



Nutritional Value and Chemical Composition of *Artemisia herba alba* Asso, *Atriplex halimus* and *Salsola vermiculata* in Algeria Steppe Rangelands

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10.18805/ajdfr.DRF-428

ABSTRACT

Background: Need for fodder in semi arid conditions prompted us to investigate nutritional of some resilience forage in Algerian rangelands. The study purpose is to evaluate nutritional attributes value of *Artemisia herba alba* Asso, *Atriplex halimus* and *Salsola vermiculata*. The study area is located at the northeastern of Algeria at Tebessa province.

Methods: Nutrient composition value, fiber composition and *in vitro* digestibility were determined by the method of the AOAC (1990). *In vitro* digestibility was determined by the enzymatic pepsin-cellulase method and the nutritional performance parameters were calculated according to the INRA 2018 system.

Result: Nutritional composition analysis results revealed a significant level of organic matter contents; it varies from 74% to 91%, while the total nitrogenous matter was more than 14% DM, the higher level is recorded by *Atriplex halimus* with 17%. Results of fiber contents mention a significant values, the lower level is recorded by *Atriplex halimus* (NDF 54% DM; ADF 24% DM and ADL 10% DM). However a significant level of digestible dry matter and digestible organic matter were assessed for all species, *Atriplex halimus* is significantly higher with 60% D.cell DM and 50.5% D.cell OM compared with *Artemisia herba alba* Asso and *Salsola vermiculata*. These findings suggest that these species could constitute a favorable nutritional value for livestock. And it can guarantee the sustainability of breeding.

Key words: Digestibility, Fodder, *In vitro*, Nutritional value, Resilience.

INTRODUCTION

Vegetal biodiversity provides a significant advancement to the growing world population through contribution to food security. Conservation of plant genetic resources is an international issue and a collaborative world effort, in order to protect the ecosystem sustainability and to respond to the increased demand for plant and animal foods (Kholif *et al.*, 2022; Khanal Prabhat, 2024). Nowadays, Scientists are committed to valorize natural product in nutrition, pharmacology and cosmetic (Shamsutdinova and Shamsutdinov, 2023; Harshavardan *et al.*, 2023). In North Africa rangeland, within vegetal richness we quote *Artemisia herba alba* Asso, *Atriplex halimus* and *Salsola vermiculata*, which are recommended for livestock as precious resource for grazing for small ruminant and camels (Yerou, 2022; Hammouda *et al.*, 2024). These autocton plant species in semi-arid and arid conditions, they are rather resistant, well adapted to the local ecological conditions and rich in natural compounds (Homrani *et al.*, 2020; Bozhanska, 2023). However, in recent years, ecosystems rangelandes have unexpected alarming disparity due to significant global warming, consequently to the drought, insufficiency rainfall and anthropogenic factors (Meradi *et al.*, 2016; Gaci *et al.*, 2021; Yerou *et al.*, 2022). The degradation of environments affected not only their appearance but also the quality and quantity characteristics of their productions (Nedjraoui, 2003). However, in Algeria in order to deal with rangelands

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How to cite this article: Meradi, S., Aouachria, M. and Chekkal, F.E. (2026). Nutritional Value and Chemical Composition of *Artemisia herba alba* Asso, *Atriplex halimus* and *Salsola vermiculata* in Algeria Steppe Rangelands. *Asian Journal of Dairy and Food Research*. **45(5)**: 930-936. doi: 10.18805/ajdfr.DRF-428.

Submitted: 10-07-2024 **Accepted:** 03-02-2025 **Online:** 21-03-2025

degradation, it has initiated sustainable development projects, through defending approach, which consists to prohibiting grazing for a few years and controlling the animal load (Salemkour *et al.*, 2016; Merdas *et al.*, 2021; Bouyahia *et al.*, 2023). Several studies have generated evidence on this rangeland management process, which has improved the state of wealthy ecosystems, the degradation is slowed down and the regeneration of perennial vegetation cover is improved in these ecosystems (Salemkour *et al.*, 2016; Hammouda *et al.*, 2024). Sustainable rangeland management allows a balance between primary vegetative productivity and pastoral resources used by ruminants and domestic

needs of pastoralists (Bouyahia *et al.*, 2023). The study of the feed value of rangeland is an approach allowing the rational management of livestock farming (Chibani *et al.*, 2010; Kumar *et al.*, 2021; Rekik, 2021; Marotti *et al.*, 2023). Therefore, the species highlighted previously are very spread in widespread in desert and in Algeria rangelands, they are available forage, its nutritional composition improves development of livestock. Its components characterized by a relative rate of protein and energy value within fat and extractives percentage (Shamsutdinova and Shamsutdinov, 2023). However, Scientists suggested that phenological stages of plants affect benefits forage quality, the vegetative stage is a highest nutritional resource for growth livestock and provides optimal nutritional value levels, then later growth stages (Ayadi, 2022). Therefore, *Artemisia herba alba* Asso includes essential oils characterise by its health benefits and high nutrients digestibility (Messai *et al.* 2021). Despite valorization of *Atriplex halimus* is limited by its sodium chloride levels, which requires enhancing management regulation by nutritional additives (Akbarian and Yosefelahi, 2015). Recently there is growing interest in the context of optimization of forage valorization, by biotechnologie approach with exploration nutritional potential (Bozhanska, 2023). Therefore, researchers have investigated and demonstrated many hypotheses, they have incorporated this fodder in feed diet with mechanic and biochemical treatment. Such as ensiling, broyage and adding exogenous dietary enzymes, organic acids or probiotics (Salem, 2012; Hammouda *et al.*, 2024). Within this context, need for fodder in semi arid conditions prompted us to investigate nutritional amount of *Artemisia herba alba*, *Atriplex halimus* and *Salsola vermiculata*, by determination of bio-chemical composition, enzymatic digestibility by cellulase and pepsin. And to assess the nutrient profiles

composition linked with livestock aptitudes, we have calculated the voluntary intake sheep, cattle and lactation, fodder units milk and for meat and digestibility of several original proteins.

MATERIALS AND METHODS

The study area

Tebessa is located at the northeastern of Algeria, coordinates geographical are 35°24'15" North and 8°7'27" East. It extended from the high plateau area in the North to the steppe region in the South, analogous to Tunisia (Fig 1). The climate of Tebessa is a transitional mediterranean climate, with some continental and semi-arid characteristics (Fig 2).

Nutrient composition value, fiber composition

This research was conducted at Livestock Production Laboratory, Department of Agriculture Sciences, Life Sciences Faculty, University of Batna; (Algeria). We have investigated *Artemisia herba alba*, *Atriplex halimus* and *Salsola vermiculata* because they have a wide distribution in the study area. Sampling of vegetal product was carried out in April. The green parts (leaves and stem) were collected and were weighed in the fresh state. A voucher specimen is deposited under the number 001.CRSTRA. 0004 for *Artemisia herba alba*, 013.CRSTRA. 0002 for *Atriplex halimus* and 013.CRSTRA.0010 for *Salsola vermiculata* in the herbarium of scientific and technical research center CRSTRA, Biskra, Algeria. The sampling was powdered and stored after they have dried at ambient temperature. The proximate chemical analyzes with three replicates were carried out on the obtained of dry matter (DM), organic matter (OM), ash, total nitrogenous content (MAT), crude protein and crude cellulose. However,

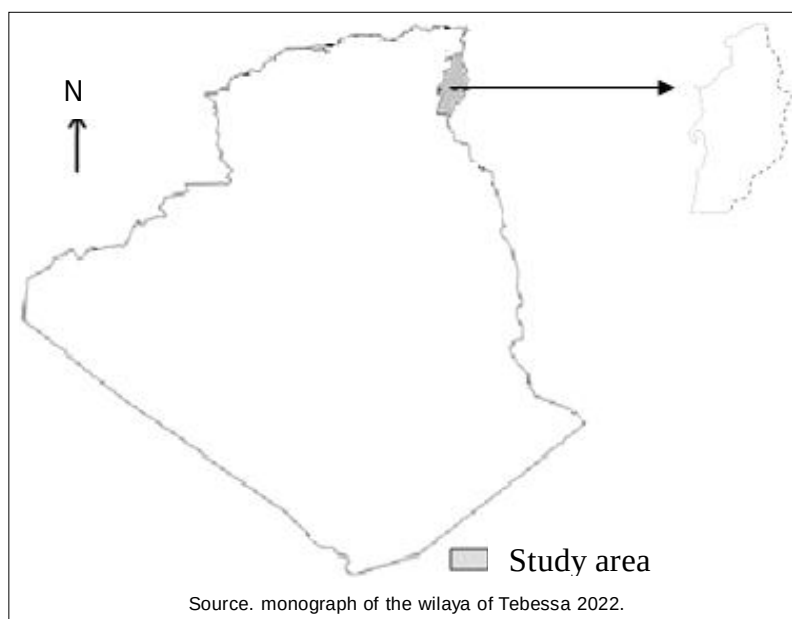


Fig 1: Geographical location of Tebessa in Algeria.

determination of fiber composition was included neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin. The protocols were determined by the method of the AOAC (1990).

In vitro digestibility and nutritional profile

In vitro digestibility was conducted in order to predict forage organic matter digestibility (OMd) and dry matter digestibility (DMd). It was determined by the enzymatic pepsin-cellulase method (Aufrère *et al.*, 2007). We have assessed the nutrient profiles composition linked with livestock aptitudes by INRA 2018 systeme we have calculated a voluntary Intake of sheep, cattle and for lactation, fill units for sheeps, cows and milk, metabolisable energie (kcal/kg dM), unites fourragères for milk and for meat and digestibility of several original proteins protein digestibly original from feed, from microbienne original, proteic rumen balance, equilibrate azote/energy in the rumen.

Statistical analyzes

Descriptive statistics and analysis of variance are carried out to compare the means of the various parameters studied. To classify the means, comparison test of Newman and Keuls was used, significant differences is $P < 0.05$.

RESULTS AND DISCUSSION

Nutrient composition value (DM %)

The means and standard errors of nutrient composition of *Artemisia herba alba*, *Atriplex halimus* and *Salsola vermiculata* are given in (Table 1). The DM amount of all spices was within the range 89 to 98%. *Artemisia herba*

alba had the lowest DM content. Despite it has the highest OM (91% DM). However, *Atriplex halimus* had the highest mineral matter (25% DM), followed by *Salsola vermiculata* with 16% DM. The means crude cellulose was significantly highest in *Salsola vermiculata* (50% DM) followed by *Artemisia herba alba* (32% DM). The total nitrogen content among the samples ranged from 14.7 to 17.7% DM. Furthermore, *Atriplex halimus* and *Salsola vermiculata* were recorded more than 16% DM of total nitrogen content. Through the results, we observed high level of DM of all plants studied. However, we distinguished the particularity of each spice, where *Artemisia* is rich in organic matter, *A. halimus* is rich with ash and *Salsola* has a high amount of crude cellulose. In the context of nutritional requirement of livestock, we concluded that in the rangeland studied there is a nature balance among these plants because they could cover physiologic needs of animals by their nutritional composition. View the particularity of the study region and the severe extreme weather, the plants studied were an excellent nutritious feed, as compared to barley, alfalfa in the flowering stage and berseem clover in the early flowering stage (Chibani *et al.*, 2010), it seems that their richness in nitrogen gives them a distinct advantage as compared to grasses hays and permanent meadows (Mebirouk-Boudechiche *et al.*, 2010). Shamsutdinova and Shamsutdinov (2023) have highlighted that the three spices can be considered as excellent forage pastures for small ruminants, it contains 16.9% protein, 4.4% fat and 39% nitrogen-free extractives. Indeed, Berreguioua and Ziane (2024) have reported that Saharan vegetation has resistance to natural stress factors and contains interest

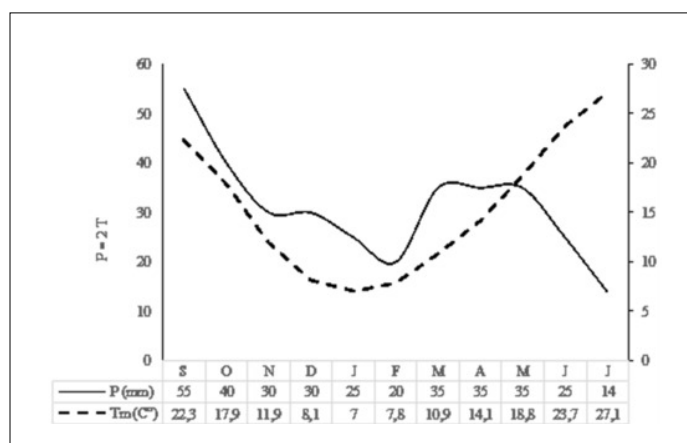


Fig 2: Climatic characteristics of Tebessa.

Table 1: Chemical composition of different species studied (% DM basis).

Species	DM (%)	OM	Ash	CB	Total nitrogen
<i>Atriplex halimus</i>	94.70 ^(a) ±0.20	74.80 ^(b) ±0.38	25.20 ^(a) ± 0.38	8.20 ^(c) ±1.14	17.70 ^(a) ±2.11
<i>Salsola vermiculata</i>	98.80 ^(b) ±0.40	83.30 ^(a) ±0.60	16.70 ^(b) ±0.60	50.30 ^(a) ±0.8	16.30 ^(a) ±1.53
<i>Artemisia herba alba</i>	89.20 ^(a) ±0.50	91.21 ^(b) ±0.20	8.90 ^(c) ±0.2	32.90 ^(b) ±0.87	14.70 ^(a) ±0.69

DM: Dry matter; MO: Organic matter; Ash: Mineral matter; CB: Crude cellulose. abc means assigned different letters in the same column are statistically different at the level of significance $P < 5\%$.

nutrition composition. However, the richness of plants in nitrogen does not mean that it would be entirely usable by the animal. Indeed, these contents were found in the spring season where there is the presence of a rich and palatable floristic procession composed of annuals which could be a limiting factor with regard to the use of the opportunity offered by the nitrogen content of perennial plants, smell, taste and the presence of anti-nutritional substances may limited their use during spring period (Ayadi *et al.*, 2022).

Proximate fiber constituents (DM %)

Fiber constituents are performed on different fodder spices, the means and standard errors for proximate fiber constituents (DM %) are given in (Table 2). Neutral detergent fiber was higher in all analyzed species *Artemisia herba alba*, *Atriplex halimus* and *Salsola vermiculata*, it was more than 50% of dry matter. The ADF content ranged from 24% to 30% DM. The lignin levels were varied between 8% DM and 13% DM. Crude fiber continents of whole perennials species analysed were highest as compared to forage used in semi arid region of India (Singw *et al.*, 2020). According to Merdas (2016), during the spring period, grazing significantly reduced the diversity of annual species. However, perennials are not significantly affected, when the cover of perennial plants is important and the ecosystem is equilibrating. Nevertheless, protection from grazing (prohibition) significantly increased annual species diversity and vegetation cover. The whole spices may be a fulfill feed in the dry months when deficiency feed and fodder increased (Arif *et al.*, 2020).

Enzymatic digestibility

Means and standard errors for enzymatic digestibility are given in (Table 3). The comparative analysis of cellulase-pepsin enzymatic digestibility indicates that digestibility of dry matter is 66.7%, 62% and 57.8% in *Atriplex halimus*, *Salsola vermiculata* and *Artemisia herba alba* respectively. Furthermore, enzymatic digestibility of organic matter

ranged from 58.9% to 60.7%. The highest value of cellulase digestibility of dry matter was recorded by *Atriplex halimus* with 60% followed by *Salsola vermiculata* than *Artemisia herba alba*. However, cellulase digestibility of organic matter is the same in all plants (50.5%). We have noticed that there is a relative link between crude fiber constituents and digestibility rate. Our results were comparable to the results reported by Yacoub (2006) and Rekik *et al.* (2014) were recorded an interesting rate of enzymatic digestibility of dry matter 51.62% DDM. According to these results, in general in spring season and particularly at the flowering stage corresponding to our case of sampling, the lignin content should be low, we were found high levels of fibers, probably causes of this state were mainly due to the climatic condition with less rainy and high temperatures. Furthermore, it is established that perennial steppe plants are not consumed by animals during the spring season for the following reasons: Presence of a rich and abundant flora composed by annuals plants and presence of anti-nutritional substances. The consequences of these results are the richness of the plant by principles nutrient, it is rich in nitrogen in our case, which does not beneficial for animals. Therefore, consumption of perennials plants is only possible from the disappearance of the annual palatable species (Rekik *et al.*, 2014). At this time, the deterioration of the nutritional value of forage species is perceived on two levels, chemical composition, by a regression in the nitrogen content and the accentuation of lignifications phenomenon which can decrease feed intake and digestibility. Finally, forage value is directly linked to the quantity of ingested fodder, when digestibility is important; metabolic process regulate the quantities ingested which are limited by the needs expressed by the animals (Chehma *et al.*, 2010).

Optimizing of valorization of *Atriplex halimus* is beneficial by sun-drying and the effect of exogenous dietary enzymes supplementation for zootechnic performances of sheep specifically the intake parameter and its digestibility. It was

Table 2: Detergent fiber composition of the different species studied.

Composition species	NDF (%DM)	ADF (%DM)	ADL (%DM)
<i>Atriplex halimus</i>	54.80 ^(c) ±1.52	24.90 ^(c) ±1.52	10.10 ^(a) ±0.99
<i>Salsola vermiculata</i>	55.60 ^(c) ±1.37	26.20 ^(c) ±2.16	8.10 ^(b) ±0.04
<i>Artemisia herba alba</i>	57.90 ^(c) ±0.88	30.30 ^(c) ±2.54	13.60 ^(a) ±1.01

NDF: Neutral detergent fiber; ADF: Acid detergent fiber; ADL: Lignin detergent fiber.

a,b means with different letters in the same column are statistically different at the significance level P<5%.

Table 3: Enzymatic digestibility of DM and DOM of the species studied.

Digestibility	DDM (%)	DMO (%)	D. cell. DM (%)	D.cell.OM (%)
<i>Atriplex halimus</i>	66.70 ^(a) ±0.18	60.70 ^(a) ±0.39	60.60 ^(a) ±0.25	50.50 ^(a) ±0.80
<i>Salsola vermiculata</i>	62.30 ^(b) ±0.39	60.70 ^(a) ±0.25	54.40 ^(b) ±0.59	50.50 ^(b) ±0.32
<i>Artemisia herba alba</i>	57.80 ^(c) ±0.62	58.90 ^(b) ±0.53	48.10 ^(c) ±0.88	47.70 ^(c) ±0.82

DDM : Digestible dry matter ; DOM : Digestible organic matter; D.cell. DM: Cellulase digestibility of dry matter; D.cell OM: Cellulase digestibility of organic matter. A, b, c moyennes affectées de lettres différentes dans une même colonne sont statistiquement différentes au seuil de signification P<5%.

confirmed that the proportion of twigs and leaves affected positively the palatability of animals (Otal *et al.*, 2010).

When the supply of degradable nitrogen in the ration is excessive, some authors have noticed an increased production of ammonia causing a significant drop in appetite. Moreover, with diets or rations with a slight deficit, the recycling of endogenous urea (saliva, exchange through the wall of the rumen) can participate effectively in covering the nitrogen needs of the microbial population.

Intercropping with medicinal and aromatic plants, as a climate change adaptation strategy. Economic and ecological importance. Profitability as well as to enhance soil and biodiversity conservation.

Nutritional profile analysis of forage species

Nutritional profile analysis data of forage species are illustrated in (Table 4). Voluntary intake of dry matter by sheep, cattle and dairy cow are lowest in *Artemisia herba alba* (109 g, 129 g and 175 g) respectively. However, they are closed for *Salsola vermiculata* and *Atriplex halimus*. Instead, we have found an increase in fill units of sheep, cow and dairy cow in *Artemisia herba alba* (0.69, 0.73, 0.8) respectively. Metabolizable energy is considerable in *Artemisia herba alba* with 2093 calories. UFL and UFV are important in all forage species. We have calculated a total of proteins digestibility in average of 93 and 98.65. Despite

the highest PDIA is marked by *Atriplex halimus* (56.12) and the PDIM is marked in *Artemisia herba alba*. Regarding the radar graph (Fig 3), it based on representation of nutritional parameter, each axis normalized between 0 and 1 to allow a clear visual comparison. This graph compares the nutritional performances of the species *Atriplex halimus*, *Salsola vermiculata* and *Artemisia herba alba*. Each polygon represents the relative performance of a species on different nutritional parameters. Digestibility (dMO) of *Atriplex halimus* and *Salsola vermiculata* have the same rate, despite it is quite high in *Artemisia herba alba*. Voluntary Intake (DMVI) sheep, cattle and dairy cow the voluntary quantity of dry matter ingested is higher in *Salsola vermiculata*. Particularly for MSVIB followed by *Atriplex halimus*. whereas *Artemisia herba alba* marked the lowest. Fill Units encumbrance in sheep, cattle and dairy cow indicate the capacity of the forage to fill the rumen, *Artemisia herba alba* has an important value, *Atriplex halimus* and *Salsola vermiculata* are closely and quite lower. We have distinguished highest value of metabolizable energy of *Artemisia herba alba* followed by *Salsola vermiculata* and *Atriplex halimus*. *Artemisia herba alba* is ranked the first in Feed Units (UFL, UFV), thus it is an excellent forage for meat and milk production. However, *Salsola vermiculata* and *Atriplex halimus* have lower performances. Regarding protein fractions (PDIA, PDI, PDIM) *Artemisia herba alba*

Table 4: Nutritional profile analysis of forage species.

	MSVIM	MSVIB	MSVIL	UEM	UEB	UEL	EM	UFL	UFV	PDIA	PDI	PDIM	BPR
<i>Atriplex halimus</i>	118.25	138.03	182.69	0.63	0.69	0.77	1784	0.62	0.56	56.12	98.65	42.53	34.7
<i>Salsola vermiculata</i>	119.45	139.25	183.88	0.63	0.68	0.76	1986	0.7	0.62	52.58	97.68	45.09	19.79
<i>Artemisia herba alba</i>	109.57	129.53	175.12	0.68	0.73	0.8	2093	0.73	0.65	46.44	93.22	46.78	6.94

MSVIM Voluntary Intake sheep, MSVIB: Voluntary Intake bovins, MSVIL Voluntary Intake lactation). UEM: Fill Units sheep, UEB: Fill Units bovins, UEL: Fill Units lait. EM: Energie métabolisable (kcal/kg MS). UFL: fodder units milk. UFV: Fodder units meat. PDIA: Protéines digestibles d'origine alimentaire. PDI: Total des protéines digestibles. PDIM: Protéines digestibles d'origine microbienne. BPR: Balance Protéique du Rumen, équilibre azote/énergie dans le rumen).

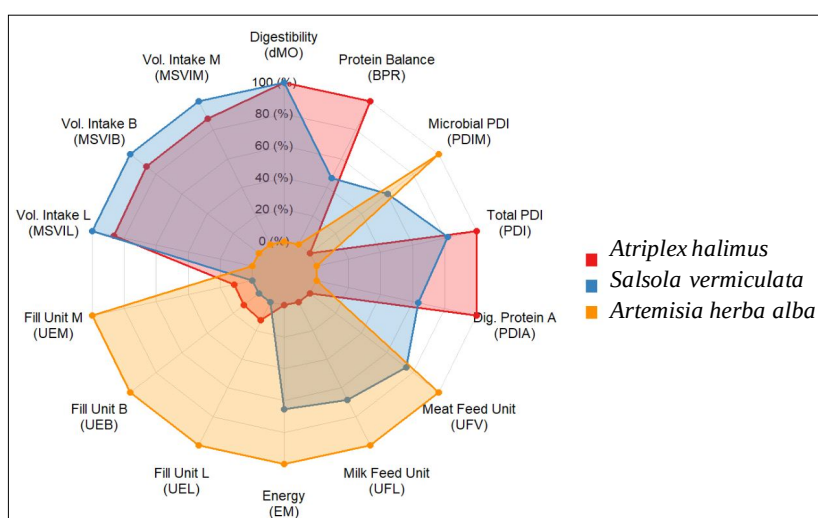


Fig 3: Nutritional profile analysis of forage species.

Atriplex halimus is dominated followed by *Salsola vermiculata*. *Artemisia herba alba* has the lowest performances. We have found a high performance of total proteins digestible of *Atriplex halimus* and *Salsola vermiculata*. Protéines digestible of microbienne original by *Artemisia herba alba* reflecting efficient microbial synthesis more than *Salsola vermiculata* and *Atriplex halimus*. Regarding balance protéique of rumen BPR. *Atriplex halimus* and *Salsola vermiculata* affixed an advantage BPR with an equilibrate balance between fermentation energie and protein degradability. *Artemisia herba alba* has the lowest BPR indicate insufficiency of azote to allow reproduction of ruminal microbes. Brief, *Atriplex halimus* could contribute to provide an important amount of digestible protein needs (PDIA, PDI) in fact it has a good ruminal balance (BPR). *Salsola vermiculata*. Offers a balanced profile with high performance of DMVI, PDIM and EM. *Artemisia herba alba* is Ideal for high energetic needs (EM, UFL, UFV) and microbiens protéins (PDIM), despite it poorless in digestibility feed proteins. Thus, radar graphic highlights the relative strengths and weaknesses of the three species based on nutritional parameters. *Artemisia herba alba* is great for energy and forage units, while *Atriplex halimus* is better for digestible protein. *Salsola vermiculata* offers a balanced profile.

CONCLUSION

Based on laboratory tests of biochemical composition, enzymatic digestibility and nutrition profile of *Artemisia herba alba*, *Atriplex halimus* and *Salsola vermiculata*, we conclude that these bioresources have high nutrition content. *Artemisia herba alba* was characterized by appreciable amounts of energy and fodder unit. Therefore, *Atriplex halimus* has significant proteins digestibility and *Salsola vermiculata* provided a balanced nutritional profile. These three species are valuable nutritional fodder in difficult areas these forage species were considered as resilience plant resources in the conditions of arid regions where green fodder shrubs are lacking in Algeria.

Conflict of interest

All authors declared that there is no conflict of interest.

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