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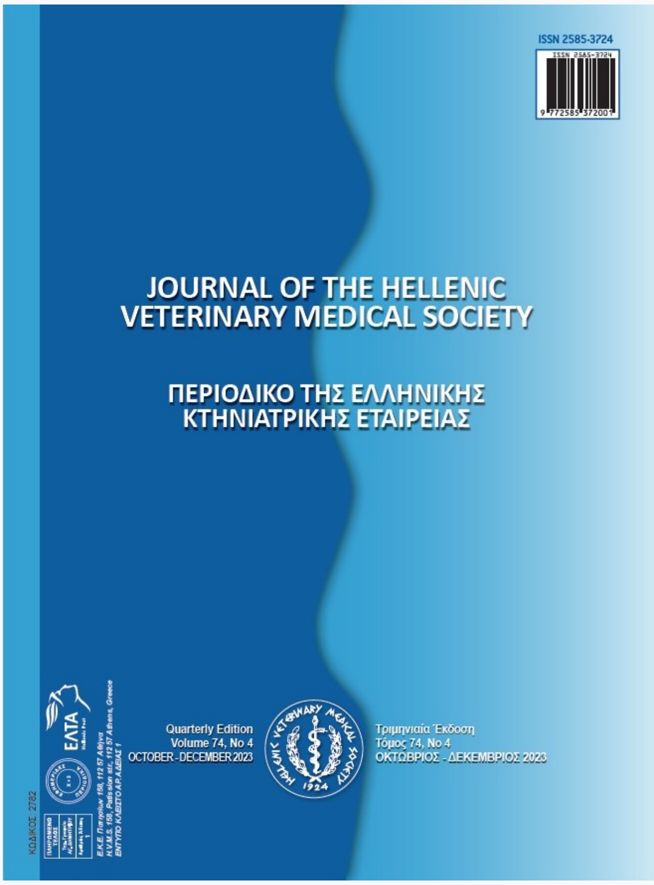

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Research article
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Effect of carob (*Ceratonia siliqua*) on growth parameters and viability of local Algerian rabbit populations (*Oryctolagus cuniculus*)

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ABSTRACT: This study aims to evaluate the effect of incorporating different levels of carob on growth parameters and the viability of rabbits. Carob diets with 3.5 kg/T, 5 kg/T, and 100% carob were distributed to 3 groups of kids from the local population, from weaning at 28 days to slaughter at the age of 110 days. The results show the effect of using carob on the live weight (1356.95 g) of the rabbits and led to a decrease in feed conversion ratio, good feed efficiency, and feeding costs. However, the average daily gain had been affected by the addition of carob to the diet between the groups control and the other groups in the whole period between 28 and 42 days of age and 42-108 days($P < 0.01$).Carob improve growth rate in rabbits with a little and best performing consumption index (3.32) during the growing period for a rabbit weaned at 28 days (Group 1) in comparison with the groups Group C, Group 2, and Group 3 respectively (3.87, 5.38, 3.73). The effect has been significant between the groups between 42 and 108 days of age ($P < 0.01$) but it was not different for the period between 28-35 days ($P = 0.115$).Mortality and morbidity measurements do not indicate any significant effect of carob use on the health status of rabbits ($P < 0.05$).On the other hand, the incorporation rate of 3.5 kg/T of carob gives good feed efficiency and carcass weight (1854 g)compared to 5 kg/T(1730.5).In conclusion, the supplementation of carob may improve the growth performance, dressing yield,and carcass weight of local rabbits.

***Keywords*:** Carob; growth performance; Local rabbit; Morbidity; Yields.

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INTRODUCTION

Rabbit meat is considered high-quality meat since it is high in protein while being low in fat, cholesterol, and sodium (Jones, 1990). Because it does not produce uric acid during metabolism, rabbit meat is recommended for people (Iyeghe-Erakpotobor, 2007). Rabbits are efficient converters of feed to meat and can utilize up to 30% of crude fiber as against 10% for most of the poultry species (Egbo et al., 2001).

The growth of rabbit production in Algeria was slow and suppressed for a long period. Production of rabbit meat came mainly from subsistence-oriented family farms, usually maintained by women. In reality, rabbit meat consumption is insufficiently anchored in culinary traditions compared to other types of meat that are widely consumed, namely sheep and chicken (Sanah et al.,2020).This situation prevailed until the eighties when we saw the emergence of a rational area consisting of medium units and marketing-oriented productions (MeftiKorteby et al., 2014). Because of its adaptability, the Algerian scientists opted to include the local rabbit in rational farms. It is inadequate to just leave the animals alone while improving the environment (MeftiKorteby et al., 2014). The local rabbit is of small size with an average breeding performance whose coefficient of variation is high (MeftiKorteby et al., 2010) and a relatively low prolificacy at birth and weaning (Zerrouki et al., 2001, 2002, 2003). It is characterized by a high reproduction ability with a short generation interval, so it can produce a high quantity of meat in a short period. (Zerrouki et al., 2005). It is also endowed with proven resistance to heat, and adaptation to harsh climatic conditions and poor quality food (Belabeset al., 2011).

The early fattening period (from weaning to about 56 days) is critical in rabbit production. Antibiotics are often used to solve these difficulties. But at the same time, natural solutions are more and more sought after (Maertens et al., 2006). Carob seed and pod can be one of these solutions. Thus, positive effects on diarrhea prevention have been observed in piglets (Lizardo et al., 2002; Lallès et al., 2007) and rabbits (Teillet et al., 2011). Many studies (Medjekal et al. 2018; Abdel-Wareth et al.2019; Awawdeh et al. 2019; Ozunget al. 2022) reported that alternative feed resources may be employed for animal feeding without negatively impacting production performance, reducing livestock reliance on conventional feed.

Carob (*Ceratonia siliqua*) is an ancient Middle Eastern tree that is now grown in many other parts of the world (Gugliuzzo et al., 2019). It contains 40 percent of carbohydrate, 1 percent of fat, and 4 percent of protein, and comprises high fiber, vitamins E, D, C, and B6, niacin, folic acid, polyphenol, and minerals such as potassium, sodium, calcium, iron, and phosphorus (Mokhtary et al., 2013). In addition, carob has exhibited significant pharmacological activities in the digestive tract including antidiarrheal, antibacterial, anti-ulcer, and anti-inflammatory actions, and possesses a laxative effect on gastrointestinal propulsion (Fidan et al., 2020). Carob shows a wide variety of health benefits, including its ability to boost the immune system, reduce the risk of cancer, improve digestion, slow down aging, prevent cardiovascular diseases, and help prevent and manage diabetes (Kaïs et al., 2017). Studies showed that carob improved blood pressure and diabetes (Mokhtary et al., 2013). Lipid parameters and histopathology of the heart, liver, and kidneys were improved by the supplementation of 10 and 20% carob powder in the diet (Hassanein et al., 2015). Carob administration reduced levels of malondialdehyde, and increased levels of antioxidant enzymes in the ulcerative colitis mice model (Rtibi et al., 2016), anti-inflammatory (Aboura et al., 2017), and neurotoxic (El-Sayyad et al., 2017), properties have been reported for carob.

In Algeria, the carob treegrows throughout a broad area,from East to West, spanning low and medium elevations as well as semi-arid and humid bioclimates (kocherane et al., 2019).

In the last three years, a few important review articles have been published about the medicinal and nutritional properties of carob, and the few important studies that have concerned the use of carob in animal feed have been limited to the incorporation of its pulp in rations for fattening (Benbatiet al., 2021). Little information is available on feeding carob on growth performance, nutrient utilization, and carcass quality in the rabbit and precisely on the local rabbita little for the little studies. Therefore, this present work was undertaken to investigate the effects of different doses of the fruit extract (Ceratonia siliqua) on the growth performance (Ingestion, Weight gain, and Consumption Index), carcass quality, and the viability of the local rabbit to reduce the cost of animal feed, by far the most important item of expenditure in animal husbandry, while maintaining good performance.

MATERIALS AND METHODS

The trial took place from February to May 2020, on a strip of animals, in a favorable location for breeding (well isolated and less stressed) to compare two carob seed incorporation rates (5 and 3.5 kg/T) according to the same protocol. The study was conducted by following the ethical guideline approved by the Institutional Animal Care Committee of the National Administration of the Algerian Higher Education and Scientific Research (Ethical approval number: 98-11, Law of August 22, 1998) and was conducted according to the recommendations of the "Guide for the Care and Use of Laboratory Animals". No medication was administered in the feed, drinking water, or injectable form, and the treatment was carried out in two stages: adaptation or habituation to the experimental feed (7 days) and measurement of growth parameters and quality meat.

Animals and housing

The animal material is represented by 32 kids of the local population, obtained from a small breeding farm in the region of Batna (east of Algeria). The age of the animals at their reception is 28 days, from weaning (at 28 days) until the age of 110 days. They are kits, having undergone early weaning. The kits were healthy and their condition was judged as good at the commencement of the experiment. They were placed in digestibility cages allowing the collection of feces and were divided according to the litter into four groups to reduce the heterogeneity between individuals: control group (C) and experimental groups G1, G2, and G3. Animals from experimental groups G1, G2, and control group (C) were given a granulated feed for fattening at will. It is of local manufacture and based on 7 ingredients: barley, corn, alfalfa flour, wheat bran, soya, and mineral-vitamin complement. It is presented in the form of granules with a diameter of 2.5 mm and a length of 4 to 20 mm. The chemical composition of granulated feed and carob are provided by the animal feed production unit of FAB GRAIN (Sétif, Algeria) and shown in Table 1.Thecarobs that are used were collected in north Algeria which is Jijel. The supplementation levels (3.5 kg/T, 5 kg/T, and 100% carob) were based on research carried out in the same context.

-Group (C): Control group, the granulated feed is given alone to the control group (n=7);

-Group (G1): The kits (n=10) received an incorporation rate of 3.5 kg/T of carob seeds (from carob seeds cleaned of their various impurities, then crushed) to investigate whether a lower dose is also effective;

-Group (G2): The kits (n=11) received an incorporation rate of 5kg/T carob seeds to facilitate the detection of a possible zoo technical effect;

-Group (G3): The experimental diet of kits in this group (n=4) contains only carob to investigate a possible zoo technical effect.

The experiment was carried out in a ventilated, closed building (temperature range = 17 to 24 ºC).It is designed in brick, with two ventilation openings and a door on the northwest side. The kits were housed in individual flat-deck wire cages (area 0.34 m^2) under a constant photoperiod of 14 hours of daylight. Each cage is equipped with a feed trough and a gravity watering system using teats. It is a "drop by drop" distribution. Automatic drinking troughs provided water at all times.

Ventilation and lighting are naturally provided by the windows and artificially by 4 lamps of 60W each. The weighing of the animals and the feed is carried out with two different electronic scales with respective capacities of 5 and 10 Kg.

METHODS

1. Experimental design and diets

The animals are identified and weighed on arrival and placed in the cages according to litter size. The kits were subjected to7days of rearing adaptation (adaptation to the environment, cages, feed, and watering system) before the experiment to ensure feed acceptability and to determine the amount of feed to be fed to the kits.

The first trial started with a post-weaning period of 21 days (adaptation and measurement phase).

-The 2nd trial started from the 13th week to the 15th week (to look for possible effects of the carob at

Table 1. Chemical composition (% DM) of the experimental diets (Guenaoui, 2019).

Composition	DM (%)	MAT (%)	Total minerals (%)	Cellulose fiber (%)	Gross energy, (Kcal/kg)
Granulated feed	89.58	19.61	7.41	14.43	2403
Carob	88.7	6,38	2.76	12	2147

the end of the fattening period).

2. Measurement of zootechnical growth performance and health status control

Measures included feed intake, daily weight gain, feed efficiency, and slaughter yield. Food intake and daily weight gain, and feed efficiency were measured every day to allow the detection of growth disturbances.

Recording of feed intake (FI)

The rabbits were supplied with experimental diets; twice daily and leftover was collected. The refusal of concentrate feed of the subsequent days was collected, weighed, and recorded the following morning before offering a feed. The following formula was used to determine the amount of food consumed: Feed intake (FI) was calculated as follows:

FI (g/rabbit) = Feed supply (g) - leftover (g)

Measurements of live weight, live weight gain and feed conversion ratio

At the start of the experiment, the rabbits were individually weighed, and the average weight was used as the initial body weight. Following that, the rabbits were weighed individually every week before morning feeding using an electric digital weighing balance. The FCR (feed conversion ratio) and weekly live weight gain were calculated as follows:

FCR=Total Feed Intake (g) / Weekly Live Weight Gain (g);

Weight Gain = (Final body weight - Initial body weight).

Calculation methods for zootechnical parameters

- Bodyweight (BW): It concerns a weekly weighing of animals.
- Average daily gain (ADG) (g/d) = (final weight - initial weight) / number of days of measurement.
- Average daily consumption ADC (g/d) = (Distributed uneaten) / the number of individuals present.
- Consumption Index (CI) = Average Feed Consumption (AFC) (g/Day) / Average Daily gained (ADG) (g/Day).
- Slaughter yield = (carcass weight / live weight) (x) 100.

Health status control

Health status was individually recorded from weaning to slaughter: every day for mortality and to check all clinical signs of sickness (transient diarrhea, presence of mucus in excreta, abnormal behavior, etc), and the apparent causes of death are recorded. In addition, morbidity was defined as animals still alive at the end of the period but showing digestive disorders, diarrhea, enterocolitis, paresis, respiratory disorders, and others).

Because each animal was only recovered once and classified as either dead or morbid, we calculated a health risk index (HRi) proportional to the sum of morbidity and mortality rates.

Carcass quality measurement

At the end of the experimental period, the rabbits were weighed and slaughtered in an experimental slaughterhouse for the measurement of carcass and the slaughter yield. The carcasses were prepared by removing the stomach, small intestine, large intestine, and urinary bladder with contents Commercial carcass weights were obtained after chilling for 24 hours in a ventilated cold room (0 to 4ºC), according toBlascoet al. (1996); Ouhayounet al. (1986). The meat samples were collected one hour after slaughter, wrapped in aluminum foil, and stored at 4°C for 24 hours.

3 Statistical analysis

Data were expressed as percentages and mean ± standard deviation. All collected data and sample evaluated values were imported into Microsoft office Excel-2007 and transferred to Minitab for analysis. Descriptive statistics of some parameters were performed. Quantitative performance parameters from different groups of carob incorporation were performed with test Student"t" using Minitab. Data of mortality and morbidity parameters were treated and were compared by one-way ANOVA using Minitab. Mortality and morbidity rates were presented according to the diet effect only.

The level of statistical significance was $p<0.05$. The differences in different parameters were considered significant when the p-value was < 0.05 and highly significant when the p-value was <0.01.

RESULTS AND DISCUSSION

The findings on growth performances along with different parameters are discussed hereafter following some different subheadings.

Feed intake (FI)

The average feed intake measured in (g) during the twelve weeks of the growth test for the four lots is reported in Table 2.

In the control group, we recorded a slight increase during the first week, from 58.2 g/d to 67.81 g/d, reaching the highest intake during the 3rd and 4th weeks, which is 81.87 g/d. The same fluctuation was noted in Group 2, Group 1, and Group 3, only for the latter, a fall in consumption was noted in the third week (50.13 g/d and 50.43 g/d) respectively, then a relative rise in the fourth week to stabilize in the last two weeks of the measurements. These fluctuations are probably related to stress and carob supplementation. Overall consumption follows an upward trend, which would be explained by the age of the rabbits with increasing growth requirements (Lebas, 2013).

The average feed intake recorded throughout the test is 95.2 g/d. It is similar to values reported by other authors in local rabbits where they reach 109g/d (Meftikorteby et Lebas, 2010), 93.54g/d (Beskri, 2019). It remains, however, higher than the intake reported by-Moulla et al. (2008) in local rabbits (69.8 g/d).

Rabbit growth performance

Table 3 summarizes the growth performance of rabbits fed different types of feed. The average daily body weight (g) changes of kits in different groups, during the experimental period, have been presented in Table 3 and graphically represented in Figure 1.

Table2. Average ingested quantities (g) were recorded during the test.

Period Food (g/day)	Group (C)	Group 1	Group2	Group 3
28-35 days	58.2	65.1	80.26	82.33
35-42 days	67.81	50.13	73.83	50.43
42-49 days	81.87	60.91	89.61	86.4
49-108 days	161.05	153.60	160.30	146.2
Average (g/d)	92.23	82.435	101	91.34

Table 3. Average zoo technical performance between 28 and 108 days of the age of the local rabbit.

	Age	BW(g)	Feed g/d	g/d/kg of body weight	ADG (g/d)	IC
Group C	28-35	651	58.2	89.4	31.97	1.95
	35-42	793.62	67.81	85.44	17.67	3.93
	42-49	850.42	81.87	96.27	19.51	3.98
	49-108	2587.06	161.05	62.25	28.64	5.62
	Average	1220.525	92.2325	83.34	24.44	3.87
Group 1	28-35	658.5	65.1	98.86	22.28	3.57
	35-42	852.75	50.13	58.78	24.42	2.3
	42-49	1000.85	60.91	60.85	19.1	3.35
	49-108	2801.4	153.6	54.82	37.48	4.09
	Average	1328.37	82.43	68.32	25.82	3.32
Group 2	28-35	804.37	80.26	99.77	27.08	3.8
	35-42	897	73.83	82.3	17.19	4.93
	42-49	995.71	89.61	89.99	15.26	6.1
	49-108	2730.74	160.3	58.7	23.94	6.69
	Average	1356.95	101	82.69	20.86	5.38
Group 3	28-35	581.8	82.33	141.5	32.5	2.53
	35-42	634.3	50 .43	79.5	22.5	2.24
	42-49	650.1	86.4	132.9	25	3.45
	49-108	2552.88	146.2	57.26	21.76	6.71
	Average	1104.77	104.97	102.79	101.76	3.73
	Overall period	**1252.46**	**95.2**	**84.3**	**24.1**	**4.07**

BW: body weight, ADG: Average daily gain, CI: Consumption Index
The differences in different parameters were considered significant when the P-value was < 0.05.

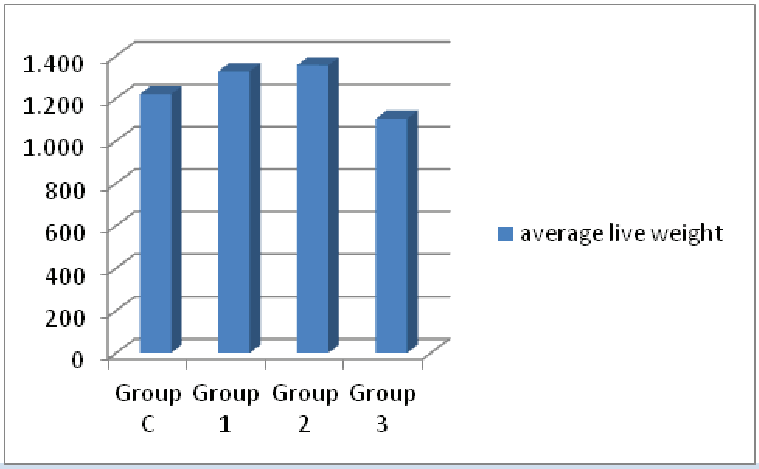

Figure 1: The average live weight (g) according to age.

Growth (evolution of weight)

During the trial period, the curves of the evolution of kit weight gain of the four groups are represented in figure1; show an average live weight of 1220.52g, 1328.37g, 1356.95g, and 1107.02g for groups C, G1, G 2, and G 3, respectively.

The Average Daily Weight Gain (g) calculated every week during the 9 week feeding trial period is presented in Table2. The ADG (g) in the experiment was 24.44g (Control group), 25.82g (G1), 20.86 g (G2) and 101.76g (G3).

At weaning, the kits had different live weights, even though they came from the same litter (Ouhayoun, 1986). The average live weights of the kits at weaning were 651g, 658.5g, 804.37g, and 581.8g for Group C, G1, G2, and G3 (28-35 days). It is higher than that observed by Zerrouki et al. (2007) in local rabbits (475g), lower than that recorded by Ponjardieu and Matheron (1984)in New Zealand rabbits (840g), and similar to that observed in 28 to 35 days by Beskri (2019) (640g).

Between 42 and 49 days of age, the average live weight of the rabbits of the same group (C) was 850.42g (Table 3) with a decrease of 150.43g, compared to G1, and then increased to 2587.06g at 108 days of age (end of the trial). This final live weight is close to that recorded by (Beskri, 2019) and is higher than those recorded in rabbits of local strains: 1675.66g (at the end of fattening); 1733g, and 1610.4g, reported respectively by Moulla et al. (2008); Mefti Korte by et al. (2010).

The body weight (g) changed from 651 g, 658.5 g, 804.37 g, and 581.8 g on day 1 of the experiment to 2587.06 g, 2801.4 g, 2730.74 g, and 2552.88 g at the 12th week of the experiment in groups C, G1, G2, and G3, respectively, and it was observed that body weight gain in groups fed with carob was almost different. This is probably due to the deficiencies and eating disorders (pecking) recorded during the same period in rabbits (G2). However, we note a remarkable drop in intake towards the end of the adaptation period. According to (Gidenneand Fortun-Lamothe, 2002), when given an unbalanced food (carob alone), the young rabbit does not manage to regulate its intake. On the other hand, the rabbits receive the carob crushed into pieces of different sizes. These two factors (composition and presentation of the food) may be at the origin of this ingestibility. In addition, the hardness of the food may also affect feeding behavior (Maertens and Villamide, 1998).

Statistical analysis revealed that there were no significant differences ($p > 0.05$) between groups during the period (28 days to 49days) among the carob (Table 4). The Carob effect, in general, was not significant ($p > 0.05$) (28-49 days). It is possible that the rabbits were still developing. Furthermore, the difference was significant (28-49 days) between group C and G 1 ($p = 0.000$), G1 and G2 ($p = 0.000$) for the period of (49-108 days) between the bodyweight gain among the effect of carob.

These statistical results show the effect of using dry carob and also with an incorporation rate of 3.5kg/T on the live weight of the rabbits.

2 Speed of growth

In practice, the speed of growth is expressed by the average daily weight gain (ADG) achieved during a referenced period.

The Average Daily Weight Gain (g) calculated every week during the 9 week feeding trial period is presented in Table 2. The ADG (g) in the experiment was 24.44 (GT), 25.82(G1), 20.86 (G2), and101.76 (G3).

The values of the average daily average gains (ADG) calculated during the twelve weeks of the trial are reported in Table 3.

At 49 days of age, after 3 weeks of rationing, and while the animals in all three groups consumed almost the same amount of feed, the animals in group 1 (G1) weighed 73.53 g more than those in the control lot. The animals in groups C, 1, and 2 weighed 146g, 218.4g,and 280.34g more than the animals in group 3 (dry carob) respectively.

Animals fed the carob from group 2 (G2) (5 kg/T) weighed 61.81g more than those fed (3.5 kg/T) and over 134.34g more than the animals from the control group (C).

The average daily gain findings in Figure 2, show significant fluctuations for the two phases represented as follows with an average of: 22.5 (g/d), 21.7 (g/d), 20.2 (g/d),and 25.8 (g/d) for group (C), group (G1), group 2 (G2) and group 3 (G3) respectively.

These fluctuations in ADG observed particularly in the control group are explained by the rabbit's good ability to process the food well and in the other three groups, probably to the poor transformation of the carob by the rabbit's digestive tract and diarrhea that occurred from the first days of the measurement period (Guenaoui et al., 2019).

Table 4. Effect of carob on growth performance of the local rabbit in control (C) and testgroups (Group 1, Group2, and Group 3).

	Group C	Group 1	Group 2	Group 3	P
BW(g)					
28-35day	651	658.5	804.37	581.8	NS
35-42day	793.62	852.75	897	634.3	NS
42-49day	850.42^{a}	1000.85^{b}	995.71^{b}	650.1^{a}	P <0.01
49-108day	2587.06^{a}	2801.4^{c}	2730.74^{b}	2552.88^{b}	P <0.01
ADG (g/d)					
28-35 days	31.97^{a}	22.28^{b}	27.08^{c}	32.5^{b}	P <0.01
35-42 days	17.67^{a}	24.42^{b}	17.19^{c}	22.5^{b}	P <0.01
42-49 days	19.51^{a}	19.1^{a}	15.26^{b}	25^{c}	P = 0.003
49-108 days	28.64^{a}	37.48^{b}	23.94^{a}	21.76^{a}	P = 0.000
Consumption index					
28-35days	1.95	3.57	3.8	2.53	P = 0.115
35-42days	3.93^{a}	2.3^{b}	4.93^{a}	2.24^{a}	P<0.01
42-49days	3.98^{a}	3.35^{b}	6.1^{b}	3.45^{b}	P<0.01
49-108days	5.62^{a}	4.09^{b}	6.69^{c}	6.71^{c}	P<0.01

The differences in different parameters were considered significant when the P-value was <0.05

^{abc} Means in the same row without a common letter are different at P<0.05.

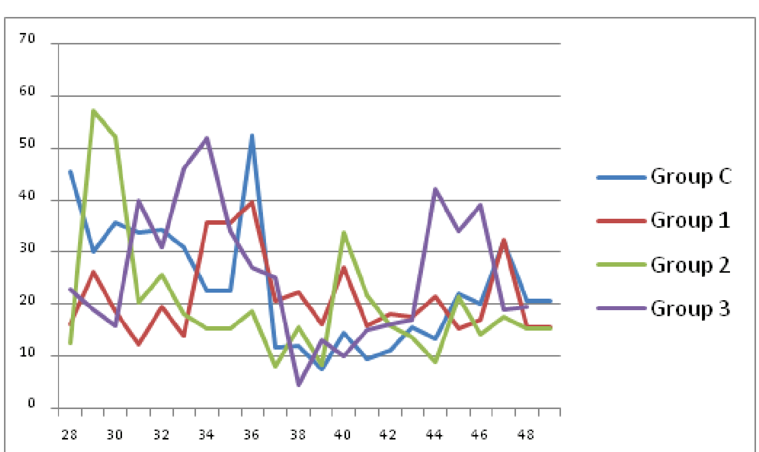

Figure 2: Evolution of Average Daily gain (ADG) of the groups according to age.

3 Live weight gain

The live weight gain findings in Figure 2 show significant fluctuations for the two phases represented as follows with an average of 22.5 (g/d), 21.7 (g/d), 20.2 (g/d), and 25.8 (g/d) for Group C, G1, G2, and G3, respectively. These fluctuations observed particularly in the control group are explained by the rabbit's good ability to process the food well and in the other three groups, probably to the poor transformation of the carob by the rabbit's digestive tract and diarrhea that occurred from the first days of the measurement period (Guenaoui et al., 2019). It is reported that the best ADG obtained is that of group 3 compared to the other three groups, which are almost similar. The finding showed that supplementation of carob affected the live weight gain and consumption index (CI) and significant variation *(*$p < 0.05$) was found among the incorporation of carob among the three dietary treatment groups, with a rate of 3.5kg/T compared to 5kg/T.

4 The consumption index (CI)

The average CI values recorded during the twelve weeks of the trial are shown in Table 4 and their evolution is illustrated in Figure 3.

We record an average CI of 3.87 (Group C) which reflects an average level of food processing. The best performing CI is 3.32 obtained during the growing period for a rabbit weaned at 28 days (Group1) receiving carob supplementation. This is close to that indicated by (Guenaoui et al., 2019)(2.16 and 2.15) for rabbits during the same breeding period. The least productive, on the other hand, is 5.38 for rabbits in group 2 receiving a 5kg/t carob supplementation (obtained with rabbit7 from group 2 (10.1)).

The CI recorded is better than that reported by Meftikorteby and Lebas (2010), which is 7.1. It is similar to the one found by Moulla (2008) which reached an average value of 3 and an average of 3.5 by Beskri (2019) in local rabbits.

No significant effect was observed for the consumption index (CI) between group 3 and group C ($p = 0.115$), group C and group 1(G1) ($p = 0.419$) On the other hand, the effect was significant between G1 and G2 ($p = 0.003$), which explains the effect of carob in obtaining an efficient consumption index and that the incorporation rate of 3.5 kg/T of carob also gives good feed efficiency compared to 5kg/T.

Mortality,morbidity,and health risk index

The morbidity corresponded either to animals showing transient diarrhea (but still alive at slaughter). For rabbits, morbidity was due in 72% of the cases to diarrhea symptoms.

In the period post weaning between 28 and 35 days of age, we have contested the difference between groups in morbidity where we found a high number of animals affected by diarrhea in Group 1 (8 rabbits) compared with the second Group (2rabbits) and the third group (1 rabbit) P= 0.02. Rabbits of group 1 showed higher morbidity rates after 6 weeks of age, while those the group 2.

Therefore, the health risk index 'HRi' was higher for rabbits of G1 and G2 whole fattening period (28-35 days and 35-49 days) and then decreased for the remaining period. Even if the environment of rearing was not perfectly respected with the absence of antibiotics but the diarrheas which are observed are of type 1 and 2. The duration of these diarrheas is high

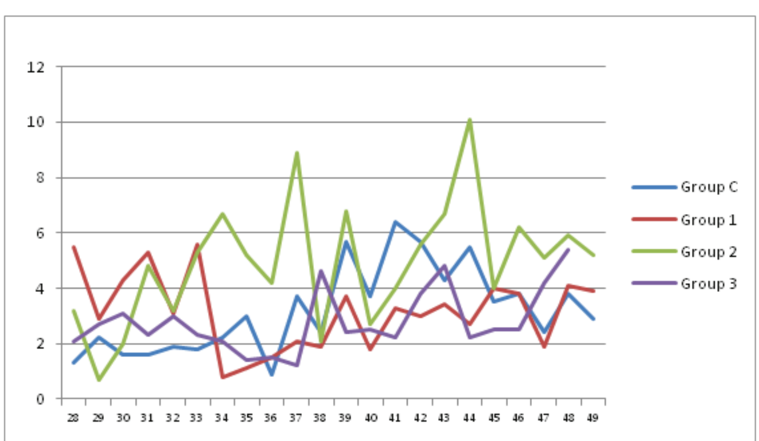

Figure 3: Evolution of the average consumption index (CI) of the groups according to age.

Table 5. Mortality, morbidity, and health risk index (HRi) results in %.

Number of rabbits	Group C	Group 1	Group 2	Group 3	Test
28-35 days					
Morbidity(%,Number)	0(7)	80(10)	2(11)	1(4)	NS
Mortality (%,Number)	0(7)	0(10)	0(11)	0(4)	NS
HRi	0	80	20	25	
35-49 days					
Morbidity(%,Number)	57.14(7)	30(10)	18.18(11)	0 (4)	NS
Mortality(%,Number)	0(7)	40(10)	27.27(11)	0 (4)	NS
HRi	57.14	70	45.45	0	
49-108 days					
Morbidity(%,Number)	0(7)	0(10)	0(10)	0 (4)	NS
Mortality(%,Number)	0(7)	0(10)	0(10)	0 (4)	NS
HRi	0	0	0	0	

HRi: health risk index. The differences in different parameters were considered significant when the P-value was < 0.05.

in the period after weaning about 7 to 10 days(Teillet et al., 2011).

The average mortality of our trial indicated in Table 5, corresponds to 40% (G1) and 27.27% (G2) recorded between 35 and 49 days of age, it is null for this same period for the control group (C) and Group 3 and even for the last period of the trial (from 49 to 108 days). The mortality rate was significantly higher for kits of group 1 compared with those fed only carobs and for incorporation of (5 kg/T) of carob (G2 and G3). Diarrhea and enterocolitis are the two main causes of mortality probably related to the ingestion of carob added with food and not distributed alone, while several authors have.

In our experiment, we found a reduction of this later when we add carob to rabbits' diets (G1, G2, and G3) from 49 to 108 days.

Whatever the trial and the period considered, the average mortality seems to be higher (33%) by the use of carob accompanied with granulated food, with differences in incorporation rate (G2 and G1) compared to G3 (dry carob) and Control group (C) (0%). This could be explained by the disturbance and the non-adaptation of the rabbits to the mixture of food with carob grains.

Mortality and morbidity measurements do not indicate any significant effect of carob use on the health status of rabbits (Table 5). Furthermore, Teillet et al. (2011) discovered and reported that carob seed extract mainly affects diarrhea at the beginning of fattening by decreasing mortality.

Out of a total of 32 rabbits, 25 were able to reach the end of the trial. Perez et al. (2000) report that in rabbit farms independent of the diet, the mortality rate by digestive disorders varied strongly according to the experimental site of the Technical Institute for Industrial (ITAVI) is between 3.3% and 9.9% from weaning to slaughter. Our results are considered acceptable (21.8%) when compared to the work of Lebas (1991) conducted under more controllable conditions. They indicate mortality rates of 8% to 12% and sometimes 25% to 30%.

Adding carob seed extract to rabbits' diets reduced mortality and improved their health in the subsequent fattening period, according to Guenaoui et al (2019). In our experiment, Diarrhea and enterocolitis are the two main causes of mortality and we found a reduction of this later when we add carob to rabbits' diets which contributes to the viability of animals and have a beneficial effect on animal health due to its high antioxidant (Würsch, 1987) and tannin content (Custodio et al., 2011).

Carcass characteristics

Slaughter yield

It is the ratio between the weight of the carcass and the live weight. The slaughter is carried out after 110 days of fattening, after 15 weeks of age. The Measurement of different carcass characteristics of the rabbit of the four groups and the results concerning the effect of carob on the parameters of slaughter yield and carcass components are presented in Table 6.

The carcass weight was 1747 g, 1854 g, 1730.5 g,

Table 6. Carcass components and yield expressedin grams.

	Group C	Group 1	Group 2	Group 3	P-value
Hair +Limbs	690	672.5	591	544.5	NS
Giblets	432	436	434.5	401.5	NS
Digestive tract	157	156	157	156	NS
Carcass	1747	1854	1730.5	1585	NS

The differences in different parameters were considered significant when the P-value was < 0.05.

and 1585 g for groups C, G1, G2, and G3 respectively and the dressing yield of the rabbits in groups C, G1, G2, and G3 were 62.79%, 62.56%, 62.14%, and 66.17% respectively. There was no significant variation among the treatment groups ($p > 0.05$). The highest yield was found in group 3 (66.17%) which received only carob, followed by the control group (C). This result justifies that rabbits accept carob as feed, the animals showed a high feed intake consumption of the latter which could be converted into carcass weight (1854 g) and maximum yield (66.17%).

The results of this present study collaborate with the findings of Ouhayoun et al. (1986) (55.05%) and Lebas (2013) (56.6%). The average carcass weight (1729.12 g) is low compared to that recorded for local populations by Lounaouci-Ouyed et al. (2008) (1949 g).

According to previous studies by Guenaoui et al. (2019), it is shown that the incorporation of carob increases the carcass weight of rabbits. At final, we found an increase in growth rate and carcass weight by rabbits that received carob.

CONCLUSION

The results showed that the supplementation of carob improves the growth performance, dressing yield, and meat quality of rabbits. It appears that the rabbits struggled to adjust to the dispersed food (carob); an unstable and reduced food consumption during the whole adaptation period during the first trial period. Early growth on the carob diet tended to be higher than on the control diet. The use of carob in rabbits improves feed efficiency substantially. In comparison to the 5 kg/T rate, the insertion of 3.5 kg/T greatly enhanced the growth performance and slaughter output of the local rabbit. Carcass yield is still enough. Therefore, it can be said that adding carob may be effective for rabbit production, particularly concerning feeding efficiency and slaughter yield. Consequently, carob could be a potential feed for fattening rabbits. Therefore, it is required to expand the list of substances that might be utilized in the preparation of rabbit feed to increase rabbit meat production and promote rabbit farming in Algeria,

The results of this study are only preliminary. However, it is important to verify in future experiments the incorporation of carob in diets containing different levels of carob and will be compared under more controllable conditions using a high number of animals.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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