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The effect of substituting wheat straw with different levels of cumin (*Cuminum cyminum*) crop residues on growth, blood metabolites and hematological values of Moghani male lambs

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Abstract

The purpose of the present work was to study potential benefits of cumin (*Cuminum cyminum*) crop residues (CCR) on growth performance, blood metabolites and hematological indices. Eighteen Moghani male lambs were assigned to four following dietary treatment groups: basal diet (control; 0%CCR); control plus 7%CCR; control plus 14%CCR; control plus 21%CCR. Basal diet consisted of forage (35%) and concentrate (65%).The CCR supplementation had no significant effect on final weight and dry matter intake, however, increasing 7% and 14% CCR of diet caused an increase in average daily gain (204.86 g/d and 197.53 g/d vs. 179.42g/d and 177.50; $p<0.05$) and, feed conversion ratio increased in 21%CCR (9.27 vs. 8.92; 8.26 and 8.23) than other treatments. Lambs were fed diet containing 21%CCR had the highest blood urea nitrogen (16.98 vs. 13.04, 13.72 and 15.16 mg/dl; $p<0.05$) and lowest blood glucose (53.25 vs. 63.25, 60.75 and 62.25 mg/dl; $p<0.05$). Animals were fed no CCR had highest blood calcium concentration ($p<0.05$).There was no unfavorable effect on aspartate amino transferase (AST) and alanine amino transferase (ALT) concentrations as indices for liver inflammation in highest amount of CCR consumption. The results suggest that substituting wheat straw with different levels of CCR not only do not effect liver inflammation but can improve average daily gain and feed conversion ratio in levels of 7%CCR and 14%CCR in Moghani male lambs.

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Introduction

Due to the ever increasing human population and the consequent increase in demand for food, livestock feed tends to be derived from residues and by-products of the food industry. Most residues are also deficient in fermentable carbohydrates, reflected by the relatively low organic matter digestibility (Jayasuriya, 2000). Cumin (*Cuminum cyminum L.*) is a herbaceous, annual and medicinal plant which is one of the most important export crops for countries such as India, Iran and some other Asian countries (El-sawi and Mohammad 2002, Kafi *et al.,* 2002, Duke *et al.,* 2003). More than 7000 tons of cumin seed is produced in Iran annually (Kazemi *et al.,* 2010) and the residues of the plant after harvesting cumin due to high levels of neutral detergent fiber has a potential as an inexpensive fiber source for ruminant diets. Cumin plant is also a source of essential oil with major effective compound *cuminaldehyde*. Previous studies have shown that adding the cumin's essential oil can reduce methane and NH_3-N production (Jahani-Azizabadi *et al.*, 2010) and whole spice can improve digestibility of dry matter and organic matter(Khan and Chaudhry, 2010). Antioxidant and tyrosinase inhibition properties and antibacterial activity of cumin have beenproved (Kubo and Kinst-Hori 1998, Tajkarimi *et al.*, 2010, Einafshar *et al.*, 2012). Recent studies on the effect of cumin on ruminal ecology has indicated greater digestibility of dry matter and organic matter in forages and lower methane emission after application of cumin with ruminal fluid *in vitro* (Khan and Chaudhry, 2010). But very little information is available on performance and blood indices of Moghani lambs in Iran. So the objective of this study was to investigate the effect of substituting wheat straw with different levels of cumin crop residues on growth performance and blood metabolites of Moghani male lambs.

Material and methods

Number of 36 Moghani male fat-tailed lambs (160±10 days old), and average initial body weight (BW) of 32.5±2.5 kg were divided to four groups based on weight in a completely randomized design and were held in standard individual cages. Animals received pretreatments such as anti-parasite drugs, enterotoxemia vaccine and wool cutting prior to trial. Each group received one of the diets: 1) Diet with no cumin crop residues (0%CCR), 2) Diet with 7% cumin crop residues (7%CCR), 3) Diet with 14% cumin crop residues (14%CCR) and 4) Diet with 21% cumin crop residues (21%CCR). Diets were isonitrogenus and isoenergetic and were prepared according to NRC recommendations (NRC 1985). Feed was offered twice daily were fed at 06:00 am and 16:00 pm. Lambs were housed in individual pens (1.5 m × 2.5 m) and fresh drinking water was available at all times. The ingredient and chemical composition ofthe diets used in first experiment is shown in Table 1. Weight of each lamb was recorded at the beginning of adaptation and end of experimental period with removing feed and supplying fresh water 6 hours before weighing. Feed consumption was measured as the difference between the amount offered and residues. Samples from lambs within each treatment group were composited and stored for chemical analyses. The average daily gain (ADG) were determined and feed conversion ratio (FCR) for each individual lamb was calculated from feed intake (g/day) and weight gain (g/day). Blood samples were taken in the one day before last day of trial and approximately 2 h after morning feeding.Plasma was obtained by centrifuge (15 min at 3500× g) and frozen at −20°C until analysis.Analysis of blood metabolites was performed using an auto-analyzer (Biosystem, A15, Spain). Anticoagulated blood samples were analyzed shortly after collection for: number of red blood cells (RBC), hemoglobin concentration (Hb), total white blood cells (WBC), by an automaticveterinary hematology cell counter (Nihon kohden, Cell Tac Alpha, Tokyo, Japan).

Data were analyzed in a completely randomized design considering initial weight as covariate effect using SAS program (version 9.1). Duncan multiple range test was used for comparison of means. The statistical design can be described as below:

$\gamma ijk = \mu + \tau i + rj (\tau i) + \varepsilon ijk$.

In which γ_{ijk} represents dependent variable, μ stands for total mean, τ_i shows the effect of treatment "i", r_j (τ_i) describes covariate effect of weight and ε_{ijk} represents random error effect.

Results and discussion

Animal performance

Effects of substituting wheat straw with different levels of cumin crop residues (CCR) on lamb's performance is presented in table 2. Although weight at the end of trial and dry matter intake did not varied between diets, animals that consumed diets containing 7%CCR and 14%CCR had higher average daily gain and numerically better feed conversion comparing to control group (0%CCR). *Cuminum cyminum L.* contains several nutrients (such as vitamins, amino acids, protein, starch, sugars and other carbohydrates, tannins and phytic acid), and certain amounts of minerals and trace elements (Uma *et al.,* 1993; El-sawi and Mohammad 2002; Al-Bataina *et al.,* 2003). Minerals and trace elements have been shown to improve *in vitro* rumen cellulose digestion in non-toxic levels (Martinez, 1971). Also Khan and Chaudhry (2010) reported that different amounts of cumin can improve digestibility of low quality fibrous materials *in-vitro* as a result of high levels of Zn, PHOS, Ca, Mg, Cu and Co in *cuminum cyminum L.*. Jahani-Azizabadi *et al. (* 2010) reported the negative effect of cumin oil on *in-vitro* dry matter disappearance in diets containing high forage proportion. As cumin crop residues contains less amounts of cumin oil and the effect of cumin on fiber digestion depends on the level of consumption (Khan and Chaudhry, 2010) it seems regarding to mentioned results the positive effect of high mineral content of cumin in diets containing 7%CCR and 14%CCR improved average daily gain and feed conversion as a result of improved digestibility while in the diet containing 21%CCR along with increase of cumin oil, the digestibility, average daily gain and feed conversion was suppressed in comparison to diets containing 7%CCR and 14%CCR. Any way there were no comparable data on CCR digestibility or its effects on digestibility of other components in the diet. Since actual effects of CCR according to *in vivo* situation are widely unknown, interpretations based on limited *in vitro* data are extremely dubious.

Table 1. Ingredients and chemical composition of the treatments consumed by lambs.

Item	Treatment[a]			
	1	2	3	4
Ingredients(% of DM)				
Lucerne hay	19.5	17	15	14
Wheat straw	15.5	11	6.0	-
Cumin crop residues	-	7.0	14	21
Barley grain (cracked)	24.6	24.6	24.6	24.6
Wheat Grain (cracked)	18	18	18	18
Cottonseed Meal	6.5	6.5	6.5	6.5
Wheat Straw	8.5	8.4	8.53	8.9
Beat Pulp	5.0	5.0	5.0	5.0
Urea	0.4	0.4	0.4	0.4
Calcium Carbonate	0.5	0.6	0.65	0.7
Vitamin and Mineral Premix[b]	0.6	0.6	0.6	0.6
Sodium Bicarbonate	0.6	0.6	0.6	0.6
Salt	0.4	0.4	0.4	0.4
Chemical composition				
Metabolizable energy (Mcal/Kg DM)	2.55	2.55	2.55	2.55
Crude protein (%)	13.8	13.6	13.5	13.7
Neutral detergent fiber (%)	41.0	40.8	40.5	41.1
Acid detergent fiber (%)	31.2	30.7	30.9	31.1
Ash (%)	7.9	7.7	7.6	7.8
Calcium (%)	0.81	0.78	0.86	0.84
Phosphorus (%)	0.36	0.34	0.36	0.35

1)Diet with no cumin crop residues (0%CCR), 2) Diet with 7% cumin crop residues (7%CCR), 3) Diet with 14% cumin crop residues (14%CCR) and 4) Diet with 21% cumin crop residues (21%CCR).

[b]Each kg of the vitamin–mineral premix contained (DM basis): vitamin A (50,000 IU), vitamin D3 (10,000 IU), vitamin E (0.1 g), calcium (196 g), phosphorus (96 g), sodium (71 g), magnesium (19 g), iron (3 g), copper (0.3 g), manganese (2 g), zinc (3 g), cobalt (0.1 g), iodine (0.1 g), selenium (0.001 g). The treatment is Estimated based on NRC (2001).

Blood metabolites

Effects of substituting wheat straw with different levels of CCR on blood metabolites is presented in table 3. The animals which received 0%CCR and 7%CCR diets had the less blood urea nitrogen and blood glucose in the group that consumed the diet with 21%CCR was lower than other treatment ($p<0.05$). Unfortunately there are very limited data on the effects of cumin on ruminant's metabolism and the major difference resulting from pre-stomach fermentation and different metabolism patterns makes it impossible to generalize results obtained from other species to ruminants and these data can be used only to give a perspective of potential effects. In some studies amethanolic extract of cumin seeds reduced the blood glucose and inhibited glycosylated hemoglobin, creatinine, blood urea nitrogen and improved serum insulin and glycogen (liver and skeletal muscle) content in alloxan and streptozotocin (STZ) diabetic rats (Dhandapani *et al.,* 2002, Jagtap and Patil, 2010). Alsohypoglycemic effect of cumin has been reported in both normal and diabetic rabbits (Akhtar and Ali 1985), while blood calcium level was highest in control group (0%CR), levels of phosphorus, ALT and AST did not differ among different diets. Plant constituents may cause a damage to body tissues such as intestine, liver and kidneys (Ibrahim *et al.,* 2007). ALT and AST are known as indicators of liver damage and inflammation (Ibrahim *et al.,* 2007). Although increase in AST in rabbits have been reported as a consequence of consumption of cumin seeds or cumin oil (EL-Manylawi and Ali 2009), our results suggest that consuming the CCR up to 21%CCR didn't alter liver health status which may be a result of lower amounts of cumin oil in CCR and less proportion of cumin in diets considering the body weight of species.

Table 2. Effects of substituting wheat straw with different levels of CCR on lamb's performance.

Parameter	Treatment[a]				SEM
	1	2	3	4	
Final Weight(kg)	50.32	53. 54	51. 93	51.29	4.78
Average Daily Gain (g)	179.42[b]	204.86[a]	197.53[a]	177.50[b]	17.12
Dry Matter Intake(kg)	1.57	1.57	1.61	1.55	0.06
Feed Conversion	8.92[ab]	8.26[b]	8.23[b]	9.27[a]	0.72

[a]1) Diet with no cumin crop residues (0%CCR), 2) Diet with 7% cumin crop residues(7%CCR),

3) Diet with 14% cumin crop residues (14%CCR) and 4) diet with 21% cumin crop residues(21%CCR).

[a,b] Values in the same row without a common superscript letter are significantly different ($P< 0.05$).

Table 3. Effects of substituting wheat straw with different levels of cumin crop residues on blood metabolites.

Parameters	Treatment[a]				SEM
	1	2	3	4	
Ammonia Nitrogen (mg/dl)	15.28[b]	19.60 [a]	14.25[b]	18.00[a]	1.25
Blood Glucose (mg/dl)	63.25[a]	60.75[a]	62.25[a]	53.25[b]	3.58
Blood Urea Nitrogen (mg/dl)	13.04[c]	13.72[c]	15.16[b]	16.98[a]	0.56
Calcium (mmolml^{-1})	11.95[a]	11.00[ab]	9.24[b]	10.93[ab]	1.41
Phosphorus(mmolml^{-1})	1.57	1.57	1.61	1.55	0.86
AST (UL^{-1})[b]	142.50	159.00	102.38	90.00	50.51
ALT (UL^{-1})[c]	3.29	3.99	2.92	3.56	0.80

[a]1) Diet with no cumin crop residues (0%CCR), 2) Diet with 7% cumin crop residues(7%CCR),

3) Diet with 14% cumin crop residues (14%CCR) and 4) Diet with 21% cumin crop residues (21%CCR).

[b]AST: Aspartate Amino Transfrase; [c]ALT: Alanine Amino Transfrase

[a,b,c] Values in the same row without a common superscript letter are significantly different ($P< 0.05$).

Hematological characteristics

Effects of substituting wheat straw with different levels of CCR on hematological parameter is presented in table 4. By increasing the portion of CCR in the diets, the number of red blood cells reduced so the animals that received 21%CCR, had the least RBC value. Such a dose dependent decrease in RBC has been reported in broiler chicks (Al-Kassi, 2010). The decrease in RBC can be related to materials found in cumin, involved in the derangement of the haemopoietic process of the body (Ibrahim *et al.,* 2007). Number of white blood cells was not affected by diets in this experiment, which is not in accordance to Al-Kassi (2010) who reported an increase in WBC in response to higher doses of cumin in broiler chicks. Animals that received experimental diets, showed an increase in platelets numbers and decreased levels of hemoglobin numerically comparing to control group. The same results for hemoglobin have been reported for broiler chicks receiving higher doses of cumin (Al-Kassi, 2010) but Dhandapani *et al.* (2002) reported that feeding cumin had no effect on levels of hemoglobin in alloxan induced diabetic or normal rats. It has been reported that acute and subchronic administration of cumin oil decreased WBC count and increased the hemoglobin concentration, hematocrit, and platelet counts (Srivastava 1989; Srivastava and Mustafa 1994). These inconsistencies may be related to dosage, herbal source and species differences among the studies.

Table 4. Effects of substituting wheat straw with different levels of cumin crop residues on hematological parameter.

Parameter	Treatment[a]				SEM
	1	2	3	4	
RBC($\times 10^6/\mu l$)	11.65[a]	10.81[ab]	10.61[ab]	10.40[b]	0.36
WBC ($\times 10^3/\mu l$)	9.68	11.30	9.58	9.08	1.04
Platelets ($\times 10^5/\mu l$)	2.53[b]	3.45[ab]	3.97[ab]	4.76[a]	0.58
Hemoglobin (mg/dl)	10.50[a]	10.35[ab]	9.75[b]	9.82[ab]	0.21

[a]1) Diet with no cumin crop residues (0%CCR), 2) Diet with 7% cumin crop residues(7%CCR), 3) Diet with 14% cumin crop residues (14%CCR) and 4) Diet with 21% cumin crop residues (21%CCR).

[a,b] Values in the same row without a common superscript letter are significantly different (P< 0.05).

NH_3-N and pH

Effect of substituting wheat straw with different levels of cumin crop residues on rumen fermentation is presented in Table 5. Treatments of 14 and 21%CCR had the lowest pH than control group. There was no regular relation between treatments for ammonia nitrogen.Control of effective rumen pH is critical to maintaining a healthy rumen.

Table 5. Effects of substituting wheat straw with different levels of cumin crop residues on rumen fermentation parameters.

Parameters	Diets[a]				SEM
	1	2	3	4	
pH	6.18[a]	6.27[a]	5.84[c]	5.88[ab]	0.13
NH3-N (mg/dl)	15.28[b]	19.60 [a]	14.25[b]	18.00[a]	1.25

[a]1) Diet with no cumin crop residues (0%CCR), 2) Diet with 7% cumin crop residues(7%CCR), 3) Diet with 14% cumin crop residues (14%CCR) and 4) Diet with 21% cumin crop residues (21%CCR).

[a,b] Values in the same row without a common superscript letter are significantly different (P< 0.05).

Treatment of 7%CCR had the highest NH3-N than other treatments. Essential oils had variable impacts on ruminal NH_3-N concentration in the different studies. Results from different *in vitro* studies showed that the effects of essential oils and their main components on rumen NH_3-N concentration are dose dependent and that these compounds are more effective when used at high doses compared with at low doses. Many researchers reported that there was much essential oil in the cumin (*cuminum cyminum*) and it might be effective on *in vitro* rumen fermentation parameters (Alinian and Razmjoo 2014, Heidarian Miri *et al.*, 2013, Jahani-Azizabadi *et al.*, 2010). So some differentiations between treatments about NH3-N and pH parameters may be resulted from this. Essential oils had variable impacts on ruminal NH_3-N concentration in the different studies. Results from different *in vitro* studies showed that the effects of essential oil and their main components on rumen NH_3-N concentration are dose dependent and that these compounds are more effective when used at high doses compared with low doses (Vakili *et al.*, 2013). Relative to the control, the addition of cumin essential oil resulted in a significantincrease ($P < 0.05$) of the final pH of the medium culture (Jahani-azizabadi *et al.*, 2010). In the study there was a regular relationship between treatments for pHand NH3-N parameters, but it seems that application of high level of CCR might be an acidic effect on rumen pH parameters. Jahani-azizabadi *et al.*, (2010) reported that the medicinal plant essentialoils, such as thyme, dill, cinnamon, cumin andcaraway had highinhibitory effect on *in vitro* rumen methaneproduction and NH3-N concentration that in contrast with our results.

Conclusion

The results revealed that CCR have a potential as an in expensive fibrous feed source for Moghani male lambs. Although this study and pervious *invitro* studies suggest the potential of *cuminum cyminum L.* to improve fiber digestion, maybe via increasing availability of minerals.Further studies are needed to clarify this phenomenon and factors affecting on it. Cumin crop residues also contain variety of active compounds including *cuminaldehyde*. Obviously the susceptibility of animals to feeding plant materials depends on type of the active compounds and their concentration considering the amount added to the diet and their metabolic rate of conversion in the liver to metabolites and excretion. More research is needed to determine proper amount of *cuminum cyminum L.* in ruminant's diets in different forms and metabolic consequences of it. Regarding to lack of data on hematological effects of cumin and its effects on blood metabolites in ruminants, comparisons with data on the other species (monogastrics) should be done with caution.

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