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OAK AS A FEED INGREDIENT FOR RUMINANTS: A REVIEW

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ABSTRACT

The influences of oak inclusion into the diet of ruminants on performance, feed digestibility, milk production and blood metabolites are reviewed herein. Oak as an alternative and available feed are being utilized in many parts of the world, especially in areas suffering from shortage of feed ingredients. It is evident that different oak species have different impacts on various animal species. Oak fed at low levels in the diet may not affect digestibility, but when they are fed at high level may lead to lessen the digestibility of dry matter. Adding oak products may improve the daily milk yield of goats. Feeding oak acorns and leaves to growing goat kids might not been accompanied by significant improvement in daily weight gain and feed conversion ratio, while when feeding adult sheep on high level of dietary oak, it may result in lowered daily weight gain. Different oak species produce different amounts of tannins, which after ingestion by animals, act to form complexes with the proteins of diet, this may lead to lower digestibility of nutrients or may beneficially affect to positive flow of amino acids into abomasum and small intestine by reducing the protein degradability in the rumen. Thus, the extent of the impact of dietary oak on ruminants' performance depends on the species of both animals and oak, and the level of oak being used in the diet.

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INTRODUCTION

The Quercus genus is considered one of the indigenous species in Iraq, where it is the dominant tree covering in the northern and northeastern region of Iraq (Almaroof, 2005). Oak is a woody perennial plant that belongs to the genus *Quercus* (Pourhashemi *et al.,* 2018), has a big impact on the ecosystem of the world and possess the ability to prevent soil erosion, preserve water resources and provide a rich environment for wildlife. The fruit produced by the trees are edible for many animals and insects which rely on these trees to get their feed for survival. Acorns as a cheap and available plant material, supplies a potential source of biologically active compounds, which is applicable in many industries including food and pharmaceutical industries (Rakić *et al.*, 2005). Tannins are found throughout the oak plant, with higher levels in the leaves, buds, twigs, and acorns (Bausch and Carson, 1981) they decrease the degradability of dietary protein in the rumen through making complexes with proteins and increase the efficiency in nitrogen recycling. The formed tannin-protein complexes may be dissociated in the abomasum, leading to an

increase the amount of by-pass dietary amino acids available for absorption in the intestine (Patra and Saxena, 2011). The increase in amino acids availability could enhance energy partitioning toward milk production (Frutos *et al.,* 2004), and improve milk, fat and protein yield of sheep and Meriz goat (Alkass, *et al*., 2018; Dosky *et al*. 2012). Moujahed *et al.,* (2007) concluded that inclusion of oak acorns in diets to more than 50% of concentrate diet as a replacement of barley changed fermentation pattern including reduction in *in vitro* gas production that is used as an indication to lowered microbial activity in the rumen. In rabbits, boiled extract of oak leaves resulted in an improvement in lipid profile and continuous significant decrease in glucose for 24 hrs. (Abdul-Rahman, 2008). Depending on the low cost of oak acorns, Al Jassim, *et al.,* 1998 have suggested that substitution of 25% of barley with oak acorns would be economically beneficial for feeding Awassi lambs. Similarly, Kaya and Kamalak, (2012) suggested that inclusion of oak acorns in the concentrate mixtures of goats can be economically advantageous particularly in autumn and winter when scarcity of feedstuffs happens. This paper reviews the impact arisen upon feeding oak products to ruminant animals in terms of animal performance including diet digestibility, rumen fermentation, milk yield, milk composition and growth performance.

Composition of oak acorns

The proximate analysis and active compounds of different species of oak acorns has been carried out by many workers throughout different regions of the world as shown in Table (1) and they vary considerably in their chemical composition, especially in ether extract and tannin contents. Generally, the DM content in oak acorns varies from 530 to 910g kg^{-1} and by comparing to other wildlife foods, the CP content of acorns is relatively low, which ranges between 28.4 and 79 g kg^{-1} (Kirkpatrick and Pekins, 1989), such variation in the chemical composition of the oak acorns could be expected due to difference in oak species, stage of oak maturity, as well as the production site (Gasmi-Boubaker *et al.,*2007). Oak contain tannins, which are found throughout the oak plant, with higher levels were found in the leaves, buds, twigs, and acorns (Bausch and Carson, 1981). Tannins are chemically diverse group of water soluble phenolics which bind proteins to form soluble or insoluble complexes (Hagerman and Buttler, 1989; Mueller-Harvey *et al.,* 2019) and occur primarily in condensed and hydrolysable forms (Min *et al.,* 2003; Makkar, 2003). Acorns contain both types of tannins; condensed and hydrolysable (Łuczaj *et al.,* 2014).

It was demonstrated that condensed tannins are more effective than hydrolysable form on animal performance (Makkar *et al.,* 1995) as the condensed form is usually nor broken down, neither absorbed in the intestine, and is able to make complexes with proteins of feed, mucosa and digestive enzymes. Therefore, they primarily act to decrease protein digestibility causing animals to be in negative nitrogen balance, when animals lose more nitrogen than they ingest (Makkar, 2003). When a forage containing condensed tannin is consumed, complexes are formed and

then condensed tannin in the rumen become bound to cell coat polymers of bacterial cells (Jones *et al.*, 1994), thus affecting the proteolysis in the rumen (Frutos *et al.*, 2004). Differently, hydrolysable tannins are broken down in the gastro-intestinal tract into smaller phenols, some of these phenols are absorbed into the bloodstream, detoxified and excreted from the body (Kirkpatrick, and Pekins, 1989).

Table (1): The composition of oak acorns of different species (g kg-1DM).

Acorn's species	DM	OM	CP	EE	CF	NDF	TPh	TT	CT	Reference
Q. aegilops	530	976	39	25	236	516	-	-	-	Al Jassim *et al.*, (1998)
Q. coccifera	537	972	29	23	253	498	-	-	-	
Q. coccifera	-	978	39	-	-	362	-	-	-	Moujahed *et al.*, (2007)
Q. suber	715	971	79	-	118	274	-	-	-	Gasmi-Boubaker *et al.*, (2007)
Q. ithaburensis	-	967	28.4	7.6	342	-	-	-	-	Rababah *et al.*, (2008)
Q. calliprinos	-	982	49.4	23.1	131	-	-	-	-	
Q. persica	910	980	54.5	-	-	231	5.36	4.68	1	Aghamohamadi *et al.*, (2014)
Q. coccifera	648	977	42.3	45	-	284	-	-	3.68	Kamalak *et al.*, (2005)
Q. persica	920	971	40.5	60.5	-	280	12.79	8.79	2.01	Jafari *et al.*, (2018)
Q. aegilops	593	968	42	87.7	73.2	-	94.61	-	3.76	Hidayet and Mustafa, (2020a)

Q.: Quercus, DM: dry matter, OM: organic matter, CP: crude protein, EE: ether extract, CF: crude fiber, NDF: neutral detergent fiber, TPh: Total Phenolics, TT: Total Tannins, CT: Condensed Tannins.

Effect on feed intake

Studies on the effect of different species of oak (*Quercus* spp.) acorns and leaves on voluntary feed intake in different species are given in Table (2). It seems from the table that feeding acorns has resulted in either to increase dry matter intake (Froutan *et al.*, 2015) or has no effect on dry matter intake in goats (Gasmi-Boubaker *et al*, 2007) or a reduction of dry matter intake was noticed (Jafari *et al.*, 2018). Also, a significant increase in dry matter intake was indicated when feeding calves on oak leaves (Sharma *et al.*, 2008).

Table (2): Effect of dietary oak leaves or acorns on dry matter intake.

Species	No.	Treatments	DMI kg d^{-1}	Finding	Reference
Goat kids	24	Control	0.975 [a]	Feeding acorns at levels of 80, 170 or 250g kg^{-1} feed to growing goat kids caused a significant increase in daily DMI as compared to that of control group.	Froutan *et al.*, (2015)
		Oak acorns 80g kg^{-1} feed	1.018 [b]		
		Oak acorns 170g kg^{-1} feed	1.058 [b]		
		Oak acorns 250g kg^{-1} feed	1.059 [b]		
		P value	0.004		
Male calves	15	Control	2.05 a	A significant increase in daily DMI in growing calves was noticed inclusion of oak leaves in the diet at the levels of 220 and 400g kg^{-1} feed.	Sharma *et al.*, (2008)
		Oak leaves 220g kg^{-1}	2.83 b		
		feed Oak leaves 400g kg^{-1} feed	2.90 b		
		P value	<0.05		
Heifers	6	Control	2.96	No effect of feeding oak leaves on DMI was found in heifers when fed to the level up to 636g kg^{-1} feed.	Paswan and Sahoo, (2012)
		Oak leaves 425g kg^{-1} feed	3.11		
		Oak leaves 636g kg^{-1} feed	3.52		
		P value	>0.05		
Boer goat	10	Control	0.891	No effect of consuming acorns was noticed in goats fed on acorn to the level of 753 g kg^{-1} DM.	Gasmi-Boubaker *et al.*, (2007)
		Oak acorns 753 g kg^{-1} DM	0.868		
		P value	>0.05		
Goat	24	Control	1.75 a	In goats fed on acorns at 200 g kg^{-1} DM no effect of of acorns on DMI was found, but in the other group when the level of acorns was elevated to 400 g kg^{-1} DM, a dignificant reduction in DMI happened.	Jafari *et al.*, (2018)
		Oak acorns 200 g kg^{-1} DM	1.63 a		
		Oak acorns 400 g kg^{-1} DM	1.41 b		
		P value	<0.01		

DMI: Dry matter intake, No.: Number of animals studied. Different letters within the column of each reference show significant difference.

It is known that there is a difference in the ratio of tannins in different oak species and oak plant parts, therefore, the increase in dry matter intake in goat kids consumed diets containing acorns might be a result of the low concentration of hydrolysable tannins in the oak acorn diets or it might be due to the higher efficiency of goat ruminal microbes in degradation or detoxification of the tannins (Froutan *et al.*, 2015). The decrease in DM intake in goats fed oak acorns can be attributed to the decreasing palatability due to bitter or astringent taste of tannins (Becker and Makkar, 1999).

Digestibility

In vitro digestibility

Is well known that in vitro techniques have been widely used to establish assessment of animal diets, supplemented herbs and their extractives as feed components. In vitro gas production technique has been commonly used to determine the metabolizable energy and organic matter digestibility of feeds (Kamalak *et al.*, 2005). In an in vitro work, Aghamohamadi *et al.*, (2014) found that the produced methane volume was unaffected by inclusion of *Quercus persica* acorns at the level of100g kg^{-1} feed, while when the level of acorns in the diet was increased to 300g kg^{-1} feed, a significant reduction in methane produced from fermentation of diet was observed as shown in Table (3). Furthermore, Moujahed *et al.*, (2007) indicated a lag time represented by negative values (-0.5, -1.0, -1.3) respectively by replacing 50, 75 and 100% of diet barley with *Quercus coccifera* acorns. The finding had been supported by a significant reduction in immediate in vitro gas production of diets followed replacing 50, 75 and 100% of the barley with oak acorns. The same authors found that replacing 75% or 100% of diet barley with acorns, also caused a significant ($P<0.01$) reduction in total in vitro gas production, while the researches noticed no change in lag time, methane and total gas production of fermentation after replacing 25% of diet barley with acorns in vitro. The authors documented that *Quecus coccifera* acorns could not replace diets barley over than 50% of concentrate with an oat hay basal diet, beyond this level, there is a significant reduction of in vitro gas production which may indicate a decrease in microbial activity. Similarly, it has been demonstrated that the increasing level of oak acorns in the diet to 300g kg^{-1} feed might be responsible for the reduction in methane production due the inhibitory impact of oak acorns on rumen protozoa population (Aghamohamadi *et al.*, 2014). Experimenting oak leaves, Doce *et al.*, (2007), reported a negative impact of oak *Quercus pyrenaica* leaves on in vitro ruminal fermentation of conventional feeds (hay) depending on the dose administrated to the animals. The same authors suggested an adaptation to tanniniferous feeds by the rumen microbial population in Brown Swiss bulls consuming oak leaves, which may be beneficial for cattle being fed on tannin-rich forages. They concluded these findings when they noticed a significant decrease in lag time and a significant increase in in vitro DM disappearance of oak leaves incubated for 24h in rumen fluid from bulls fed on either 2.5Kg or 5.2 Kg of oak leaves per day (51.62 and 51.16%) respectively as compared to in vitro DM disappearance in rumen fluid from bulls fed on control diet (43.12%).

In vivo digestibility

Studies on the effect of feeding oak acorns or leaves on digestibility of dry matter, organic matter and crude protein have yielded different results Table (4). A significant reduction was noticed by Al Jassim *et al.*, (1998), Gasmi-Boubaker *et al.*,

(2007) and Hidayet and Mustafa (2020a). While, Jafari *et al.,* (2018) found a significant increase in digestibility of dry matter as shown in Table (4). Likewise, (Narjisse *et al.,* 1995) reported that using tannin methanol extract of acorns as infested intraruminally at a rate of 0.1% of live body weight caused no effect on in vivo dry matter digestibility coefficient of Moroccan Timahdit rams and Moroccan native goats which were being fed ad libitum on chopped hay. It has been reported that the dry matter digestibility coefficient of several oak acorn species ranges between 57-89% (Kirkpatrick, and Pekins, 1989). Concerning the digestibility coefficient of crude fiber, no significant differences had been reported.

Table (3): Effect of oak acorns or leaves on in vitro total gas production.
DM: dry matter, OM: organic matter. Different letters within the column of each reference show significant difference.

Part of oak used	Treatments	Total gas production	Findings	Reference
Acorns	Control	452.62ml g^{-1} OM	No effect of including oak acorns up to 300g kg^{-1} feed on in vitro total gas production.	Aghamohamadi *et al.,* (2014)
	100g kg^{-1} feed	463.40ml g^{-1} OM		
	300g kg^{-1} feed	455.70ml g^{-1} OM		
	P value	0.48		
Acorns	Control (hay+ barley)	69.6^{a}ml 300 mg^{-1} DM	No effect of replacing barley in ration with acorns up to 50%, but when 75% or 100% of barley in the diet was replaced by acorns, a significant reduction was noticed in in vitro total gas production.	Moujahed *et al.,* (2007)
	Hay+25%acorns +75%barley	68.6^{a}ml 300 mg^{-1} DM		
	Hay+50%acorns +50%barley	69.8^{a}ml 300 mg^{-1} DM		
	Hay+75%acorns +25%barley	66.2^{b}ml 300 mg^{-1} DM		
	Hay+ acorns	64.5^{b}ml 300 mg^{-1} DM		
	P value	<0.01		
Leaves	Control (grass hay)	221.9 ml g-1 OM	No effect of inclusion of oak leaves in the diet up to 500g kg^{-1} DM on in vitro total gas production.	Doce *et al.,* (2007)
	333g kg^{-1} DM	227.2 ml g-1 OM		
	500g kg^{-1} DM	231.4 ml g-1 OM		

Sharma *et al.,* (2008), suggested that the higher amount of non-structural carbohydrates in mature oak leaves may be supportive in supplementing degradable energy source for microbial protein synthesis in the rumen. It is documented that oak leaves and acorns contain tannins by both types; hydrolysable and condensed tannins.

Table (4): Digestibility of oak acorns included diets by ruminant animals.

Species	Part of oak fed	No.	Level of acorns in diet	Digestibility coefficient g kg^{-1} DM			Finding	Reference
				DM	OM	CP		
Goats	Acorn	21	Control	440 ^{a}	410 ^{a}	650^{a}	No effect of feeding acorns at the level of 100g kg^{-1} DM on DM and OM digestibility in goats was found, but addition of 20g of polyethylene glycol on the same level of acorns significantly increased both mentioned parameters. A significant reduction in CP digestibility was noticed due to the treatment without polyethylene glycol.	Alipanahi *et al.*, (2019)
			100 g kg^{-1} DM without polyethylene glycol	360 ^{a}	340 ^{a}	470^{b}		
			100 g kg^{-1} DM and 20 g/d polyethylene glycol	510 ^{b}	490 ^{b}	700^{a}		
			P value	<0.01	<0.01	<0.01		
Goats	Acorn	50	Control		673^{a}	725^{a}	A significant increase in OM digestibility was found after feeding goats on acorns at the level of 400g kg^{-1} DM, while a significant decrease in CP digestibility was noticed by feeding acorns at the levels of 200 or 400g kg^{-1} DM.	Jafari *et al.*, (2018)
			200g kg^{-1} DM		694^{a}	694^{b}		
			400g kg^{-1} DM		584^{b}	451^{b}		
			P value		0.07	<0.01		
Goats	Acorn	10	Control	680^{a}	707^{a}	667^{a}	A significant reduction in digestibility of DM, OM and CP was reported in goats upon feeding them on 600g of acorns/head/day.	Gasmi-Boubaker *et al.*, (2007)
			600g head^{-1}	567^{b}	579^{b}	532^{b}		
			P value	<0.05	<0.05	<0.05		
Sheep	Acorn	30	Control	787^{a}	810^{a}	740^{a}	A significant reduction in digestibility of DM, OM and CP was shown in sheep consuming acorns at the level of either 250 or 500g kg^{-1} feed.	Al Jassim *et al.*, (1998)
			250g kg^{-1} feed	717^{b}	737^{b}	690^{b}		
			500g kg^{-1} feed	660^{c}	683^{c}	633^{c}		
			P value	<0.01	<0.01	<0.01		
Sheep	Acorn	8	Control	805^{a}	834	774	A significant decrease in DM digestibility was found in sheep fed on acorns by the levels of 100 and 150g kg^{-1} feed, while there was no effect of feeding acorns by levels of 50, 100 and 150g kg^{-1} feed on the digestibility of OM and CP.	Hidayet and Mustafa, (2020a)
			50g kg^{-1} feed	762^{ab}	795	735		
			100g kg^{-1} feed	710^{bc}	753	693		
			150g kg^{-1} feed	727^{bc}	766	726		
			P value	0.05	0.08	0.37		
Sheep	Acorn	15	Control	750	739	604	A numerical decline could be noticed in the digestibility of DM, OM and CP in sheep fed on acorns at the level of either 100 or 300g kg-1 feed, but the decline is statistically insignificant.	Aghamohamadi *et al.*, (2014)
			100g kg-1 feed	720	602	492		
			300g kg-1 feed	691	540	356		
			P value	>0.05	>0.05	>0.05		
Goats	Leave		Control	647	654		There was no effect of replacing 250, 500 or 750g of control diet (hay) with same quantity of oak leaves on DM and OM digestibility in goats.	Sevim and Sarı (2014)
			250g kg-1 feed	575	579			
			500g kg-1 feed	538	542			
			750g kg-1 feed	566	572			
			P value	>0.05	>0.05	>0.05		

No.: Number of animals in the study, DM: Dry matter, OM: Organic matter, CP: Crude protein. Different letters within the column of each reference show significant difference.

Silanikove *et al.*, (1994), demonstrated that the decline in the apparent digestibility coefficient of dry matter in sheep consuming tannin-containing leaves

may be due to the hydrolysable tannins that act to reduce the cell wall digestibility through inhibiting the activity of rumen microorganisms and their enzymes and/or making indigestible complexes with cell wall carbohydrates.

Tannins make complexes with proteins in which prevent the degradation of proteins in rumen leading to increase in the flow of proteins to the intestine and eventually, leading to lower apparent digestibility of crude protein (Patra and Saxena, 2011; McNabb *et al.*, 1996). In other words tannins act to protect the substrate from hydrolysis in rumen in addition to the direct inhibitory effect of tannins on digestive enzymes may explain the negative effects of tannin-containing feeds on the apparent digestibility coefficients of dry matter, organic matter and crude protein (Gasmi-Boubaker *et al.,* 2007). In parallel, Wangi *et al.,* (1994) showed that high tannin concentration reduces digestibility of proteins. In goats, there is a superiority for dealing with tannins as compared to sheep and this might be due to the greater ability of microbial population of goats' rumen to degrade tannins (Grenet *et al.,* 1977).

Rumen fluid pH and ammonia-nitrogen concentration

The rumen fluid pH and ammonia-nitrogen concentration are being used as reliable indicators of nutrient degradation in rumen. The effect of oak on pH value and ammonia-nitrogen levels in rumen fluid is shown in table (5). Alipanahi *et al.,* (2019) concluded that the value of rumen fluid pH was unaffected in lactating multi-parous Kurdish goat does being fed on extruded soybean and acorns of *Quercus persica* at a level of 100g Kg^{1} DM Table (5). Comparably in sheep, feeding acorns of *Quercus persica* to Sanjabi rams at levels of 100g kg^{-1} feed and 300g kg^{-1} feed did not cause a difference in the value of rumen fluid pH at times before feeding and at 2, 4, 6 and 8 hours post feeding, the pH values ranged from 5.85 to 5.89 (Aghamohamadi *et al.,* 2014). Likewise, no effect of feeding acorns of *Quercus aegilos* at levels of 50, 100 and 150g kg^{-1} feed on rumen fluid pH has been noticed in sheep and goats at 2,4 and 6hours following morning feeding (Hidayet and Mustafa, 2020a).

Feeding acorns of *Quercus persica* at a level of 100g Kg^{-1} feed to lactating multi-parous Kurdish goats breed added to extruded soybean diet exhibited a significant decline in rumen ammonia- nitrogen concentration that was 7.22mg/dL whereas that of control was 10.58mg/dL Alipanahi *et al.,* (2019). Also, goat does in late pregnancy exhibited a significant lessening in rumen ammonia-nitrogen level following consumption of diets containing acorns at rate of either 200g Kg^{1} feed or 400g Kg^{1} feed (Jafari *et al.,* 2018). In addition, a significant decline in rumen ammonia-nitrogen concentration was found by Aghamohamadi *et al.,* (2014), when Sanjabi rams were fed on acorns of *Quercus persica* at rates of 100 g Kg^{1} feed or 300 g Kg^{1} feed. In contrast, Hidayet and Mustafa, (2020a) documented a significant increase in rumen ammonia-nitrogen level in bucks consuming a feed containing acorns of *Quercus aegilos* at the level of 150g kg^{-1} feed as compared to rams fed on

either 50 or 150g kg^{-1} feed after 4hours of morning meal. The same authors revealed that after 6hours post morning feeding, a significant elevation happened in rumen ammonia-nitrogen concentration of bucks fed on acorns at levels 50 and 100g kg^{-1} feed as compared to that of rams fed on same levels of acorns, and rams fed on 150g kg^{-1} feed showed a significant elevation as compared to that fed control at 6 hours post morning feeding.

Table (5): Effect of oak acorns on pH value and ammonia-nitrogen concentration in rumen fluid.

Species	No.	Level of acorns in diet	Time of sampling (h after morning feeding)	pH	NH_3-N (mg^{-1} dL)	Finding	Reference
Goats	21	Control	3	6.92	10.58[a]	Addition of acorns in the diet of goats to the level of 100g kg^{-1} DM with or without adding polyethylene glycol by 20g d^{-1} caused a significant reduction in rumen fluid NH_3-N concentration at 3 hours post morning feeding without effect on rumen fluid pH.	Alipanahi *et al.,* (2019)
		100g kg^{-1}DM without polyethylene glycol		6.72	7.22[b]		
		100g kg^{-1} DM and 20 g d^{-1} polyethylene glycol		6.84	9.98[a]		
		P value		0.42	<0.01		
Goats	50	Control	3	-	10.61 [a]	Addition of acorns at both levels of 200 and 400g kg^{-1} DM significantly reduced rumen NH_3-N concentration in goats at 3 hours post morning feeding.	Jafari *et al.,* (2018)
		200g kg^{-1} DM		-	7.18 [b]		
		400g kg^{-1} DM		-	5.86 [c]		
		P value			<0.01		
Sheep	15	Control	8	5.85	8.06[a]	In sheep, addition of acorns at both levels of 100 and 300g kg^{-1} DM significantly reduced rumen NH_3-N concentration at 8 hours post morning feeding, while not affecting rumen fluid pH.	Aghamohamadi *et al.,* (2014)
		100g kg^{-1} DM		5.89	2.63[b]		
		300g kg^{-1} DM		5.85	1.54[b]		
		P value		0.13	<0.01		
Sheep	8	Control	6	6.21	3.50 [a]	The rumen NH_3-N concentration was reduced when sheep fed on acorns at the level 100g kg^{-1} feed at 6 hours post morning feeding, while all dietary treatments did not have effect on rumen fluid pH.	Hidayet and Mustafa, (2020a)
		50g kg^{-1} feed		6.24	3.50 [a]		
		100g kg^{-1} feed		6.55	5.01 [b]		
		150g kg^{-1} feed		6.53	3.15 [a]		
		P value		0.1	0.02		

No.: Number of animals in the study, DM; Dry matter, NH_3-N: ammonia-nitrogen concentration. Different letters within the column of each reference show significant difference.

Milk yield and composition

Oak acorns and leaves as available and alternative feedstuffs are used considerably for feeding lactating animals in many regions of the world. Limited literature is available about the effect of oak on milk yield and composition in ruminants. In goats, Alipanahi *et al.*, (2019) demonstrated no effect of feeding oak

acorns on milk yield and milk components. Differently a significant increase in daily milk yield was reported by Hidayet and Mustafa (2021) and Sameh, *et al.,* (2022) in goats consuming oak acorns within diet Table (6).

Table (6): Effect of feeding different levels of acorns on milk yield and constituents.

Species	No.	Level of acorns in diet	Milk yield Kg^{-1} day	Milk components (g kg^{-1} milk)				Finding	Reference
				Fat	Protein	Lactose	SNF		
Goats	21	Control	0.26	36.30	38.10	55.80	102.10	No effect of feeding goats on acorns at the level of 100 g kg^{-1} DM on daily milk yield and milk fat, protein, lactose and SNF components.	Alipanahi *et al.,* (2019)
		100 g kg^{-1} DM	0.32	33.30	37.90	55.60	101.60		
		P value	0.81	0.45	0.96	0.98	0.87		
Goats	24	Control	0.46 ^{a}	43.4	54.9 a	45.1	108.5 ^{a}	No effects of feeding acorns at the levels of 50 and 100 g kg^{-1} feed on daily milk yield and milk components, but at the dietary level of 150g kg^{-1} feed a significant increase the daily milk yield was found in goats, with a s significant reduction in milk SNF component.	Hidayet and Mustafa, (2021)
		50g kg^{-1} feed	0.64^{ab}	37.2	49.2 ab	44.7	101.9 ^{ab}		
		100g kg^{-1} feed	0.51 ^{a}	50.7	47.3 ab	44.2	99.1 ^{ab}		
		150g kg^{-1} feed	0.86 ^{b}	31.6	44.8 b	44.4	96.7 ^{b}		
		P value	0.03	0.2	0.05	0.15	0.05		
Goats	40	Control	0.79 ^{a}	30.7	27.1	46.7	-	There was significant increase in daily milk production in goats fed on rations containing acorns at levels either of 200g kg^{-1} feed or 250g kg^{-1} feed. The daily yield of milk fat and lactose and protein components remained unaffected by the treatments.	Sameh *et al.,* (2022)
		100g kg^{-1} feed	1.28 ^{a}	32.4	28.8	47.5	-		
		200g kg^{-1} feed	1.43 ^{b}	37.3	31.4	47.7	-		
		250g kg^{-1} feed	2.34 ^{b}	39.5	34.5	50.8	-		
		P value	0.01	0.30	<0.001	0.46	-		

DM: Dry matter, SNF: Solid non-fat. Different letters within the column of each reference show significant difference.

Regarding milk composition, a significant reduction was found by Hidayet and Mustafa (2021) in milk solid non-fat component, while no effect of acorns was found by Alipanahi *et al.,* (2019) and Sameh *et al.,* (2022).

It was shown by Min *et al.,* (2003) that condensed tannins may increase milk production in ruminants, probably due to their action in increasing essential amino acids absorption in small intestine and due to their inhibitory effects on internal parasites activity. In addition, it was stated by Alipanahi *et al.,* (2019) that feeding

lactating goats on acorns caused no effect on the concentration of both of acetate and butyrate in rumen fluid and on plasma triglycerides level and these may partly explain why milk fat content is unaffected by dietary acorns, depending on the findings of Mansbridge and Blake, (1997) who demonstrated that milk fat is derived from *de novo* synthesis using circulatory acetate and butyrate that originate from the rumen and uptake of plasma lipids . Furthermore, it is found that milk protein percentage was not changed by feeding or supplementing oak acorns, this may be attributed partly to the absence of effect of acorns on plasma protein concentrations (Alipanahi *et al.,* 2019).

Growth performance

The effects of oak on growth rate are demonstrated in Table (7). It has been revealed by Froutan *et al.,* (2015) that rearing Markhoz male goat kids for 105 days of growth period on different levels of acorns (80,170 and 250 g Kg^1 feed), showed no impact of feeding acorns on dressing percentage which ranged between 39.79 and 40.53%, average daily weight gain (152.15g/day), feed conversion ratio (6.41). While it has been noticed in the same study that goat kids fed on dietary levels of containing 170 and 250 g Kg^1 feed exhibited a significant lessening in 12^{th} rib fat thickness (2.22 and 2.23mm respectively) as compared to that of control (2.89mm). In another growth trial by Gasmi-Boubaker *et al.,* (2007), a significant reduction was reported in daily weight gain of Boer goat kids that received 600g of *Quercus suber* acorns and 500g oat hay/head/day resulted as compared to goat kids consuming 600g barley and 500g oat hay/head/day (43g/d vs. 80g/d).

In sheep, through an experiment of growth that lasted for 105 days, it is shown that there were no effects of feeding green acorns of *Quercus ilex* on daily weight gain, while a significant decrease in dressing percentage in Ouled Djella lambs kept on a diet consisting of acorns at level 500g Kg^1 feed as compared to those fed on a diet consisting of barley at level 500g Kg^1 feed (Keddam, *et al.,* 2010). Comparably, Al Jassim *et al.,* (1998) stated that feeding Awassi growing lambs on a concentrate diet composing of *Quercus aegilops* acorns at the level of 250g Kg^1 feed did not affect the daily weight gain (187.61g/d on average) and feed conversion ratio (4.73 Kg DM/ Kg live body weight gain) Figure (1). Whereas in the same study, the lambs of the other treatment that fed on dietary level of 500g Kg^1 feed, exhibited a significant reduction in daily weight gain and feed conversion ration as compared to control (144 vs. 186g/d) and (6.01 vs. 4.68 Kg feed/Kg live body weight gain). conversion ratio.

It has been indicated by Hidayet and Mustafa, (2020b) that Awassi lambs fed on dietary treatments of *Quercus aegilops* acorns at levels of 50, 100 and 150g kg^{-1} feed, caused in no impact of acorns on dry matter intake, daily weight gain, feed conversion ratio, in addition to carcass characteristics, the shrinkage and dressing percentages were not affected. The authors found a significant increase only in rib-

eye area of lambs fed on the treatment 50g kg^{-1} feed and the group fed on 150g kg^{-1} feed tended to have a lower feed conversion ratio.

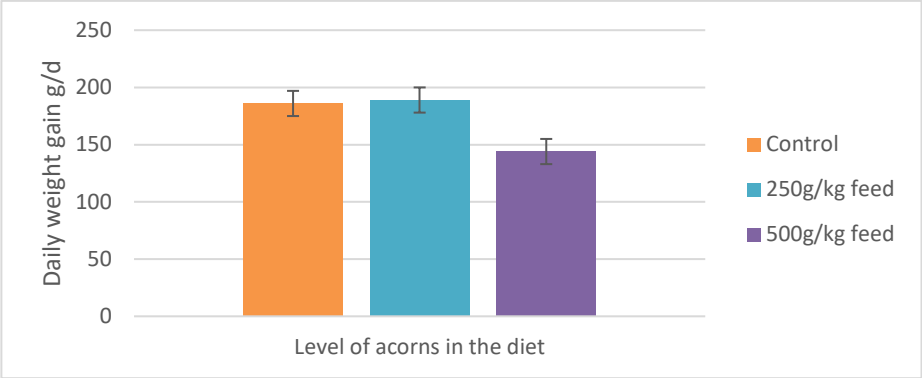

Figure (1): Effect of different levels dietary acorns on daily weight gain of growing Awassi lambs (Al-Jasim *et al.*, 1998)

In cattle, Sharma *et al.*, (2008) showed that feeding Zebu calves on a diet consisting of leaves 0f *Quercus incana* at the ratio of 500g Kg^{1} feed resulted in a significant increase in average daily gain (386g/d) as compared to that of control group (136 g/d). Also it was reported by Paswan and Sahoo, (2012) that heifers fed on diets composing of grass hay plus oak leaves at levels of either 425 or 630 g Kg^{1} feed oak led to a significant decline in average daily weight gain as compared to control group heifers which were kept on grass hay solely.

It was stated by Froutan *et al.*, (2015), that there are differences among animals species in terms to response among tannin-containing feeds. Morever, Alipanahi *et al.*, (2019) demonstrated that in addition to oak species, different kinds or doses of tannins and interactive effects between tannins and other feed ingredients might be the reasons of differences among the findings of studies. The variation in chemical composition of oak acorns is expected due to species, growing site and stage of maturity (Gasmi-Boubaker *et al.*, 2007).

Blood metabolites

The impact of oak on blood metabolites as provided by literature is summarized in Table (8). It is documented in multi-parous lactating Kurdish goat does fed on extruded soybean along with *Quercus persica* acorns at a level of 100g Kg^{-1} DM, do not cause a differences in plasma glucose, protein, albumin, cholesterol, and triglycerides levels (Alipanahi *et al.*, 2019).

Table (7): Effect of dietary oak acorns and leaves on growth performance of goat kids and lambs.

Species	No.	Part of oak	Level in diet	DWG g d^{-1}	FCR	Finding	Reference
Goats	24	Acorn	Control	146.52	6.33	There was no effect of feeding acorns at the levels of 80, 170 and 250g kg^{-1} feed on DWG and FCR in goat.	Froutan *et al.*, (2015)
			80g kg^{-1} feed	149.02	6.52		
			170g kg^{-1} feed	155.95	6.39		
			250g kg^{-1} feed	157.14	6.43		
			P value	0.17	0.97		
Goats	10	Acorn	Control	80.26		There was no effect of feeding 600g of acorns to each goat kid on DWG.	Gasmi-Boubaker *et al.*, (2007)
			600g^{-1} head	43.21			
			P value	<0.05			
Sheep	10	Acorn	Control	97.28		There was no effect of feeding 400g of acorns to each lamb on DWG.	Keddam *et al.*, (2010)
			400g $head^{-1}$	92.85			
			P value	>0.05			
Sheep	30	Acorn	Control	186[a]	4.68 [a]	No effect of feeding acorns at the level of 250g kg^{-1} feed on DWG and FCR in lambs, but feeding acorns at the level 500g kg^{-1} feed significantly decreased the DWG, while caused a significant increase in FCR.	Al Jassim *et al.*, (1998)
			250g kg^{-1} feed	189 [a]	4.79 [a]		
			500g kg^{-1} feed	144 [b]	6.01 [b]		
			P value	<0.01	<0.01		
Sheep	24	Acorn	Control	94.4	11.44	The were no effects of feeding acorns at levels of 50, 100 and 150g kg^{-1} feed on DWG and FCR in lambs.	Hidayet and Mustafa, (2020b)
			50g kg^{-1} feed	117.6	11.59		
			100g kg^{-1} feed	99.4	12.26		
			150g kg^{-1} feed	124.4	8.24		
			P value	0.39	0.07		
Cattle	15	Leave	Control	136 [a]	-	Consuming oak leaves at the level of 325g kg^{-1} feed had no effect on DWG in calves, but the level 500g kg^{-1} feed significantly raised the DWG.	Sharma *et al.*, (2008)
			325g kg^{-1} feed	300 [ab]	-		
			500g kg^{-1} feed	386 [b]	-		
			P value	0.04			
Cattle	6	Leave	Control (Grass hay)	-50 [a]	-	Feeding calves on oak leaves on both levels of 430 and 640g kg^{-1} feed significantly increased the DWG as compared to that of control.	Paswan and Sahoo, (2012)
			430g kg^{-1} feed	142 [b]	-		
			640g kg^{-1} feed	306 [c]	-		
			P value	<0.001			

No.: Number of animals in the study, DWG: Daily weight gain, FCR: Feed conversion ratio. Different letters within the column of each reference show significant difference.

Table (8): Effect of oak acorns on blood metabolites of ruminants.

Species	No.	Level of acorns in diet	Blood metabolite (mg^{-1} dL)				Finding	Reference
			Gl	TP	Tr	Ch		
Goats	21	Control	48.8	7.55	13.2	99.2	No effect of feeding acorns on the level 100g kg^{-1} DM with or without polyethylene glycol on blood Gl, Pr, Tr and Ch levels in goats.	Alipanahi *et al.*, (2019)
		100g kg^{-1} DM without polyethylene glycol	40.2	71.3	14.4	81.6		
		OA 100g kg^{-1} DM and 20 g/d polyethylene glycol	44.5	73.6	12.7	86.7		
		P value	0.25	0.10	0.66	0.20		
Goats	50	Control	64.1 [a]	71	36 a	92	In goats being fed on acorns on levels of 200 and 400g kg^{-1} DM significantly decreased blood Gl and Tr levels, without affecting the blood Pr and Ch concentrations.	Jafari *et al.*, (2018)
		200g kg^{-1} DM	54.7 [b]	66	22 b	100.8		
		400g kg^{-1} DM	53.6[b]	68	27 b	101.1		
		P value	<0.01	0.17	<0.01	0.13		
Goats	24	Control	70.1	70.1	29.3	66.1	No effect of dietary acorns levels of 80, 170 and 250g^{-1} kg feed on blood Gl, Pr, Tr and Ch levels in goats.	Froutan *et al.*, (2015)
		80g^{-1} kg feed	66.4	72.4	23.5	58.7		
		170g^{-1} kg feed	60.2	71.7	20.8	69.9		
		250g^{-1} kg feed	60.9	84.6	22.3	58.4		
		P value	>0.05	>0.05	>0.05	>0.05		
Goats	24	Control	44.5 [a]	68	14	-	The oak acorns fed at levels of 50, 100 and 150g kg^{-1} feed had no effects on blood Gl, Pr, Tr and Ch levels in goats, except the blood Gl concentration which was significantly lowered in goats fed on the oak level of 100g kg^{-1} feed.	Hidayet and Mustafa, (2021)
		50g kg^{-1} feed	57.8 [ab]	74	18	-		
		100g kg^{-1} feed	49 [b]	74	16.2	-		
		150g kg^{-1} feed	44.2 [ab]	72	12.7	-		
		P value	0.03	0.65	0.28			

No.: Number of animals in the study, Gl: Glucose, TP: Total proteins, Tr: Triglycerides, Ch: Cholesterol. Different letters within the column of each reference show significant difference.

Jafari *et al.*, (2018) also reported that goat does at late pregnancy exhibited no effects of consuming acorns at levels of 200 and 400g Kg^{1} feed on plasma biochemical parameters except for plasma glucose and triglycerides concentrations. The plasma glucose levels of the does receiving acorns were significantly lower than that of control, it was 54.76 and 53.64mg/dL in does received 200 and 400g Kg^{1} feed respectively, while in does fed on control diet it was 64.18mg/dL.

The plasma triglycerides level in does feed on dietary acorns level of 200 and 400g Kg^{1} feed were 22 and 27.02mg/dL respectively which were lower than that of control (36.06mg/dL). In a study on growing Markhoz male goat kids by, no effects

of feeding oak acorns at levels 80, 170 and 250 g Kg^{1} feed were found on plasma glucose, protein, triglycerides and cholesterol concentrations. Differently a significant elevation was found in the concentration of serum globulin (57.8 mg/dL) in lactating Black goats breed at the 10^{th} week of lactation when compared to that of control (44.50mg/ dL) (Hidayet and Mustafa, 2021).

Furthermore, no influence of feeding either Karadi rams or Black bucks on acorns of *Quercus aegilops* at levels of 50, 100 and 150g kg^{-1} feed were found by Hidayet and Mustafa, (2020a) on serum biochemical metabolites.

CONCLUSIONS

It could be concluded from the literature reviewed that it is possible to use oak acorns and leaves as feedstuffs in ruminant diets. The degree of the impact of oak consumption depends on the level of oak products in the diet, oak species, type and chemical structure of tannins present in the oak, in addition to animal species. It could be concluded also that goats are more capable than sheep on utilizing oak active materials.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interests.

البلوط كمكون علفي للحيوانات المجترة: مراجعة

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الخلاصة

تم في هذه المراجعة للدراسات السابقة بيان تأثيرات إضافة البلوط في علائق الحيوانات المجترة على الأداء وهضم الأعلاف وإنتاج الحليب وصفات الدم الكيموحيوية. يستخدم البلوط كعلف بديل ومتوفر في العديد من دول العالم، وخاصة في المناطق التي تعاني من نقص مواد العلف. من الواضح ونظرا لاختلاف أنواع البلوط فان تأثيراته مختلفة على أنواع الحيوانات المختلفة. إن تغذية البلوط بنسب قليلة في تغذية الحيوان قد لا تؤثر على عملية الهضم، ولكن عندما يتم تغذيتها بنسب عالية قد تؤدي إلى خفض نسب هضم المادة الجافة وقد تبين بان إضافة منتجات البلوط قد تؤدي إلى تحسين إنتاج الحليب اليومي للماعز في حين لم تؤدي تغذية ثمار البلوط وأوراقها لجداء الماعز الى تحسن في الزيادة الوزنية اليومية وكفاءة التحويل الغذائي، بينما تغذية الأغنام

البالغة بنسب عالية من ثمار البلوط أدت إلى انخفاض الزيادة الوزنية اليومية. ومن المعروف بان الأنواع المختلفة من البلوط تنتج كميات مختلفة من التانينات، والتي بعد تناولها من قبل الحيوانات، تعمل على تكوين بروتينات معقدة في الغذاء وبروتينات الجسم، وقد يؤدي ذلك إلى انخفاض هضم العناصر الغذائية أو قد يؤثر بشكل ايجابي على تدفق الأحماض الأمينية إلى المعدة الحقيقية والامعاء عن طريق تقليل تحلل البروتين في الكرش. وبالتالي، فإن مدى تأثير إضافة البلوط الى علائق المجترات على أداء الحيوانات يعتمد على نوع الحيوان ونوع والبلوط، ونسبته في العليقة.

الكلمات المفتاحية: ثمار البلوط، المجترات، الأغنام، الماعز.

REFERENCES

Abdul-Rahman, S. Y, (2008). Effect of oak (*Quercus Aegilops*) leaves extract on blood glucose and lipid profile in rabbits. *Mesopotamia Journal of Agriculture. 36*(3):57-62. https://doi.org/10.33899/MAGRJ.2008.26788

Aghamohamadi, N., Hozhabri, F. & Alipour D. (2014). Effect of oak acorn (*Quercus persica*) on ruminal fermentation of sheep. *Small Ruminant Research.120,* (1):42-50. https://doi.org/10.1016/j.smallrumres.2014.04.015

Al Jassim, R. A. M., Ereifej, K.I., Shibli, R.A. & Abudabos, A., (1998). Utilization of concentrate diets containing acorns (*Quercus aegilops* and *Quercus coccifer)* and urea by growing Awassi lambs. *Small Ruminant Research* 29, 289–293. https://2u.pw/cgVyN5n

Alipanahi, Z., Fatahnia, F., Jafari, H., Taasoli, G., Mirzaei-Alamouti, H., Barrett, D. & Pormalekshahi A., (2019). Effect of oak acorn with or without polyethylene glycol in diets containing extruded soybean on milk fatty acid profile, ruminal fermentation and plasma metabolites of lactating goats. *Livestock Science.* 221, 57–62. https://doi.org/10.1016/j.livsci.2019.01.003

Alkass, J. E., Dosky, K. N. & Buti, E. T. (2018). Influence of varying rumen degradable to undegradable protein ratios on milk yield, composition and some blood parameters of Karadi ewes. *Mesopotamia Journal of Agriculture. 46*(4):469-478. https://doi.org/10.33899/magrj.2018.161519

Almaroof, I. N. (2005). Ecological study on oak seed weevil *Cucrulio longipennis* Rett *Curculioidae*: *Coleoptera*) in swaratuka region/ Duhok governorate. *Mesopotamia Journal of Agriculture.33*(4): 114-120. https://doi.org/10.33899/magrj.2005.34850

Bausch J. D. & Carson T. L. (1981). *Oak Poisoning in Cattle*. Iowa State University Veterinarian. 3: 108–111.

Becker, K. & Makkar, H. P. S. (1999). Effects of dietary tannic acid and quebracho tannin on growth performance and metabolic rates of common carp (*Cyprinus carpio* L.). *Aquaculture*, 175,(3-4):327–355.

Doce, R. R., Hervás, G., Belenguer, A., Toral, P.G., Giráldez, F. J. & Frutos, P. (2007). Effect of the administration of young oak (*Quercus pyrenaica*) leaves

to cattle on ruminal fermentation. *Animal Feed Science and Technology*. *150*, (1–2): 75-85. https://doi.org/10.1016/j.anifeedsci.2008.08.005

Dosky, K. N. S., Sh. S. A. Jaaf & L. T. Mohammed. (2012). Effect of protected soybean meal on milk yield and composition in local Meriz goats. *Mesopotamia Journal of Agriculture* *40*(1): 1-10. https://doi.org/10.33899/magrj.2012.32593

Froutan E., Azizi, O., Sadeghi G., Fatehi F. & Lashkari S. (2015). Effects of different concentrations of ground oak acorn on growth performance, blood parameters and carcass characteristics of goat kids. *Animal Production Science*, 55, 87-92. http://dx.doi.org/10.1071/AN13312

Frutos P., Hervás G., Giráldez F. J. & Mantecón A. R. (2004). Review. Tannins and ruminant nutrition. *Spanish Journal of Agricultural Research. 2*(2):191-202. https://doi.org/10.5424/sjar/2004022-73

Gasmi-Boubaker, A., Abdouli, A., H., Khelil, H., Mouhbi, R. & Tayachi L. (2007). Nutritional Value of Cork Oak Acorn (Quercus suber L.) as an Energy Source for Growing Goats. *Asian Journal of Animal and Veterinary Advances, 2*(1):32-37. https://doi.org/10.3923/ajava.2007.32.37

Grenet, É., Demarquilly, C., Boissau, J. M., Bousquet, H., Dudilieu, M. Jailler, M., Jamot, J., & l'Hotelier, L. (1977). Utilisation de l'azote des fourrages verts par le mouton en croissance : influence du stade de végétation, de l'espèce fourragère, de la fertilisation azotée et de l'addition d'orge. Annales de zootechnie, INRA/EDP Sciences, 26 (4):481-501. https://doi.org/10.1051/animres:19770402

Hagerman, A. E. & Butler L. G. (1989). Choosing appropriate methods and standards for assaying tannin. *Journal of Chemical Ecology*. *15*(6): 1795-1810. https://doi.org/10.2307/4002526

Hidayet, H. M. & Mustafa K. N. (2020a). Effect of feeding oak (Quercus aegilops) acorns on nutrient digestibility, nutrient balance, ruminal fluid characteristics and some blood metaboliets in sheep and goats. *Journal of University of Duhok. (Agriculture and Veterinary Sciences) 23*(2):44-54. https://doi.org/10.26682/ajuod.2020.23.2.7

Hidayet, H. M. & Mustafa. K. N. (2020b). Influence of different levels of ground oak (*quercus Aegilops*) acorns on growth performance and some carcass characteristics of Awassi lambs. *Science* Journal *of University of Zakho*. *8*(2), 58-61. https://doi.org/10.25271/sjuoz.2020.8.2.711

Hidayet, H. M. & Mustafa. K. N. (2021). Effect of feeding oak (*quercus Aegilops*) acorns on milk production, milk composition and some blood biochemical parameters of black goats. *Iraqi Journal of Agricultural Sciences. 52*(1):28-35. https://doi.org/10.36103/ijas.v52i1.1233

Jafari, H., Fatahnia, F., Khatibjoo, A., Taasoli, G. & Fazaeli, H. (2018). Effect of oak acorn level on colostrum composition and plasma immunoglobulin G of late-pregnant goats and their kids. *Animal 12*(11): 2300–2309. https://doi.org/10.1017/S1751731118000368

Jones, G. A., McAllister, T. A., Muir, A. D. & Cheng, K.-j. (1994). Effects of Sainfoin (*Onobrychis vicifolia Scop*.) Condensed Tannins on Growth and Proteolysis by Four Strains of Ruminal Bacteria. *Applied and Environmental Microbiology. 60*(4):1374-1378. https://doi.org/10.1128/aem.60.4.1374-1378.1994

Kamalak, A., Canbolat, O., Erol, A., Kilinc, C., Kizilsimsek, M., Ozkan, C. O. & Ozkose, E. (2005). Effect of variety on chemical composition, *in vitro* gas production, metobolizable energy and organic matter digestibility of alfalfa hays. *Livestock Research for Rural Development 17* (7). https://www.lrrd.cipav.org.co/lrrd17/7/kama17077.htm

Kaya E. & Kamalak A. (2012). Potential nutritive value and condensed tannin contents of acorns from different oak species. *Kafkas Üniversitesi Veteriner Fakultesi Dergisi. 18*(6):1061-1066. https://2h.ae/CGEN

Keddam, R. Bouderoua, K., El-Affifi, M. & Selselet-Attou, G. (2010). Growth performances, carcasses parameters and meat fatty acid composition of lamb fed green oak acorns (*Quercus ilex*) based diet. *African Journal of Biotechnology. 9*(29): 4631-4637. https://www.ajol.info/index.php/ajb/article/view/82736

Kirkpatrick, R. L.; Pekins, P. J. (2002). *Nutritional value of acorns for wildlife*. In: McShea, W.J. and Healy, W.M., eds., *Oak Forest Ecosystems*: Ecology and Management for Wildlife. Baltimore, MD: Johns Hopkins University Press. Pp 173-181. https://press.jhu.edu/books/title/2059/oak-forest-ecosystems

Łuczaj, Ł., Adamczak, A. & Duda, M. (2014). Tannin content in acorns (Quercus spp.) from Poland. *Dendrobiology* 72,103-111. http://dx.doi.org/10.12657/denbio.072.009

Makkar, H. P. S. (2003). *Quantification of tannins in tree and shrub foliage: a laboratory manual*. Boston (MA): Kluwer Academic Publishers. [Google Scholar]**.**

Makkar, H. P. S., Becker, K., Abel Hj. & Szegletti. C. (1995). Degradation of condensed tannins by rumen microbes exposed to quebracho tannins (QT) in rumen simulation technique (RUSITEC) and effects of QT on fermentative processes in the RUSITEC. *Journal of the Science of Food and Agriculture. 69*,495-500. https://doi.org/10.1002/jsfa.2740690414

Mansbridge, R. J. & Blake, J. S. (1997). Nutritional factors affecting the fatty acid composition of bovine milk. *British Journal* of *Nutrition, 78,* Suppl. 1, S37S47. https://doi.org/10.1079/BJN19970133

McNabb, W. C., Waghorn, G. C., Peters, J. S. & Barry, T. N. (1996). The effect of condensed tannins in Lotus pedunculatus on the solubilization and degradation of ribulose-1,5-bisphosphate carboxylase (EC 4.1.1.39; Rubisco) protein in the rumen and the sites of Rubisco digestion. *British Journal of Nutrition, 76,* 535-549. https://doi.org/10.1079/bjn19960061

Min, B. R., Barry, T. N., Attwood, G. T. & McNabb, W. C. (2003). The effect of condensed tannins on the nutrition and health of ruminants fed fresh temperate forages: a review. *Animal Feed Science and Technology 106*(1-4):3–19. https://doi.org/10.1016/S0377-8401(03)00041-5

Moujahed N., Ben Mustafa Ch. & Kayouli, Ch. (2007). Effect of barley replacement by acorns (Quercus coccifera L.) as energy supplement on *in vitro* fermentation. *CIHEAM Options Méditerranéennes : Série A. Séminaires Méditerranéens;* 74, 183-187. https://om.ciheam.org/article.php?IDPDF=800376

Mueller-Harvey, I.; Bee, G.; Dohme-Meier, F.; Hoste, H.; Karonen, M.; Kölliker, R.; Lüscher, A.; Niderkorn, V.; Pellikaan, W.F.; Salminen, J.-P.; *et al*. (2019). Benefits of condensed tannins in forage legumes fed to ruminants: Importance of structure, concentration and diet composition. *Crop Science.* 59, 861–885. https://doi.org/10.2135/cropsci2017.06.0369

Narjisse, H., Elhonsali, M. A. & Olsen, J. D. (1995). Effects of oak (Quercus ibex) tannins on digestion and nitrogen balance in sheep and goats. *Small Ruminant Research 18*(3):201-206. https://doi.org/10.1016/0921-4488(95)00700-0

Paswan, V. K. & Sahoo, A. (2012). Feeding of oak (Quercus leucotrichophora) leaves and evaluation for its potential inclusion in the feeding of native heifers of Kumaon Himalaya. *Tropical Animal and Health Production*. 44:1931–1938. https://doi.org/10.1007/s11250-012-0159-4

Patra, A. K. & Saxena J. (2011). Exploitation of dietary tannins to improve rumen metabolism and ruminant nutrition. *Journal of Science Food Agric*ulture. 91:24–37. https://doi.org/10.1002/jsfa.4152

Pourhashemi, M., Dey D. C., Mehdifar D., Panahi P. & Zandebasiri M. (2018). Evaluating acorn crops in an oak-dominated stand to identify good acorn producers. *Austrian Journal of Forest Science.35*(3):213-234. https://2u.pw/DXVc4bH

Rababah, T. M., Ereifej, Kh. I., Al-Mahasneh, M. A., Alhamad, M. N., Alrababah, M. A. & Muhammad, A. H. (2008). The Physicochemical Composition of Acorns for Two Mediterranean Quercus Species. *Jordan Journal of Agricultural Sciences, 4*(2):131-137. https://2h.ae/maLQ

Rakić, S., Povrenović D., Maletić R. & Živkovi M. (2005). Drying of the aqueous extract of acorn *Quercus* Robur in a spout-fluid bed. *Journal of Agricultural Sciences. 50* (2):173-182. https://doi.org/10.2298/JAS0502173R

Sameh, S, Houria, O., Anouar, B. & Malak, B. (2022). Effect of incorporating holm oakacorn in the feed of "Saanen" breed dairy goats in the wilaya of Batna. *Livestock Research for Rural Development.34(10).* http://www.lrrd.org/lrrd34/10/3496same.html

Sevim, Ö. & Sari, M. (2014). Effects of Different Levels of Oak Leaves on Digestibility, Some Rumen and Blood Parameters in Goats. *Animal Health, Production and Hygiene.* *3*(1): 253 – 257.https://dergipark.org.tr/en/download/article-file/1475070

Sharma, R. K., Singh, B. & Sahoo, A. (2008). Exploring feeding value of oak (Quercus incana) leaves: Nutrient intake and utilization in calves. *Livestock Science* 118,157–165. https://doi.org/10.1016/j.livsci.2008.01.022

Silanikove, N., Nitsan, Z. & Perevolotsky, A. (1994). Effect of adaily supplementation of polyethylene glycol on intake and digestion of tannin-containing leaves *(Cerutoniu siliquu)* bysheep. *Journal of Agricultural and Food Chemistry.* 42, 2844-2847**.** https://doi.org/10.1021/jf00048a035

Wangi, Y., Waghorn, G. C., Barry T. N., & Shelton, I. D. (1994). The effect of condensed tannins in Lotus *cornidatus* on plasma metabolism of methionine, cystine and inorganic sulphate by sheep. *British Journal of Nutrition* (1994), *72, 923-935.* https://doi.org/10.1079/BJN19940096