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EFFECT OF SIMPLIFIED FEEDING BASED ONLY ON WHEAT BRAN AND BREWER'S GRAIN ON RABBIT PERFORMANCE AND ECONOMIC EFFICIENCY

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Abstract: Simplified diets aim to maximise the incorporation rate of fodder and/or by-products into animal feed to minimise costs and importation dependency. This study aimed to evaluate the possibility of feeding fattening rabbits with a simplified diet composed of only 2 inexpensive and locally available agro-industrial by-products: brewer's grain and wheat bran. At weaning (35 d of age), 68 rabbits were divided into 2 groups (mean body weight: 833±126 g) and housed in individual cages until slaughter (77 d). Rabbits were fed *ad libitum* either a commercial pelleted feed (control: B0 group), or a simplified pelleted experimental diet (SF group) containing 72% wheat bran and 27% brewer's grain. The feed conversion ratio was similar in the 2 groups (3.55 on av.). The daily weight gain and daily feed intake were 12% higher (P<0.001) in the B0 group than in the SF group (35.2 *vs.* 31.2 g and 128.3 *vs.* 113 g/d). The cold carcass yield (+4 percentage points) and carcass weight (+9%) were higher (P<0.001) in B0 than in SF group. The carcass was less fatty in SF than in B0 group (perirenal fat: –23%, inguinal fat: –41% and scapular fat: –14%). The economic efficiency was 40% better when rabbits were fed SF diet (+0.37 €/kg of meat) in current local market conditions.

Key Words: rabbit, growth, slaughter traits, economic efficiency, brewer's grain, wheat bran.

INTRODUCTION

In rabbit production, feed represents about 60% of the production costs (Gidenne *et al.,* 2017). In Algeria, feed formulation is based largely on imported raw materials (maize, soybean meal and alfalfa), whose prices tend to increase in the world market. The use of locally produced by-product in rabbit feeding would lower the production costs and could also reduce the competition with human food. Rabbit is a hindgut-fermenter, so it can valorise high fibre diets more efficiently than other monogastrics. Therefore, it can be fed with numerous agricultural or agro-industrial by-products to produce meat of high nutritional value (Gidenne, 2015a), while reducing the competition with human food.

Several works (Berchiche *et al.,* 1999 [field beans and brewer's grains]; Kadi *et al.,* 2004 [crude olive cake]; Lounaouci-Ouyed *et al.,* 2008 [field beans and brewer's grains]; Kadi *et al.,* 2011 [sun dried Sulla]; Lounaouci *et al.,* 2014 [field bean and pea]; Djellal *et al.,* 2016 [fresh ash]; Dorbane *et al.,* 2016 [crude olive cake]; Kadi *et al.,* 2016 [*Quercus ilex*]; Kadi *et al.,* 2017a [Sulla hay] and b [fig leaves] have already studied the possibility of substituting imported raw materials with those available locally.

Brewer's grains, an agro-industrial by-product of beer production, are locally available and can be considered a good source of protein (24%) and fibre (neutral detergent fibre [NDF]: 62.4%, acid detergent fibre [ADF]: 19.7%). Their usefulness in the feed of fattening rabbits has been proven (Maertens and Salifou, 1997; Berchiche *et al.,* 1999; Lounaouci-Ouyed *et al.,* 2008; Guermah *et al.,* 2016).

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Wheat bran is also one of the most widely available and widely used by-products in animal nutrition in Algeria. Furthermore, its chemical composition and nutritional value makes it widely used in rabbit feed (Blas *et al.,* 2000) even for high incorporation rates (Robinson *et al.,* 1986 [98.75%], Berchiche *et al.,* 2000 [56%] and Lounaouci-Ouyed *et al.,* 2014 [60%]). Simplified diets (Faria *et al.,* 2008; Molette *et al.,* 2009; Oliveira *et al.,* 2011) containing high levels of forage and/or by-products in rabbit feed could lead to consistent reduction of feed costs (–24%; Oliveira, 2011). On the other hand, agricultural surfaces and resources can be used to produce human food or, first, animal feed. Thus, it is interesting to assess whether simplified diets for livestock reduce the competition between human food and animal feed. This calculation is indeed very original in rabbit feeding.

The aim of our study was to evaluate the interest in feeding fattening rabbits with a very simplified diet, consisting only of 2 by-products (brewers' grain + wheat bran), measuring the consequences on performance of rabbits, economic efficiency and competition between rabbit feed and human food.

MATERIALS AND METHODS

Experimental diets

Fresh brewer's grains were obtained from a local brewery (Rouiba, Algiers) and sun-dried at CFPA of Mechtras (Tizi-Ouzou). Due to its high moisture content (80%), it was spread out in a thin layer on a plastic sheet and turned twice a day to improve the drying process and avoid bacterial and fungal contamination (Simas *et al.,* 2007). After 5 d, the dried grains are bagged, weighed and transported to the feed mill SARL "Production locale" located in Bouzareah (Algiers) for their incorporation to the experimental diet. Wheat bran was provided by the feed mill from surrounding wheat mills.

A simplified experimental feed (SF) consisting of these 2 locally available industrial by-products (brewer's grain and wheat bran) was formulated using the WUFFDA software (http://world-rabbit-science.com/Documents/Formulation/Formulation-general.htm), to fit the nutritional requirement of the growing rabbits (De Blas and Mateos, 2010). It was compared to a control diet (B0) containing barley, soybean meal and alfalfa. Both feeds are pelleted (4 mm diameter, 10 mm length). Ingredients and nutrient content of the 2 experimental diets are given in Table 1.

Animals and measurements

The trial was carried out in the rabbitry of the centre of vocational training (CFPA) of Mechtras located near Tizi-Ouzou (Algeria). A total of 68 rabbits of a local white population weaned at 35 d (body weight 833±126 g) were divided in 2 groups (n=34 in each), according to weaning weight and litter origin. The rabbits come from a commercial farm located in Tizi-Ouzou (35 km away from the experimental site).

The rabbits were identified and placed in wire mesh individual cages (56×38×28 cm) in flat deck layout till 77 d old of age. During the 6 wk of the experiment, rabbits were fed *ad libitum* one of the experimental diets, with a weekly control of live weight, feed intake and a daily control of mortality and morbidity, as recommended by Fernandez-Carmona *et al.* (2005). Fresh drinking water was freely available.

For organisational reasons, the slaughter took place one day after the end of the experiment (77 d of age +1 d). Twenty rabbits per diet, selected from the average weight of each group, were slaughtered at 10:00 am, without prior feeding, under controlled conditions. Following the recommendations of Blasco and Ouhayoun (1996), the weight of full digestive tract, skin and hot carcass were recorded immediately after slaughter. The carcasses were placed in a ventilated cold room (4°C) for chilling during 24 h. Then, the weight of cold carcass, liver, perirenal fat, inguinal fat, scapular fat, dorsal and thigh length and lumbar circumference were recorded.

Chemical analyses

Chemical analyses of diets were performed at INRA (Occitanie Toulouse centre, UMR 1388 GenPhySE) according to European harmonised procedures (EGRAN, 2001): dry matter, crude ash, crude protein (N x 6.25, Dumas method, Leco), gross energy (Parr adiabatic calorimeter) and fibre fractions (NDF, ADF, acid detergent lignin [ADL]) according to the Van Soest sequential method. The pellet hardness (Kahl index) corresponds to the pressure (kg) for breaking a pellet, using a Kahl apparatus (Noyon, France) on a set of 20 pellets.

Table 1: Ingredients, measured nutrient content and hardness of the control (B0) and simplified diets (SF).

	B0	SF	Brewer's grain	wheat bran
Ingredient (%)				
Brewer's grain	-	27		
Wheat bran	31	72		
Barley	20	-		
Soybean meal	12	-		
Local dried alfalfa	35	-		
Minerals	1	0,5		
Premix	1	0,5		
Nutrient content (g/kg dry matter)				
Dry matter, DM (g/kg)	890	884	901	874
Crude ash	76	48	54	39
Crude protein, CP	161	157	204	145
Neutral detergent fibre	280	377	602	276
Acid detergent fibre	150	124	213	85
Acid detergent lignin	38	34	43	32
Gross energy, GE (MJ/kg)	16.00	16.90	19.90	16.30
Digestible energy, DE (MJ/kg[1])	10.11	11.44		
Digestible protein, DP (g/kg[2])	106	103		
DP/DE	10.50	9.35		
Hardness (Kahl index) [3]	12.2±1.6	13.2±0.9*		

[1]Estimated by the equation of Maertens *et al.* (1988): DE (MJ/kg DM) =0.8–0.230 ADF (%DM)+0.80 GE (MJ/kg DM).
[2]Estimated by the equation of Villamide and Fraga (1998) : DP (g/kg)=–34.67+0.876×CP (g/kg).
[3]Kahl index=Force (kg).
* *P*=0.0351.

Economic efficiency

Economic efficiency was calculated from the equation of Asar *et al.* (2010) modified by Mouhous *et al.* (2017):

Economic efficiency (%)=[weight gain revenue (€/kg)–total feed cost (€/kg)]/[total feed cost (€/kg)]×100,

where weight gain revenue (€/kg)=total weight gain (kg)×price of kg live body weight (€)

Total feed cost (€)=total feed intake (kg/rabbit)×price of kg feed (€).

Initial price in Algerian Dinar (AD) were converted in euro (€) assuming that 1€=134.5 AD.

The price of a kg of feed was calculated based on the current local market prices of raw materials at the time of the experiment (April 2016): brewer's grain (0.07 €), wheat bran (0.20 €), barley (0.26 €), soybean meal (0.40 €), local dried alfalfa (0.31 €) and minerals (0.02 €)

Competition between animal feed and human food

The competition between animal feed and human food was evaluated by the method of Pothin *et al.* (2017) based on the calculation of 2 indicators: (i) SAPAA (m^2×year/kg of food): agricultural area needed to produce animal feed, allows the evaluation of competition in space, and (ii) PAACoH (%): portion in the Animal Feed of the resources that enter in Competition with the Human Food, allows the evaluation of the competition on the resources.

These two indicators were calculated by COMPETALIM calculator (Pothin *et al.,* 2017) from the composition of the feeds used in our study (Table 1).

Statistical analyses

Data were subjected to analysis of variance, using R software, version 2.15.02 for Windows® (www.r-project.org). The analysis of variance was performed to evaluate the effects of the diet on growth performance and slaughter parameters. Significant differences between treatments were determined using Duncan's test. The chi-square test was used to compare mortality and morbidity between the 2 groups.

RESULTS AND DISCUSSION

Composition of brewer's grains, wheat bran and experimental feeds

Brewer's grains are a good source of protein, fibre and energy (Maertens and Salifou, 1997). Their composition varies according to the variety of barley seeds, the fermentation and brewing process (Santos *et al.,* 2003). Brewer's grain used in our study contained 204 g/kg of crude protein (CP) (Table 1). This value was similar to that found by Guermah *et al.* (2016) which was 207 g/kg, but 15 to 20% lower than those reported by Maertens and Salifou (1997) and the EGRAN tables (Martens *et al.,* 2002). The brewer's grain used (Table 1) had appreciable NDF fibre contents (602 g/kg) close to the value (624 g/kg) obtained by Maertens and Salifou (1997) and much higher (528 g/kg) than those reported by the EGRAN (Maertens *et al.,* 2002) and Guermah *et al.* (2016; 490 g/kg). The ADF content was 213 g/kg, slightly higher (4 to 10%) than the values found by the same authors mentioned above.

The wheat bran we used in our study (Table 1) contains 145 g/kg of CP, which is close to the values reported by the EGRAN tables (150 g/kg) and by Lounaouci *et al.* (2011; 158 g/kg). Fibre content was low (276 g/kg NDF and 84 g/kg ADF) and was below the values reported in the EGRAN reference tables (405 and 118 g/kg for NDF and ADF, respectively; Maertens *et al.,* 2002) and Lounaouci *et al.* (2011; 397 and 119 g/kg). These variations in the chemical composition of wheat bran is normal and already reported (Blas *et al.,* 2000; Boudouma, 2009).

The measured nutrient contents of the experimental diets (Table 1) were lower than the calculated composition, particularly for ADF. Accordingly, the ADF level of the SF diet was lower than expected and relatively lower than the classic fibre recommendations (Gidenne, 2015b)

Pellet size and hardness may affect the feeding behaviour of rabbits (Maertens and Villamide, 1998). The hardness of the pellets was 8% higher in SF diet than in control diet ($P=0.035$), which may partly explain the scratching behaviour (and feed waste) observed during 2 wk in 8 rabbits fed the SF feed (against 3 rabbits in the B0 group).

Table 2: Rabbit health in control (B0) and simplified diets (SF) groups.

Group	B0	SF	Significance
Rabbits (n)[1]	34	34	
Morbidity[2] (n)			
from 35 at 56 d	2/34	4/34	NS
from 56 at 77 d	2/31	3/29	NS
from 35 at 77 d	4/34	6/34	NS
Mortality (n)			
from 35 at 56 d	3/34	5/34	NS
from 56 at 77 d	0	0	
from 35 at 77 d	3/34	5/34	NS
Health risk index[3] (n)			
from 35 at 56 d	5/34	9/34	NS
from 56 at 77 d	2/31	3/29	NS
from 35 at 77 d	7/34	11/34	NS

[1] Number of rabbits at start of test. NS: Not significant.
[2] Morbidity: Corresponds to ill rabbits (but still alive within a period), showing digestive troubles (diarrhoea) or severe loss of weight during a week, or an abnormally low growth.
[3] Health risk index was the sum of morbid and dead animals.

Health status, feed intake and growth of animals

The health status was similar in both groups ($P>0.05$; Table 2). The number of dead rabbits was 3/34 in B0 group and 5/34 in SF group. Autopsy of the dead animals revealed lesions attributable to coccidiosis, enterocolitis and respiratory disorders, with 3, 2 and 3 cases, respectively. Symptoms of diarrhoea were observed in 3 animals (1 in B0 and 2 in SF group). All mortality occurred during the first and second week of fattening, which could be related to weaning stress (transport, building change, cages and feed). The health risk index (HRi: corresponding to the sum of morbid and dead animals according to Gidenne *et al.,* 2010) did not differ between the two groups and was given only as an indication, due to the limited number of rabbits.

As expected, for the whole experimental period (35 to 77 d of age), the growth (–11%) and feed intake (–12%) was lower (Table 3) in SF group than in B0 group ($P<0.001$). However, the feed conversion ratio was similar in both groups (3.55).

Table 3: Growth of rabbits, feed intake and feed conversion ratio in the control (B0) and simplified diets (SF) group.

Group	B0	SF	SEM	*P*-value
Rabbits (n)[1]	31	29		
Period 35-56 d				
Live weight at 35 d (g)	833	834	22	0.98
Live weight at 56 d (g)	1677	1442	36	<0.001
Weight gain (g/d)	40.0	34.0	1.1	<0.001
Feed intake (g/d)	105.7	101.4	3.1	0.001
Feed conversion ratio	2.9	3.0	0.1	0.32
Period 56-77 d				
Live weight at 77 d (g)	2271	2047	40	<0.001
Weight gain (g/d)	33.6	29.8	0.9	0.003
Feed intake (g/d)	135.9	117.4	3.0	<0.001
Feed conversion ratio	3.93	4.03	0.12	0.50
Period 35-77 d				
Weight gain (g/d)	35.2	31.2	0.7	0.001
Feed intake (g/d)	128.3	113.0	2.4	<0.001
Feed conversion ratio	3.52	3.59	0.10	0.51

[1]Number of rabbits at the end of the experimental period. SEM: standard error of mean.

The growth rate was lower in the SF group than in the control group for the periods 35-56 (–15%), 56-77 (–11%) and 35-77 d of age (–11%) respectively. These results could be explained by the lower amount of feed intake (–12%) in the SF group than in the control, for the whole period. The lower feed intake in the SF group was probably due to its lower lignocellulose content, which was proposed as a limiting factor of feed intake in the SF diet (Gidenne *et al.,* 2017).

During the overall period (35-77 d), rabbits in the SF group showed acceptable growth rate (mean: 31 g/d), which was slightly higher than that recorded in previous studies (25-31 g/d) with feeds based on imported raw materials (Lounaouci-Ouyed *et al.,* 2008; Lounaouci-Ouyed *et al.,* 2014; Hannachi-Rabia *et al.,* 2017).

In addition, the feed conversion ratio was similar to previous results (Gidenne *et al.,* 2017) and was similar in the 2 groups (3.55). The performance traits of the rabbits fed the SF diet were therefore very encouraging.

Table 4: Slaughter performance of rabbits in the control (B0) and simplified diets (SF) group.

Group	B0	SF	SEM	*P*-value
Body weight (g) (78 d)	2249	2211	35	0.461
Weight of skin (g)	283	248	5	<0.001
Weight of full digestive tract (g)	365	407	8	<0.001
Hot carcass weight (g)	1413	1309	24	0.005
Cold carcass weight (g)	1350	1238	24	0.002
Liver weight (g)	94	68	3	<0.001
Perirenal fat (g)	26	19	2	0.030
Inguinal fat (g)	17	10	0.9	<0.001
Scapular fat (g)	7.8	5.9	0.6	0.029
Kidneys weight (g)	15	15	0.5	0.003
Dorsal length (cm)	25	24	3.0	<0.001
Thigh length (cm)	7.7	7.9	0.1	0.034
Lumbar Circumference (cm)	17	16	0.1	0.231
Dressing out percentage of hot carcass (%)	63.0	59.7	0.7	0.003
Dressing out percentage of cold carcass (%)	60.2	56.6	0.7	<0.001

SEM: standard error of mean.

Table 5: Economic performance of rabbit units according to the diet offered to animals (control, B0 or simplified, SF).

Parameters	B0	SF
Live weight at 35 d (g)	833	834
Live weight at 77 d (g)	2271	2047
Total weight gain (kg)	1.438	1.213
Price (€/kg live weight)	3.72	3.72
Revenue in total weight gain (€)	5.34	4.51
Total feed intake/rabbit (kg)	3.52	3.59
Feed price (€/kg)	0.27	0.17
Feed cost (€/kg live rabbit)	0.95	0.61
Economic efficiency (%)	454	638
Revenue (€/kg meat produced)	2.75	3.11

Slaughter performances

Both feeds allowed the rabbits to exceed 2 kg live weight in six weeks of fattening (Table 4), which is the optimal weight for the local market (Kadi *et al.,* 2008).

Intake of the simplified feed had a depressive effect on slaughter performance. Cold yield was higher in the control group than in the SF group (60.5 *vs.* 56.6%, $P<0.001$). This result could be explained by a heavier full digestive tract (+10%) in the control SF group compared to the control group (407 *vs.* 365 g; Lebas and Laplace, 1982). However, intake of the SF feed (less energetic) was lower than that of the control feed, and leads to less fatty carcasses, considering perirenal fat (–27%), inguinal fat (–41%) or scapular fat (–14%).

Economic efficiency

The results of the economic evaluation are summarised in Table 5. The animals in the control group recorded relatively higher weight gain than those of the SF feed (1.44 *vs.* 1.21 kg) throughout the entire fattening period. However, the feeding cost was 36% lower for SF than for control diet (0.61 *vs.* 0.95 €/kg). This reduction in feed cost was explained by the difference in price of both feeds (0.17 *vs.* 0.27 €/kg). Indeed, a simplified feed, made up with only 2 locally sourced by-products (brewer's grain and wheat bran), made it possible to achieve a competitive price compared to a control feed, mainly composed of imported ingredients. Thus, the revenue was 40% higher in SF than in control group (+ 0.35 €/kg of rabbit carcass).

Competition with human food

The production of SF feed requires less cultivation area than the control feed 0.47 *vs*. 1.26 $m^2\times$year/kg respectively. This can be explained by the raw materials (barley, soya bean and alfalfa) composing B0 and which require more surfaces.

For the competition of feeds with human food, the PAACoH indicator was 20 and 0% respectively for B0 and SF feeds. For the latter, a value of 0% means that none of the raw materials used in the SF feed are used in human food. However, the score recorded for this parameter by the control feed (20%) was also relatively low (Pothin *et al.,* 2017).

CONCLUSION

Feeding rabbits with a simplified feed containing only brewer's grains and wheat bran allowed the production of low fat rabbits weighting more than 2 kg at 11 wk of age, without reducing the feed conversion ratio, while improving the economic efficiency of production and reducing the competition with human food.

Based on these first results, it seems interesting to evaluate the digestibility of simplified diets as well as the feeding behaviour (hardness and palatability of pellets) and health status of the animals using a larger number of rabbits, while combining other local sources in a simplified formulation for feed at lower cost and not competitive with human food.

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