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Effect of *Caragana korshinskii* Silage at Different Growth Stages on the Feeding of Livestock

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Abstract [**Objectives**] *Caragana korshinskii* resources are rich in Ordos with a large planting area, but they have not been fully and reasonably utilized. This study aims to effectively convert *C. korshinskii* into high-quality feed, improve the quality of milk and meat of herbivores and increase production. [**Methods**] The utilization of *C. korshinskii* in feed was studied in various aspects, the factors were selected, the level was determined, and the multi-factor experiment—orthogonal experiment was conducted. [**Results**] The effect on the growth of sheep was in the order of silage > *C. korshinskii* feed > corn stalk silage > hay meal, and the effect on the growth of goats was in the order of hay meal > *C. korshinskii* feed > silage > corn stalk silage. [**Conclusions**] From the analysis of the range results, the best level combination was selected: in different growing seasons, *C. korshinskii* branch and leaf silage in full-bloom stage had the greatest effect on the growth of sheep and goats, and the fattening effect was the best; among the different silage methods of *C. korshinskii*, the *C. korshinskii*—corn stalk mixture silage had a good feeding effect for sheep and goats.

Key words Forage, *Caragana korshinskii*, Silage, Development and utilization

1 Introduction

Caragana korshinskii has the characteristics of developed root system, strong germination ability, strong adaptability, barren soil tolerance, cold tolerance, drought tolerance and so on. In arid sandy land, desert and semi-desert areas, it is regarded as an excellent tree species with excellent stress resistance, and it is mainly planted for wind prevention, sand fixation and water and soil conservation. It has garnered more and more attention in forest land construction and ecological environment improvement, and has been popularized in practice[1]. Li Wenlong *et al.* used multi-level fuzzy comprehensive evaluation method to evaluate the growing ecosystem health from the aspects of wind prevention and sand fixation effect of *C. korshinskii*[2]. The evaluation results provide a quantitative basis for the culture and management of artificial sand-fixing forest in sandy area. Although *C. korshinskii* tree species have been widely used in windbreak and sand fixation and farmland protection, there are relatively few studies on the processing and utilization of *C. korshinskii*. In the 1990s, most of the utilization of *C. korshinskii* was still in the initial stage of direct grazing. Because of the biological characteristics of *C. korshinskii*, it must be transplanted after a growth period of 3 - 5 years[3], producing a large number of *C. korshinskii* branches as abandoned dead branches, which can not be used effectively. Now after biological and chemical treatment, it has become an important non-grain feed raw material. Especially after snow covers the grassland in winter, it becomes the only "life-saving grass" for sheep to eat. *C. korshinskii* has high nutritional value, including 22.9% crude protein, 4.9% crude fat, 27.8% crude fiber; 27.4% crude protein, 12.8% crude fat and 31.6% nitrogen-free extract in seeds. Cai Jikun *et al.*[4] treated *C. korshinskii* with EM bacteria liquid for fermentation, and the fermented material was eaten by sheep, which increased their weight obviously and had better disease resistance. Tian Jinmei *et al.*[5] fermented *C. korshinskii* grass by feed fermentation technology, which had good palatability and weight gain effect.

2 Materials and methods

2.1 Test materials Fresh branches of *C. korshinskii* were harvested in vegetative stage, full flowering stage, podding stage and ripening stage as the main materials, mixed with corn and all kinds of conventional feed. According to the quantity of livestock, there were 8 rectangular semi-underground silage cellars (in meters), that is, the size of the bottom of the cellar was slightly smaller than that of the mouth, and the cellar depth should be 2 to 3 m. One simple *C. korshinskii* grinder; 160 sheep and 160 goats, from which 112 sheep and 112 goats were selected for the experiment; 28 isolation fence pens[6]. The *C. korshinskii* collection site was selected in Angsu Town, Etuoke Front Banner, and the experimental site was selected in the Honghai Culture Base of Wushen Banner.

2.2 Operation method

2.2.1 Grouping method. After 12 months, the selected sheep and goats were fed quantitatively, and the orthogonal experiment

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method[7] was used to carry out the experiment (see Table 1 for each factor and treatment). 8 goats and sheep of the same breed, similar age and normal development were selected in the experimental group and the control group according to the principle of random distribution. From early morning to evening every day, the weight of feed was the same, and the orthogonal feeding experiment was carried out after feeding in the shed for one month.

2.2.2 Silage method. The experimental method was as follows: *C. korshinskii* single silage, *C. korshinskii* mixed silage (corn stalk with ear combined with *C. korshinskii*), unensiled *C. korshinskii*, unensiled corn stalk with ear combined with *C. korshinskii*. *C. korshinskii* single silage: fresh *C. korshinskii* branches in vegetative stage, full flowering stage, podding stage and ripening stage were crushed respectively after harvest, marked and distinguished, and then put into silage cellar after compaction. *C. korshinskii* mixed silage: corn stalk with ear and fresh *C. korshinskii* branches in vegetative stage, full flowering stage, podding stage and ripening stage were crushed at a ratio of 4∶1 for ensiling and marked respectively.

Table 1 Factors and treatment

Object	Factors	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Sheep (fed with *Caragana korshinskii* silage)	*C. korshinskii*	*C. korshinskii* in vegetative stage	*C. korshinskii* in full flowering stage	*C. korshinskii* in podding stage	*C. korshinskii* in ripening stage
	Silage mode	*C. korshinskii* single silage	*C. korshinskii* mixed silage	Unensiled *C. korshinskii* and corn stalk	Ensiled *C. korshinskii* and corn stalk
	C. korshinskii feed intake (kg)	1.00	1.50	2.00	2.50
	Corn stalk silage (kg)	2.00	1.00	0.50	0.00
	Hay meal feed intake (kg)	0.10	0.15	0.20	0.25
Goats (fed with *Caragana korshinskii* silage)	*C. korshinskii*	*C. korshinskii* in vegetative stage	*C. korshinskii* in full flowering stage	*C. korshinskii* in podding stage	*C. korshinskii* in ripening stage
	Silage mode	*C. korshinskii* single silage	*C. korshinskii* mixed silage	Unensiled *C. korshinskii* and corn stalk	Ensiled *C. korshinskii* and corn stalk
	C. korshinskii feed intake (kg)	0.50	1.00	1.50	2.00
	Corn kernels intake (kg)	0.15	0.20	0.25	0.30
	Corn stalk silage (kg)	2.00	1.00	0.50	0.00

2.3 Experimental design The experimental factors of feeding sheep with *C. korshinskii* silage were as follows: *C. korshinskii* in different growing season; silage mode; *C. korshinskii* feed intake; corn stalk silage; hay meal intake. There were four treatment levels for each factor: vegetative stage, full flowering stage, podding stage and ripening stage.

The experiment was carried out by $L_{16}^{(45)}$ orthogonal design. The experimental arrangement is shown in Table 2.

Table 2 $L_{16}^{(45)}$ orthogonal table for the experiment on daily intake of *Caragana korshinskii* for sheep

Experiment No.	*Caragana korshinskii*	Silage mode	*Caragana korshinskii* feed intake//kg	Corn stalk silage//kg	Hay meal intake//kg
1	*C. korshinskii* in vegetative stage	Single silage	1.0	0	0.1
2	*C. korshinskii* in vegetative stage	Mixed silage	1.5	0.5	0.15
3	*C. korshinskii* in vegetative stage	Unensiled *C. korshinskii* and corn stalk	2.0	1.0	0.2
4	*C. korshinskii* in vegetative stage	Ensiled *C. korshinskii* and corn stalk	2.5	2.0	0.25
5	*C. korshinskii* in full flowering stage	Single silage	1.5	1.0	0.25
6	*C. korshinskii* in full flowering stage	Mixed silage	1.0	2.0	0.2
7	*C. korshinskii* in full flowering stage	Unensiled *C. korshinskii* and corn stalk	2.5	0	0.15
8	*C. korshinskii* in full flowering stage	Ensiled *C. korshinskii* and corn stalk	2.0	0.5	0.1
9	*C. korshinskii* in podding stage	Single silage	2.0	2.0	0.15
10	*C. korshinskii* in podding stage	Mixed silage	2.5	1.0	0.1
11	*C. korshinskii* in podding stage	Unensiled *C. korshinskii* and corn stalk	1.0	0.5	0.25
12	*C. korshinskii* in podding stage	Ensiled *C. korshinskii* and corn stalk	1.5	0	0.2
13	*C. korshinskii* in ripening stage	Single silage	2.5	0.5	0.2
14	*C. korshinskii* in ripening stage	Mixed silage	2.0	0	0.25
15	*C. korshinskii* in ripening stage	Unensiled *C. korshinskii* and corn stalk	1.5	2.0	0.1
16	*C. korshinskii* in ripening stage	Ensiled *C. korshinskii* and corn stalk	1.0	1.0	0.15

The experimental factors of feeding goats with *C. korshinskii* silage were as follows: *C. korshinskii* in different growing seasons; silage mode; *C. korshinskii* feed intake; corn kernels; corn stalk silage. There were four treatment levels for each factor: vegetative stage, full flowering stage, podding stage and ripening stage. The experiment was carried out by $L_{16}^{(45)}$ orthogonal design. The experimental arrangement is shown in Table 3.

Table 3 $L_{16}^{(45)}$ orthogonal table for the experiment on daily intake of *Caragana korshinskii* for goats

Experiment No.	*Caragana korshinskii*	Silage mode	*Caragana korshinskii* feed intake//kg	Corn kernels//kg	Corn stalk silage//kg
1	*C. korshinskii* in vegetative stage	Single silage	0.5	0.15	0
2	*C. korshinskii* in vegetative stage	Mixed silage	1.0	0.2	0.5
3	*C. korshinskii* in vegetative stage	Unensiled *C. korshinskii* and corn stalk	1.5	0.25	1.0
4	*C. korshinskii* in vegetative stage	Ensiled *C. korshinskii* and corn stalk	2.0	0.3	2.0
5	*C. korshinskii* in full flowering stage	Single silage	1.0	0.25	2.0
6	*C. korshinskii* in full flowering stage	Mixed silage	0.5	0.3	1.0
7	*C. korshinskii* in full flowering stage	Unensiled *C. korshinskii* and corn stalk	2.0	0.15	0.5
8	*C. korshinskii* in full flowering stage	Ensiled *C. korshinskii* and corn stalk	1.5	0.2	0
9	*C. korshinskii* in podding stage	Single silage	1.5	0.3	0.5
10	*C. korshinskii* in podding stage	Mixed silage	2.0	0.25	2.0
11	*C. korshinskii* in podding stage	Unensiled *C. korshinskii* and corn stalk	0.5	0.2	0.25
12	*C. korshinskii* in podding stage	Ensiled *C. korshinskii* and corn stalk	1.0	0.15	1.0
13	*C. korshinskii* in ripening stage	Single silage	2.0	0.2	1.0
14	*C. korshinskii* in ripening stage	Mixed silage	1.5	0.15	2.0
15	*C. korshinskii* in ripening stage	Unensiled *C. korshinskii* and corn stalk	1.0	0.3	0
16	*C. korshinskii* in ripening stage	Ensiled *C. korshinskii* and corn stalk	0.5	0.25	0.5

2.3.1 Data processing. Through the orthogonal method, the test data were processed by SAS analysis software, and the error was analyzed by Excel.

3 Results and analysis

3.1 Effect of different *C. korshinskii* feed on the feeding of livestock The results of the range analysis of the orthogonal experiment in Table 4 showed that the silage mode in the five factors had the greatest influence on the growth effect of sheep, and the extreme difference was 13.2, which was more than 2 times that of corn stalk silage and 3 times that of hay meal. Among the several factors, hay meal had the least effect on the growth of sheep, followed by corn stalk silage, and the range was only 5.7. There was no significant difference between *C. korshinskii* feeding and *C. korshinskii* harvest time.

Table 4 Range results of orthogonal test

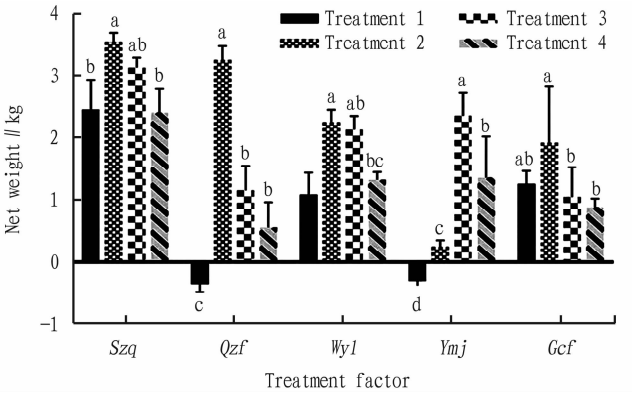
Treatment	Different growth periods	Silage mode	Feeding with *Caragana korshinskii*	Feeding amount of corn stalk silage	Hay meal intake
Sheep	9.9^{ab}	13.2^{a}	8.9^{ab}	5.7^{b}	4.5^{b}
Goats	14.1^{b}	12.6^{b}	13.1^{b}	11.0^{ab}	16.4^{a}

Note: The same letters in the same line indicate that there is a significant difference through multiple comparisons (P=5%).

The results of the range analysis of the orthogonal experiment in Table 4 showed that among the five factors, the feeding amount of corn kernels had the greatest effect on the growth of goats, and the fattening effect was the most significant, and the orthogonal range was 16.4; there were significant differences between the feeding amount of corn kernels and *C. korshinskii* in different growth periods, silage mode, *C. korshinskii* feed intake, and corn stalk silage. *C. korshinskii* in different growth periods, silage mode and *C. korshinskii* feed intake also had great effects on the growth of goats, but there was no significant difference among them.

3.2 Effect of *C. korshinskii* feed on the feeding of sheep From various factors and treatments, it can be seen that the digestible crude protein in the ensiled branches and leaves of *C. korshinskii* in flowering stage was equivalent to 2.67 kg of corn and 0.64 kg of black bean[8], so the feed had the best fattening effect on sheep, and the average monthly fat gain of each sheep was 3.58 kg. Zhang Xiaojuan *et al.* used column chart for analysis (Fig.1)[9], and found that the effect of *C. korshinskii* single silage on sheep was the worst, while the effect of *C. korshinskii* and corn stalk mixed silage on sheep was very good, and the average monthly weight of each sheep increased 3.25 kg. Because of the high content of lignin and crude fiber in *C. korshinskii*, there was often unfinished feed when feeding sheep, and the palatability of the unensiled forage was poor[10], affecting the appetite of sheep. The effect of feeding sheep with the mixture of *C. korshinskii* and corn stalk without ensiling and fermentation was not good. In recent years, there has been a deep study on nitrogen metabolism in ruminants. Xian Lili *et al.* found that urea nitrogen played an important role in the process of digestion and metabolism. Urea nitrogen is an important carrier for nitrogen recycling in rumi-

nants[11]. Many new protein nutrition systems have been proposed in many countries. The new protein system is to improve the estimated protein nutritional requirements of ruminants from the previous crude protein intake to the protein quality of the small intestine.



Note: *Szp-Caragana korshinskii* in different growth periods; *Qzf-Caragana korshinskii* silage; *Wyl-Caragana korshinskii* feed intake; *Ymj*-corn stalk silage intake; *Gcf*-hay meal intake.

Fig. 1 Effect of various factors and treatments on the fattening of sheep

3.3 Effect of *C. korshinskii* feed on the fattening of goats

The column chart analysis also showed that *C. korshinskii* and corn stalk mixed silage had the best effect on the growth of goats among different silage modes, and the average weight gain of each goat was 3.00 kg, but it was not significantly different from the fattening effect of unensiled *C. korshinskii* combined with corn stalk with ear.

In the experiment, the effect of feeding goats with *C. korshinskii* single silage was the worst, with an average increase of 1.26 kg in weight per goat. The fattening effect of *C. korshinskii* single silage was better than that of *C. korshinskii* for goats, and the difference between them was significant. There was a relatively small difference in the effect of *C. korshinskii* feed intake on goat fattening, but through comparative experiments, it was determined that the best feeding amount of *C. korshinskii* silage for goat fattening was 1.5 kg.

Insufficient or excessive addition of *C. korshinskii* silage affected the intake rate of goats to a certain extent. Insufficient addition led to the decrease of feed intake rate, possibly because the overall palatability of compound feed was poor, while excessive addition led to the strong taste of *C. korshinskii* silage, which affected the intake rate of goats, resulting in the decline of fattening effect. As a kind of auxiliary forage, corn stalk feed had the least effect on the fattening effect of goats, and the addition of corn stalk feed had little effect on the intake rate of goats. The effect on fattening and weight gain of goats was not obvious, and there was no significant difference among the factors. As a kind of concentrate feed for fattening of goats, corn kernels feed had a great effect on the fattening and weight gain of goats. The average weight gain of each goat at different levels of treatment was above 2.5 kg, but there was no significant difference among different treatments. Excessive addition produced surplus, the fattening effect of goats was not obvious, and it also increased the cost of feeding goats. Therefore, the best addition of corn kernels in feeding goats was 0.15 kg.

4 Conclusions and discussion

The content of crude protein, crude fat and crude fiber of *C. korshinskii* increased in full flowering stage[12], which had the most significant effect on the fat gain of sheep, and the average monthly weight gain of each sheep was 3.58 kg, higher than that of *C. korshinskii* in podding stage, and the effect was poor in vegetative stage and ripening stage. The effect of feeding sheep with *C. korshinskii* single silage was the worst, while the effect of mixed silage of *C. korshinskii* and corn stalk with ear was very good, and the effect of feeding sheep with mixture of *C. korshinskii* and corn stalk without ensiling and fermentation was not good.

C. korshinskii feed in ripening stage had the worst fattening effect on goats, *C. korshinskii* silage in podding stage had a good fattening effect on goats, and *C. korshinskii* in full flowering stage had the best fattening effect on goats[9]. The mixture of *C. korshinskii* and corn stalk had the best fattening effect on goats, the average weight gain of each goat per month was 3.00 kg, and the effect was not greatly different from the unensiled *C. korshinskii* and corn stalk with ear. In the experiment, the effect of feeding goats with *C. korshinskii* single silage was the worst.

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