and ADF with the level of carrot in the diet. This suggested that the cell wall polysaccharides contained in the whole carrot were relatively digestible. This may originate from the relatively low lignin (ADL) level of the carrot (Table 2). Besides the content in hemicelluloses (NDF-ADF) was moderate.

The nutritive value of the whole carrot, dehydrated at low temperature, is moderate for the growing rabbit, because the product studied here was relatively poor in organic matter. Therefore, it would be convenient to obtain whole carrot with lower content of minerals, for example after a washing of the raw material. Whole carrot could be introduced at a level of 10 to 20% in the feed, provided the ash level would be as high as in our study (21%). Thus, we proposed an energetic value of 2160 kcal/kg, since the probable incorporation rate of this product should not be over 20%, and a digestibility of protein of 66%.

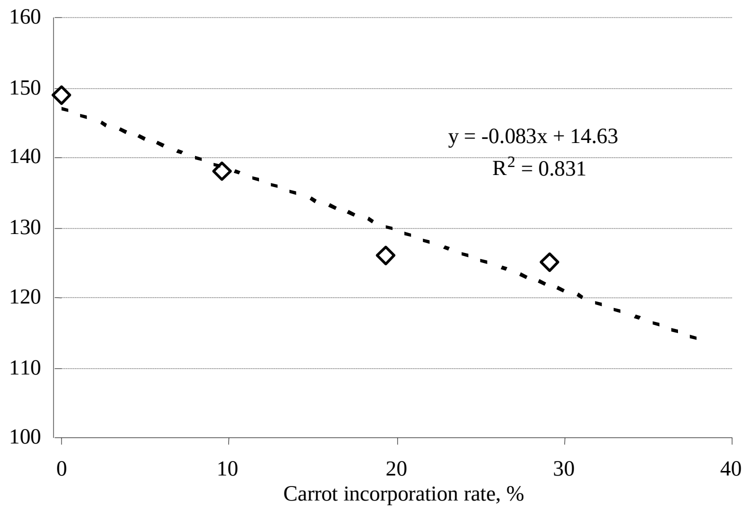

Figure 2: Digestible protein content (g/kg) of diets according to the carrot incorporation rate

CONCLUSIONS

Dehydrated whole carrot could be considered as good source of nutrients for the growing rabbit (DE=2160 kcal/kg, protein digestibility=65%, for a raw product with a humidity of 107 g/kg). Its nutritive value could be improved by reducing the level of minerals in the product, for example after a washing treatment to eliminate soil residues on the roots. Even at a high incorporation rate in the feed (30%) carrot did not produce adverse effects on the animal growth, intake, or health. However, further experiment is necessary to compare growth performances on a larger number of animals, fed with balanced diets containing an increasing level of whole carrot.

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