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STUDIES ON THE FEEDING VALUE OF TUBERS FROM JERUSALEM ARTICHOKE (*Helianthus tuberosus* L.) FRESH OR ENSILED WITH AMMONIATED RICE STRAW

Osman, A. A.
Department of Animal Production, Faculty of Agriculture, Suez Canal University, Ismailia, Egypt, osmanrawan@hotmail.com

ABSTRACT

The studied material consisted of tubers of the Jerusalem artichoke. The basic chemical composition, the amino acid and macroelement contents were determined. The dry matter content in tubers was 24.2 %. While, crude protein, crude fiber, ether extract, nitrogen free extract and ash content (on DM basis) were 8.91, 5.73, 0.85, 78.26 and 6.25 %. Results indicated that tubers contain large proportion of methionine, tryptophan, threonine and traces of cystine. The content of calcium being 0.16 g/kg DM, while, phosphorus was 1.22 g/kg DM.

Silage was made from tubers of the Jerusalem artichoke and ammoniated rice straw (25% of total fresh weight) to increase the nitrogen and crude fiber content. Composition of silage was 41.15% DM, 9.35% crude protein, 15.02% crude fiber, and 67.13 % nitrogen free extract (on DM basis). Apparent digestibility coefficients of tubers and its silage were determined in two trials using five male Ossimi sheep. The digestibility coefficients obtained from the 2 trials were 76.18 and 72.52% DM, 79.24 and 75.15% OM, 65.19 and 61.73% CP, 52.05 and 53.17% CF and 86.12 and 79.35% NFE for fresh tubers and its silage, respectively. When the tubers was ensiled with ammoniated rice straw, digestibilities of all nutrients decreased than fresh tubers except crude fiber. The nutritive values were 77.21 and 68.38% TDN, and 5.81 and 5.77% DCP for fresh tubers and its silage, respectively. It is concluded that the tubers from Jerusalem artichoke and its silage can be in feeding ruminants.

Keywords: Nutritive value - Digestibility - Jerusalem artichoke tubers - silage - sheep.

INTRODUCTION

In Egypt, there is a great shortage in animal feedstuffs particularly during summer season. Many attempts were made to introduce some crops, which suit the Egyptian weather and soil conditions. Jerusalem artichoke is a summer crop, which may participate in solving the animal feeding problem in summer season and seems to be suitable for a wide range of soils (Macias *et al,* 1994). The plant could be sown at February - April and harvested at June - August for green fodder and August - October for tubers. The yield of Jerusalem artichoke was 11-17 ton of green fodder and 15-16 ton of tubers per feddan (Petkov, *et at* 1997).

The genus Helianthus (Compositae family) contains 60 annual and perennial species originating from America. Two among them have been improved for nutritional use. *Helianthus tuberosus* L. (Jerusalem artichoke) for its succulent tubers, and *Helianthus annus* L., the cultivated sunflower, for the edible oil from seeds. *Helianthus tuberosus* L. is *known as* Jerusalem artichoke, Canadian potato, Helianthe tubereux, Topinambour, Tartuf, or Tuffah el ard. Its name, Jerusalem artichoke is derived from the Italian Girasola articiocco, the sun flower artichoke. Also, Girasole meaning "turning to the sun" (Bedevian, 1936 and Grieve, 1959).

It is cultivated for its tubers, which are used as feed for livestock, and as a source of inulin. The inulin was found to be 11.9% in the tubers, and 4.2% in leaves, the isolated heliangine from Jerusalem artichoke leaves revealed a high activity against cancer cells, also the extracted substance from plant organs (flowers, leaves and tubers) has resistant effects against some microorganisms positive and negative for gram and showed same antifungal effects (Abou-Hussein, 2000). The tubers have similar characteristics to other root crops, with high digestibility and feeding value, because of their high energy content it is suggested that the tubers can be used for fattening but should be supplemented with high protein feeds (Petkov, *et al*, 1997).The present study is aimed at determining the feeding value of tubers from Jerusalem artichoke fresh or ensiled with ammoniated rice straw by evaluation of its usability in feeding the ruminants by determining its digestibility coefficients and feeding value.

MATERIALS AND METHODS

The study was carried out at sheep and goats farm, College of Agriculture, Suez Canal University, Ismailia, Egypt. The material consisted of tubers from Jerusalem artichoke coming from Animal Production Station belonging to Improved Agricultural Systems Project Ismailia, Ministry of Agriculture. The digestion coefficients of nutrients and nutritive value of tubers from Jerusalem artichoke and its silage with ammoniated rice straw were determined by sheep. The tubers were harvested in October. The tubers were offered to animals as fresh in chopped form but silage was made immediately after harvesting and chopping into pieces (2-3 cm). The stack of rice straw bales was built and tightly covered by a polyethylene sheet. A delivery pipe from an anhydrous ammonia tanker was inserted in the stack to deliver a rate of 3 kg NH3 /100 kg straw. The stack was opened after 21 days and aerated for 3 days. Straw was chopped before preparing silage in plastic barrels, of 70 kg capacity. Layers of divided tubers were separated in the barrels by layers of ammoniated rice straw with a ratio of 3 tubers to 1 straw (fresh weight). The barrels were kept tightly closed for three months.

Two rations were used in chopped form. The first was fresh tubers from Jerusalem artichoke + ammoniated rice straw to avoid diarrhea, the second was ensiled tubers from Jerusalem artichoke with ammoniated rice straw to reduce moisture content, and increase nitrogen and fiber contents, which was fed to the animals twice a day in free choice. Residues of rations were daily weighed to determine the free choice intake of each. Animals were allowed free access to clean water. The groups of animals (five Ossimi rams in each one) were kept in individual pens for 25 days. The first trial was carried out after tubers harvested using fresh tubers, while the second, was carried out after produced the silage.

Applying the direct method using three animals of each group has performed digestibility studies. The animals were placed in individual metabolic cages. A preliminary 10-day stage and a proper 6-day collection period have been employed. In the digestibility trials the fresh tubers were offered to animals in chopped form as a sole feed. While, the silage was mixed with ammoniated rice straw in resected amounts.

Samples of feeds were taken during the collection period, dried and milled for chemical analysis. Total faeces voided were weighed, wrapped in aluminum foil and dried in oven at 60°C until constant weight. The dried faecal samples were ground and stored for analysis. Proximate analysis of the feed and faeces were carried out according to the methods of A.O.A.C. (1990), the analysis of amino acid composition has been carried out with the use of amino acid analyzer and minerals have been determined by the modified method of MAFF,(1986).Silage quality was measured according to the method of Research Institute for Cattle Feeding at Hoorn, Holland (1961). All data were subjected to analysis of variance using the General Linear Models (GLM) procedure of SAS (1994), Mean differences were compared using Duncan' multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Chemical composition

The chemical compositions of tubers from the Jerusalem artichoke are presented in Table 1. It could be observed that crude protein content was 8.91% in dry matter basis. While, there was a detectable variation concerning crude fiber content (5.73 %) and opposite trend was observed regarding nitrogen free extract content (78.26). These results are in accordance with those reported by Petkov, *et at* 1997. Data regarding amino acids and minerals of the tubers from the Jerusalem artichoke presented in Table 2 is characteristic of large proportion of methionine, tryptophan, threonine and traces of cystine. The content of calcium being 0.16 g/kg DM, while, phosphorus was found to be 1.22 g/kg DM. Magnesium, potassium and sulfur content can be admitted to be sufficient, there occurs also a large deficiency of sodium being characteristic for majority of tubers. These results are in agreement with those reported by Petkov, *et at.*, 1997. Who detected that the tubers had similar characteristics to other root crops, Because of their high-energy and low fiber contents, it is suggested that the tubers can be used in feeding ruminants, as an energetic tubers.

Table (1): Chemical composition of tubers from Jerusalem artichoke

Items	DM	DM composition %					
		OM	CP	CF	EE	NFE	Ash
Tubers	24.2	93.75	8.91	5.73	0.85	78.26	6.25

Table (2): Amino acid and mineral composition of tubers from Jerusalem artichoke

Crude protein 21.6 g/kg Amino acid g/kg					
Lysine	Methionine	Cystine	Tryptophan	Threonine	Isoleucine
0.65	1.25	Trace	0.54	0.66	0.68
Leucine	Valine	Histidine	Phenylalanine	Tyrosine	Arginine
0.99	0.85	0.35	1.06	0.65	0.67
Mineral components g/kg DM					
Ca	P	Mg	K	Na	S
0.61	1.22	2.19	9.3	0.11	1.42

Results from the data in Table (3) showed that silage from tubers of the Jerusalem artichoke and ammoniated rice straw produced the highest crude protein (9.35) and crude fiber (15.02) contents and as well as, good quality silage as shown from the silage quality. Similar conclusion was pointed out by Duranti, *et al.* (1992) who found that Jerusalem artichoke tubers were ensiled with Lucerne hay (10% of total fresh weight) and produced good quality silage containing, 10.85% crude protein and 17.33% crude fiber.

Table (3): chemical composition of ammoniated (A) rice straw and its silage with tubers from Jerusalem artichoke

	A. rice straw	Tubers + A. rice straw	Silage from Tubers +A. rice straw
DM	92.32	39.58	41.15
DM composition %			
CP	9.22	10.02	9.35
CF	36.51	13.62	15.02
EE	1.63	1.16	1.21
NFE	35.92	66.23	67.13
Ash	16.72	8.97	7.29
Silage quality			
pH			4.25
Ammonia-N g /100g			0.16
Acetic acid %			2.78
Propionic acid %			0.45
Butyric acid %			0.25
Lactic acid %			2.23
Total VFA's %			3.48

Digestibility coefficients and nutritive value

The digestibility coefficients and nutritive value of tubers from the Jerusalem artichoke, fresh or ensiled with ammoniated rice straw are presented in Table 4. It could be observed that apparent digestibility coefficients obtained from the 2 trials were for DM 76.18 and 72.52%, OM 79.24 and 75.15%, CP 65.19 and 61.73%, CF 52.05 and 53.17, EE 53.22 and 49.86 and NFE 86.12 and 79.35%. High digestibility coefficient of organic matter in fresh tubers results from the high content of carbohydrates and a small amount of fiber. Ensiling fresh tubers with ammoniated rice straw showed less digestibility coefficients for all nutrients except CF than that of fresh tubers.

The nutritive values of the fresh tubers were 77.21 and 5.81% for TDN, and DCP, respectively on DM basis. When, the fresh tubers were ensiled with ammoniated rice straw, the nutritive values decreased, the corresponding values were 68.38 and 5.77 % in the same order. While, silage was the highest in nutritive values when calculated on fresh matter as shown in Table 4. These increases may have been due to high dry matter in silage than fresh tubers.

Table (4): Digestibility coefficients and nutritive value of tubers from Jerusalem artichoke fresh or ensiled with ammoniated rice straw

%	Fresh Tubers	Silage from Tubers +A. rice straw	SE	Significance
DM	76.18	72.52	2.45	*
OM	79.24	75.15	2.62	*
CP	65.19	61.73	2.18	*
CF	52.05	53.17	1.19	NS
EE	53.22	49.86	2.34	*
NFE	86.12	79.35	3.15	**
Nutritive value % (DM basis)				
TDN	77.21	68.38	2.92	**
DCP	5.81	5.77	0.65	NS
Nutritive value % (fresh matter)				
TDN	18.68	28.14	3.24	**
DCP	1.41	2.38	2.91	**

* : Significant (P<0.05) ** : Significant (P<0.01) NS : Not Significant

Dry matter and energy intake

Data allocated in Table (5) represent dry matter and energy intake of sheep fed tubers from Jerusalem artichoke fresh or ensiled with ammoniated rice straw.

Table (5): Dry matter and energy intake of sheep fed tubers from Jerusalem artichoke fresh or ensiled with ammoniated rice straw

	A.rice straw	Fresh tubers	Tubers +A. rice straw	silage	SE	Significance
Weight Kg	40.1			42.5		
DM- intake						
g/day	369.3	650	1019.3	1120	62.32	*
$g/W^{0.75}$	23.23	40.88	64.11	67.47	4.15	NS
I / MR %			100.9	110.9	1.81	*
TDN- intake						
g/day	185.38 [1]	501.87	687.25	765.86	52.34	*
$g/W^{0.75}$	11.66	31.56	43.22	46.13	3.18	NS
I / MR %			102.27	113.97	1.94	*
DCP- intake						
g/day	12.37 [1]	37.77	50.14	64.62	2.62	*
$g/W^{0.75}$	0.77	2.38	3.15	3.89	0.75	NS
I / MR %			78.36	100.97	3.45	**

* Significant at P ≤0.05 NS not significant at P≥ 0.05
** Significant at P≤ 0.01 SE standard error
I / MR % = (intake / maintenance requirement)*100
[1] (TDN 50.2% and DCP 3.35% for ammoniated rice straw, calculated by difference using barley as a basal ration, Gihad *et al* (1989))

There were significant differences between rations in dry matter, TDN and DCP intake as g/day. While, there were no significant differences when calculated as $g/W^{0.75}$. This may be due to the changes in body size of groups.

Considering the ratio of ingested dry matter relative to maintenance requirement + 50 % activity according to (NRC, 1988) for sheep. Results showed that tubers from Jerusalem artichoke fresh or ensiled with ammoniated rice straw was somewhat palatable for sheep. However, data revealed that silage was more palatable in compared versus fresh tubers + ammoniated rice straw. The same trend was also observed in case of TDN. Regarding DCP, data revealed that there was no problem, concerning covering protein requirements from tubers ensiled with ammoniated rice straw.

CONCLUSIONS

It was found that the tubers from Jerusalem artichoke is characteristic of its high content of nitrogen free extract, low content of crude protein and crude fiber which, reflected in the feeding value. The low content of fiber in tubers and the high digestibility of organic matter allow to use this feed as an energy component in rations for animals. Ensiling fresh tubers with ammoniated rice straw produced good quality silage with reasonable crude protein and crude fiber contents.

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دراسات على القيمة الغذائية لدرنات نباتات الطرطوفة الطازجة او المحفوظة كسيلاج مع القش المعامل بالامونيا

أحمد أحمد عثمان

قسم الإنتاج الحيواني – كلية الزراعة – جامعة قناة السويس – الإسماعيلية – مصر

تم دراسة المحتوى الغذائي لدرنات نباتات الطرطوفة بالإضافة إلى المحتوى من بعض الأحماض الأمينية و العناصر المعدنية الكبرى. و كانت المادة الجافة لهذة الدرنات ٢٤,٢% بينما كان البروتين الخام ٨,٩١ %و الألياف الخام ٥,٧٣% و مستخلص الأثير ٠,٨٥% و الكربوهيدرات الذائبة ٧٨,٢٦ %و الرماد ٦,٢٥ % على أساس المادة الجافة. و كانت تحتوى على جزء كبير من الأحماض الأمينية المثايونين و التربتوفان و الثرونين بينما كمية الحامض الأميني السستين تكاد تكون معدومة. وكذلك كان هناك انخفاض في كمية الكالسيوم و الفوسفور . و قد تم عمل سيلاج من الدرنات مع القش المعامل بالامونيا بنسبة ٢٥ % من اجمالى الوزن الرطب لرفع نسبة النتروجين و الألياف الخام في السيلاج المنتج و كان محتوى السيلاج من المادة الجافة هو ٤١,١٥ % و البروتين الخام ٩,٣٥ % و الألياف الخام ١٥,٠٢ % و الكربوهيدرات الذائبة ٦٧,١٣ % على أساس الوزن الجاف. قدرت معاملات الهضم لكل من الدرنات الطازجة و السيلاج فى تجربتين هضم باستخدام خمسة كباش اوسيمى. وكانت معاملات الهضم الناتجة من التجربتين هى ٧٦,١٨ و ٧٢,٥٢ % للمادة الجافة و ٧٩,٢٤ و ٧٥,١٥ % للمادة العضوية و ٦٥,١٩ و ٦١,٧٣ % للبروتين الخام و ٥٢,٠٥ و ٥٣,١٧ % للألياف الخام و ٨٦,١٢ و ٧٩,٣٥ % للكربوهيدرات الذائبة لكل من الدرنات الطازجة و السيلاج على الترتيب. أوضحت النتائج انخفاض معاملات الهضم عند عمل السيلاج لجميع المكونات الغذائية فيما عدا الألياف الخام. بينما كانت القيم الغذائية ٧٧,٢١ و ٦٨,٣٨ % لمجموع المركبات الغذائية المهضومة و ٥,٨١ و ٥,٧٧ % للبروتين الخام المهضوم. و من هذه النتائج يتضح انه يمكن استخدام درنات نباتات الطرطوفة سواء طازجة او فى صورة سيلاج فى المكونات الغذائية للحيوانات المجترة.