The Effect of the Pellet and Crushed Diets and Addition of Different Levels of Malic Acid on the Performance and Carcass Characteristics of Male Arabi Lambs

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Abstract:

This study has been carried out in the animal field of the College of Agriculture, University of Basrah, for the period 1/12/2020 to 1/3/2021. Twenty-four male lambs of Arabi breed were randomly distributed to six treatments (4 lambs for each treatment), to investigate the effect of two type of diet (pellet and crushed) with the level of malic acid and the on some production traits such as live weights, total and daily weight gain, feed intake, feed efficiency and some of carcass characteristics such as hot carcass, dressing percentage, major cuts (neck, shoulder, rib, loin, leg and fat-tail) as well as carcass waste organs. The treatments were as follows: (T1) crushed condensed diet without the addition of malic acid (0). (T2) crushed condensed diet with the addition of malic acid as 4 g/kg feed. (T3) crushed condensed diet with added malic acid as 8 g/kg feed. (T4) without adding malicious acid (0). (T5) pellet feed with added malic acid as a 4 g/kg feed. (T6) pellet feed with added malic acid for 8 g/kg feed. The results indicated the pellet diet and the level of 4g of malic acid/kg of feed treatments were a significant increase ($P<0.05$) in the live body weights, total and daily gain weight, dressing percentage, feed efficiency, hot carcass weight and some weights of cuts compared to crushed diet and of 0g of malic acid/kg of feed treatments.

Keywords: Malic acid, Carcass characteristics, Male Arabi lambs, Pellet and crushed diets.

Introduction

Livestock farming is a major source of national income, sheep are one of the main sources of red meat, milk and wool in Iraq. Appropriate feeding strategies are essential through feed additives that help stabilize the rumen environment, prevent gastrointestinal disturbances, and optimal growth of the microbiota that is critical to the health and performance of ruminants (Sahoo and Jena, 2014).

Researchers used bio-promoters and yeasts or the so-called direct-fed microbial nutrition, which are known contain live cells or biological derivatives of some microorganisms that believed to have important benefits for improving the digestion coefficient of nutrients (Krehbiel *et al.*, 2003; Shwayel and Rasheed, 2016). For example, Helal and Abdel-Rahman (2010) indicated that yeast added at 0.5% with 4% of bentonite to the diets of Awassi lactating ewes may improve

conversion efficiency, milk production and increase birth weights of offsprings. Also, a significant increase was found in the weight of the hot carcass and the weights of some cuts carcass when yeast was added to the diets of crossbreed lambs (Pelibuey x Kathdin) compared to the control group (Estrada-Angulo *et al.*, 2013). In the past few years, the use of organic acids as feed additives has gained great importance within the European Union, due to their positive effects on feed quality and production performance, they are short chain acids (C1-C7) most of the organic acids are carboxylic acids that have been used as food additives, including formalic acid, propionic acid, malic acid, and these organic acids are a source of energy and are absorbed by microorganisms in the rumen (Elmali *et al.*, 2012). Cavini, (2015) recorded that when mixing 2.4 g of malic acid salts per kgof dry matter in the diets of growing goats, there was an increase in weight gain, final body weight, feed consumption, feed conversion efficiency, carcass weight and dressing percentage compared to the control group. In addition, Toprak *et al.*, (2018) suggested that the addition of 5 g of malic acid per kg of feed in sheep diets led to a significant increase in final body weights, carcass weight and dressing percentage compared with other treatments. However, in Bangladesh, one study indicated that feeding goats on the pellet system led to a better performance in weight gain, feed conversion efficiency and carcass weight compared to the traditional diet (crushed) (Rashid *et al.*, 2016). Also, Li *et al.*, (2021) reported that feeding lambs on pellet diet improves the daily weight gain, feed intake and reduces feeding time and waste of feed in comparison with the crushed diet.

For this purpose, the study was aimed to find the effect of pellet and crushed dietS (manufactured in the feed factory of the College of Agriculture - University of Basrah) with the three levels of malic acid and the interaction between them on growth performance and carcass characteristics of male Arabi lambs.

Materials and methods

This study has been carried out in the animal field of the College of Agriculture of the University of Basrah, for the period 1/12/2020 to 1/3/2021. Twenty-four of male lambs Arabi breed (The main breed of sheep common in southern of Iraq) were randomly distributed to six treatments (4 lambs for each treatment) includes the use of three levels of (L-Malic acid) with two types of diet either crushed or pelleted, as follows: (T1) crushed condensed diet without the addition of malic acid (0). (T2) crushed condensed diet with the addition of malic acid as 4 g/kg feed. (T3) crushed condensed diet with added malic acid as 8 g/kg feed. (T4) without adding malicious acid (0). (T5) pellet feed with added malic acid as a 4 g/kg feed. (T6) pellet feed with added malic acid for 8 g/kg feed. Malic acid powder was added in the amount of 400 and 800 gm per 100 kg of concentrated feed, and the diet was mixed with automatic machines, then packed in bags to makeup the crushed diet. As for the purpose of makeup the pellet, part of the mixed diet was transferred automatically to the pellet manufacturing unit for production it.

The lambs were placed in half-shaded pens of equal size (2 x 2.5 m2), which were provided with plastic feeders and water buckets. The diet was administered twice daily at 7:00 a.m. and 4:00 a.m. based on 3% of body weight for 90 days. Daily weight gain, food intake and food efficiency were estimated. The proportions of the food ingredients and their chemical composition are presented in Table (1). After the experiment, the animals were fasted 18 hours before being slaughtered. The weight at slaughter, the weight of the hot carcass, the percentage of dressing and the weight of the main cuts (neck, shoulder, rib, lanyard, leg and greasy tail) were recorded. Also, the carcass waste such as head, skin and feet weighing and recorded.

The data were analyzed as a factorial experiment design to study the effect of different type of diet and the level of malic acid and the interaction between them on the studied traits, and the significant differences between the means (P<0.05) were compared with the statistical program (SPSS, 2019), were used according to the following mathematical model:

$Yijk=\mu+Ai+Bj+ABij+eijk$

Where is:

Yijk = is the value observation of the type of diet i, and level of malic acid j. μ = overall mean. Ai = effect of the type of diet (1, 2). Bj = effect of malic acid levels (0, 1, 2). ABij = the effect of the interaction between the levels of malic acid and the type of diet. eijk = experimental error that is distributed randomly and naturally with mean equal to zero and variance $\sigma^2 e$.

Table (1): Ingredients of basal diets and chemical composition.

	Crushed			Pellet		
Ingredients (g/ kg DM)	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**
Barley	53	53	53	53	53	53
Wheat bran	36	36	36	36	36	36
Soybean meal	8	8	8	8	8	8
Mineral-vitamin premix	2	2	2	2	2	2
Salt	1	1	1	1	1	1
Malic acid g/kg feed	0	4	8	0	4	8
Chemical composition (%)*						
Dry matter	82.8	82.8	82.8	82.8	82.8	82.8
Crude protein	14.02	14.02	14.02	14.02	14.02	14.02
Ether extract	2.86	2.86	2.86	2.86	2.86	2.86
Crude fiber	7.38	7.38	7.38	7.38	7.38	7.38
Ash	3.63	3.63	3.63	3.63	3.63	3.63
Soluble carbohydrate	67.59	67.59	67.59	67.59	67.59	67.59
Metabolic energy MJ/ kg dry matter **	12.40	12.40	12.40	12.40	12.40	12.40

***The chemical composition of the feed materials was calculated according to NRC. (1985).**

****Metabolic energy was calculated according to the equation of the Scottish Ministry of Agriculture(MAFF, 1975). Energy represented = 0.12 x crude protein + 0.31 x crude fat + 0.05 x crude fiber + 0.14 x soluble carbohydrates.**

Results and discussion:

The effect of type of diet and different levels of malic acid on growth is presented in Table 2. Final body weight, total weight gain and the average daily gain, was significantly increased the pellet diet compared to the crushed diet, may due to the fact that making the feed in the form of pellet increases the feed intake and increases the ability to digest and enhances the rumen fermentation due to the survival of the feed materials longer duration in the gut (Lailer *et al.*, 2005; Li *et al.*, 2021), heat of manufacture improves protein digestion by inactivating inhibitors of digestive enzymes and denaturing the protein (Ran *et al.*, 2021). Results were in agreement with Rashid *et al.*, (2016) ; Ahmed *et al.*, (2020); Li *et al.*, (2021) and Raju *et al.*, (2021), who found that the pellet diet was better than crushed diet in improving growth parameters in sheep and goats.

There were significant differences (P<0.05) for the treatment 4 gm of malic acid/kg feed in the final weight, the total weight gain and the average daily compared to the other treatments (8 and 0 g of malic acid/kg feed). Used of malic acid to improve the environment of the rumen, which increase the activity of microorganisms and increases the microbial protein (Khampa *et al.*, 2009),

and carboxylic acids activate the transformation of lactic acid into propionic acid through S. rumnantium using the succinate-propionate pathway (the glucose-transformation pathway) in which malic acid increases the development of rumen papillae (length and width) causing increased absorption of nutrients (Martin *et al.*, 2000; Abdelrahman *et al.*, 2019), glucose and lactose, and in this way malic acid increases the energy available for animal growth (Martin and Streeter, 1995). Those results agreed with the results of Abas *et al.*, (2007); Elmali *et al.*, (2012) and Malekkhahi *et al.*, (2015). The interaction between the type of diet and the level of malic acid showed an increased significantly ($P<0.05$) for the treatment pellet + malic acid 4 g/kg feed in the final weight, the total weight gain and the average daily weight gain compared with the other treatments.

Table (2): Effect of type of the diet and malic acid on final live body weight, total weight gain and average daily gain of male Arabi lambs (Mean± S.E).

Treatments		Initial Weight (kg)	Final live body weight (kg)	Total weight gain (kg)	Average daily gain (g/d)
Type of diet	Crushed	22.75 ± 0.20	36.84 ± b 0.32	14.09 ± b 0.28	156 ± b 31
	Pellet	22.67 ± 0.23	37.79 ± a 0.57	15.11 ± a 0.38	167 ± a 61
Malic acid	0 g/kg feed	22.82 ± 0.34	35.75 ± c 0.35	12.92 ± c 0.33	143 ± c 36
	4 g/kg feed	22.72 ± 0.44	38.63 ± a 0.37	15.93 ± a 0.14	177 ± a 16
	8 g/kg feed	22.70 ± 0.33	37.63 ± b 0.54	14.95 ± b 0.31	165 ± b 35
Interaction		22.82 ± 0.34	35.75 ± c 0.35	12.92 ± c 0.33	143 ± c 36
Crushed + Malic acid 0 g kg feed /					
Crushed + Malic acid 4 g/kg feed		22.72 ± 0.44	37.42 ± b 0.37	14.70 ± b 0.14	162 ± b 16
Crushed + Malic acid 8 g kg feed /		22.70 ± 0.33	37.35 ± b 0.54	14.65 ± b 0.31	162 ± b 35
Pellet + Malic acid 0g/kg feed		22.67 ± 0.53	35.60 ±c 0.29	12.92 ± c 0.36	143 ± c 40
Pellet +Malic acid 4 g/kg feed		22.67 ± 0.31	39.85 ± a 0.45	17.17 ± a 0.17	191 ± a 27
Pellet + Malic acid 8 g/kg feed		22.67 ± 0.45	37.92 ± b 0.56	15.25 ± b 0.22	169 ± b 24

*** Different letters vertically differ significantly at the 5% level.**

Animals fed a pellet diet was better than those fed a crushed diet in average feed consumption (Table 3). This can be due to the fact that the pellet diet increases the digestibility and palatability of animals (Islam *et al.*, 2017; Ahmed *et al.*, 2020). The average feed consumption in 4 and 8g of malic acid/kg feed treatments were higher than in 0g of malic acid/kg feed treatment, may be due to that malic acid in the diet led to an increase in production of volatile fatty acids, which increases the activity of rumen microorganisms (Gomez *et al.*, 2005), growth and development of rumen papillae and their density (Abdelrahman *et al.*, 2019), which increases the absorption of feed materials. As for the interaction between the type of diet and levels of malic acid, it was found that the average of feed consumption increased in the treatment pellet + malic acid 4g/kg feed compared to the other treatments. Results were in agreement with Rashid *et al.*, (2016); Islam *et al.*, (2017) and Ahmed *et al.*, (2020), who found that the pellet diet was better than crushed diet in improving the feed consumption in sheep and goats. Animals fed pellets diet was better than those fed crushed diet in average feed efficiency (Table 3), may due to increased feed consumption and increased animal growth, as indicated by the results of the study (Table 1), this result was confirmed with the result of Rashid *et al.*, (2016) and Ahmed *et al.*, (2020), who found that the pellet diet was better than crushed diet in improving the feed efficiency in sheep and goats. The treatment of 4 g of malic acid/kg feed recorded feed efficiency better than 8g and 0g of malic acid/kg feed treatments. Results were in agreement with Flores Pérez, (2004); Abas *et al.*, (2007) and Mungói, (2012), who reported that malic acid and its salts had a role in improving feed efficiency in farm animals. The treatment of pellet + malic acid 4 g was improved in the average feed efficiency as compared to the other treatments.

Table (3): Effect of type of the diet and malic acid on food consumption (kg) and food conversion efficiency (kg/kg) of male Arabi lambs

Treatments		Average feed consumption	Feed conversion efficiency
Type of diet	Crushed	25.63	5.46
	Pellet	25.88	5.14
Malic acid	0 g/kg feed	25.26	5.87
	4 g/kg feed	25.83	4.92
	8 g/kg feed	25.58	5.13
Interaction		25.24	5.86
Crushed + Malic acid 0g / kg feed			
Crushed + Malic acid 4g/kg feed		25.88	5.28
Crushed + Malic acid 8g / kg feed		25.78	5.30
Pellet + Malic acid 0g/kg feed		25.28	5.99
Pellet +Malic acid 4g/kg feed		26.47	4.62
Pellet +Malic acid 8g/kg feed		25.89	5.09

No significant differences were observed in the weight of the hot carcass between the type of diet (Table 4), in spite of, there is a statistical increase in this trait in pellet diet as compared with crushed diet. due to the high amount of nitrogen intake, as a result of consuming a larger amount of feed, and excreting less nitrogen because the feed stayed for a longer period in the gastrointestinal tract, which helped to improve the digestion of the feed and increase and led to an increase in body and carcass weight (Reddy *et al.*, 2002). The result was in agreement with Pi *et al.*, (2005) Rashid *et al.*, (2016;), Islam *et al.*, (2017); Zhang *et al.*, (2019) and Li *et al.*, (2021), who found that the pellet diet was better than crushed diet in improving carcass weight in sheep and goats. On the other hand, the treatment of 4g malic acid/kg feed was significantly different ($P<0.05$) in hot carcass weight

Table (4): Effect of type of the diet and malic acid on weights of hot carcasses, dressing percentage and carcass waste organs of male Arabi lambs (Mean± SE).

Treatments		Hot carcass (kg)	Dressing percentage (%)	Carcass waste organs/g		
				Head weight	Feet weight	Skin weight
Type of diet	Crushed	15.19 ± 0.49	41.19 ± 0.67	2362 ± 71	910 ± 66	4673 ± 246
	Pellet	16.54 ± 0.56	43.69 ± 8.24	2300 ± 97	908 ± 60	4236 ± 325
Malic acid	0 g/kg feed	15.03 ± b 0.54	42.12 ± 0.94	2275 ± 133	882 ± 58	4912 ± 523
	4 g/kg feed	17.01 ± a 0.45	43.96 ± 0.57	2373 ± 79	926 ± 55	4686 ± 220
	8 g/kg feed	15.55 ± b 0.35	41.43 ± 0.43	3246 ± 100	919 ± 48	4766 ± 341
Interaction						
Crushed + Malic acid 0g / kg feed		14.59 ±b 1.13	40.76 ± 0.76	2362 ± 110	885 ± 69	5287 ± 680
Crushed + Malic acid 4g/kg feed		15.44 ± b 0.52	41.55 ± 0.40	2401 ± 113	980 ± 70	4638 ± 680
Crushed + Malic acid 8g / kg feed		15.44 ± b 0.45	41.32 ± 0.39	2325 ± 4	867 ± 66	4095 ± 700
Pellet + Malic acid 0g/kg feed		15.47 ± b 1.56	43.49 ± 0.100	2187 ± 190	880 ± 105	4537 ± 870
Pellet +Malic acid 4 g/kg feed		18.48 ± a 0.24	46.38 ± 0.26	2345 ± 140	873 ± 82	4733 ± 960
Pellet + Malic acid 8g/kg feed		15.67 ± b 0.29	41.36 ± 3.16	2367 ± 119	971 ± 130	4437 ± 490

*** Different letters vertically differ significantly at the 5% level.**

compared to other treatments. may due to that malic acid is an important source of energy and animals growth when added to their diets (Barazi et al., 2019) because it plays a role in maintaining the pH value suitable for the work of beneficial microorganisms, which are necessary for the fermentation of carbohydrate-rich diet, which share significantly to providing maximum energy to increase growth animal (Martin, 1998), and this is reflected positively in the final score in increasing the carcasses weight. The interaction between the type of diet and the level of malic acid showed that the treatment of pellet + malic acid 4 g/kg of feed increased significantly ($P<0.05$) in hot carcass compared with the other treatments. Pellet diet treatment and 4g malic acid/kg feed treatment and the interaction between them shows improved dressing percentage compared with other treatment, this result was in agreement with Islam *et al.*, (2017); Li *et al.*, (2021) and Barazi *et*

al., (2019). No significant differences were observed between the type of diet and level of malic acid and the interaction between them the weights carcass waste organs. May be due to the fact that these organs are early-maturing organs and are not affected by the contents of the diet used in the nutrition of animals (Al-Jassim and Al-Saigh, 1999).

The effect of type of diet and different levels of malic acid on the weight of cut carcasses was presented in Table 5. The animals who fed on a pellet diet increased significantly (P< 0.05) the weights of their carcass cuts such as shoulder, loin and leg compared to the crushed diet, may due to

Table (5): Effect of type of the diet and malic acid on weight of the carcass cuts (g) for the different experimental treatments (Mean± SD).

Treatments		Neck	Shoulder	Rib	Loin	Leg	Fat-tail
Type of diet	Crushed	882 ± 21	4644 ± b 86	2001 ± 101	1056 ± b 63	4744 ± b 249	1830 ± 139
	Pellet	837 ± 43	5077 ± a 112	1773 ± 129	1539 ± a 114	5346 ± a 280	1969 ± 133
Malic acid	0 g/kg feed	841 ± 60	4635 ± c 95	1826 ± 207	1162 ± b 195	4539 ± b 488	1981 ± 174
	4 g/kg feed	927 ± 11	5116 ± a 127	1935 ± 113	14662 ± a 66	5547 ± a 147	1986 ± 204
	8 g/kg feed	811 ± 32	5016 ± b 119	1850 ± 112	1268 ± b 125	4872 ± b 211	1732 ± 107
Interaction		862 ± 63	4517 ± c 158	2176 ± 227	911 ± b 123	4041 ± 501	2088 ± 365
Crushed + Malic acid 0g / kg feed							
Crushed + Malic acid 4 g/kg feed		898 ± 7	4850 ± b 151	1700 ± 104	1290 ± ab 26	5328 ± ab 216	1453 ± 47
Crushed + Malic acid 8g / kg feed		887 ± 23	4937 ± ab 47	2128 ± 74	967 ± b 19	4562 ± ab 328	1950 ± 64
Pellet + Malic acid 0g/kg feed		820 ± 11	4753 ± bc 89	1577 ± 299	1413 ± ab 348	5037 ± ab 834	1875 ± 37
Pellet + Malic acid 4g/kg feed		955 ± 7	5382 ± a 74	2171 ± 110	1635 ± a 19	5820 ± a 122	2518 ± 56
Pellet + Malic acid 8g/kg feed		736 ± 22	5095 ± ab 246	1572 ± 47	1535 ± a 114	5182 ± ab 190	1515 ± 134

*** Different letters vertically differ significantly at the 5% level.**

the increased intake of feed, which led to an increase in the weight of the animal carcasses and increase in the weight of the cuts (Islam *et al.*, 2017). Results were consistent with those of Pi *et al.*, (2005) and Li *et al.*, (2021).

It is also noted from the same table significant differences (P<0.05) in the weights of shoulder, loin and leg in the treatment of 4 gm malic acid/kg feed compared to the treatments of 0

and 8g malic acid/kg feed), may be attributed to the increase in microbial protein production, the high availability of propionate and reduced rumen methane formation (Khampa *et al.*, 2009) and both the high nitrogen and propionate levels in the rumen can increase muscle size first by depositing more nitrogen directly into the tissues, and secondly through the higher level of bioavailability that results from the metabolism of propionate through gluconeogenesis. Additionally, more propionate leads to muscle cell hypertrophy (Hosseini *et al.*, 2012). The result conformed to that of Loya-Olguin *et al.*, (2019).

The interaction between the type of diet and the level of malic acid, significant differences ($P< 0.05$) were presented in the treatment of pellet + 4 gm malic acid/kg feed in the weights of the some cuts (shoulder, loin and leg) as compared with the other treatments.

Conclusions

We conclude from the results of this study that the use of the pellet diet and the level of 4 g of malic acid/kg of feed improves feed consumption, feed efficiency and the growth of animals which improves the characteristics of carcasses.

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تأثير عليقتي الأقراص والمجروش ومستويات مختلفة من حامض الماليك في كفاءة وخصائص ذبائح الحملان العرابية الذكرية

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الملخص :

أجريت هذه الدراسة في الحقل الحيواني التابع لكلية الزراعة , جامعة البصرة للفترة بين 2020/12/1 ولغاية 2021/3/1 . وزع أربعة وعشرون حملاً ذكرياً لسلالة العرابي عشوائياً إلى ست مجاميع (4 حملان لكل مجموعة)، لمعرفة تأثير نوعين من العلائق (الأقراص والمجروش) مع مستوى حامض الماليك والتداخل بينهما في بعض الصفات الإنتاجية مثل الأوزان الحية ، الزيادة الوزنية اليومية والكلية، تناول العلف، كفاءة التغذية وبعض خصائص الذبيحة مثل وزن الذبيحة الحار ونسبة التصافي والقطعيات الرئيسية (الرقبة والكتف والضلع والخاصرة والفخذ والالية) وكذلك أعضاء مخلفات الذبيحة . كانت المعاملات كالآتي: المعاملة الأولى: عليقة مجروش مركز بدون اضافة حامض الماليك، المعاملة الثانية: عليقة مجروش مركز مع اضافة 4 غم حامض الماليك / كغم علف، المعاملة الثالثة: عليقة مجروش مركز مع اضافة 8 غم حامض الماليك / كغم علف المعاملة الرابعة: عليقة الأقراص بدون اضافة حامض الماليك والمعاملة الخامسة: عليقة الأقراص مع اضافة 4 غم حامض الماليك / كغم علف والمعاملة السادسة: عليقة الأقراص مع اضافة 8 غم حامض الماليك / كغم علف. أشارت النتائج إلى زيادة معنوية ($p<0.01$) لعليقة الحبيبات مع مستوى 4 غم / كغم علف من حامض الماليك في أوزان الجسم الحية ، الزيادة الوزنية اليومية والكلية ، نسبة التصافي ، كفاءة التغذية ، وزن الذبيحة الحار وبعض أوزان القطعيات بالمقارنة مع معاملتي العليقة المجروشة ومستوى 0 غم حامض الماليك / كغم علف.

الكلمات المفتاحية: حامض الماليك ، خصائص الذبيحة ، حملان ذكرية عرابية، علائق الأقراص و المجروش.