

Abanico Veterinario. January-December 2020; 10(1):1-11. <http://dx.doi.org/10.21929/abavet2020.6>
Original Article. Received: 16/01/2020. Accepted: 25/04/2020. Published: 30/04/2020.

Orange by-products use (*Citrus sinensis* var. *valencia*) in ruminants feed Utilización de subproductos de naranja (*Citrus sinensis* var. *valencia*) en la alimentación para rumiantes

Cabrera-Núñez Amalia [ID](#), Lammoglia-Villagómez Miguel [ID](#), Martínez-Sánchez César [ID](#), Rojas-Ronquillo Rebeca [ID](#), Montero-Solís Flor* [ID](#)

Facultad de Ciencias Biológicas y Agropecuarias, Universidad Veracruzana. Tuxpan, México. *Responsible author and for correspondence: Montero-Solís Flor. Facultad de Ciencias Biológicas y Agropecuarias de la Universidad Veracruzana. Carretera Tuxpan-Tampico Km. 7.5, Colonia Universitaria, Tuxpan, Veracruz, México, CP 92890. 017838344350 ext. 46109. Tuxpan, Veracruz. amacabrera@uv.mx, malammoglia@uv.mx, cesamartinez@uv.mx, rebrojas@uv.mx, flmontero@uv.mx.

ABSTRACT

This study was aimed to elaborate a young bull fattening supplement with Valencia orange by-products (*Citrus sinensis* var. *valencia*) in the north of Veracruz state. It was performed in a Livestock Production Unit (UPP) from the Municipality of Álamo-Temapache, Veracruz. Geographically located at North latitude: 20° 55' 19", West latitude 97° 41' 44". This place is found at 40 meters height above sea level with an average annual temperature of 19-36 ° C. 40 Zebu x Swiss bulls, with 300 kg weight approximately, were housed and assigned under a completely randomized design in four treatments, and ten repetitions (n = 10). T1 (control) fresh forage; T2: formulated concentrate based on orange bagasse + fresh forage; T3: concentrate formulated with orange peel + fresh forage; T4: concentrate formulated with orange silage + fresh forage. Food was offered twice a day "*ad libitum*" considering 3.0 % (NRC) of the live weight during the 90 days of the experiment, with two weightings at the beginning and at the end. The average daily gain (P<0.05) was 2.97 kg/animal and the cold carcass yield was 55.3%, to the animals that received a by-product supplementation based on orange silo (T4) 13.3% PC it promoted higher performance in fattening cattle.

Keywords: orange valence, by-products, yield, cattle, silo.

RESUMEN

Este trabajo tuvo como objetivo elaborar un concentrado alimenticio con subproductos de naranja valencia *Citrus sinensis* var. *Valencia* como suplemento para toretes de engorda en el norte del estado de Veracruz. Se desarrolló en una Unidad de Producción Pecuaria (UPP) del Municipio de Álamo-Temapache, Veracruz. Geográficamente localizado entre los meridianos Latitud norte: 20° 55' 19", Latitud oeste 97° 41' 44". La localidad se encuentra a una altura de 40 msnm y temperatura media anual de 19-36°C. Se evaluaron, 40 toretes Cebú x Suizo, con un peso aproximado de 300 Kg, que fueron estabulados y asignados bajo un diseño completamente aleatorio en cuatro tratamientos y diez repeticiones (n=10 c/u). T1 (testigo) forraje fresco; T2: concentrado formulado a base de bagazo de naranja + forraje fresco; T3: concentrado formulado con cascara de naranja + forraje fresco; T4: concentrado formulado a base de ensilado de naranja + forraje fresco. El alimento se ofreció dos veces al día a libre acceso considerando el 3.0% (NRC) del peso vivo durante los 90 días del experimento, realizándose dos pesajes al inicio y final. El promedio de ganancia diaria (P < 0.05) fue 2.97 kg/animal y rendimiento en canal fría de 55.3%, para los animales que recibieron una suplementación de subproductos a base de silo naranja (T4) al 13.3% PC, promovió un mayor rendimiento en los bovinos de engorda.

Palabras clave: naranja valencia, subproductos, rendimiento, bovinos y silo.

INTRODUCTION

In recent years and due to the environmental concern of society, agribusiness must be sensitive to environmental issues, seeking the increasing development of a social conscience, which requires not to produce at the expense of the planet, but in a sustainable way. Due to the above, the nutritional characteristics of the by-products of the agro-industry have been studied, for the elaboration of food rations, in cattle ([Escorza et al., 2019](#)). The best strategy to achieve higher productivity is to establish a food supplement program, using the available material, human and financial resources. Since the decision to complement represents an additional cost to the producer, the use of those supplements that provide the maximum productive and economic response must be considered ([Cury et al., 2017](#)).

Industries that process agricultural products must find a final destination for by-products, which meet two minimum requirements; that it is not polluting the environment and that the costs of processing and transportation are covered by the sale price thereof and do not generate additional costs to production ([Bisang, 2017](#)). Among the different by-products, there is a high variability in the chemical composition available; some can be very regular in composition, because the industrial processes that generate them are highly controlled. While others may present an important variation, so it is necessary to know the nutritional contributions at the time of formulating the rations ([Berenguer, 2000](#)). Once the contributions to be made through supplementation have been determined, it should be taken into account that many by-products can simultaneously provide energy and protein ([Lagos and Castro, 2019](#)); others, on the other hand, may be lacking in some nutrient. It is important to highlight that animal feed from by-products are substitutes and are also considered as alternatives that producers can choose, according to their economic possibilities and geographic distribution, in order to increase weight gains, feed conversion and greater economic profitability ([Campos and Arce, 2016](#)).

Citrus fruits are widely cultivated in subtropical or Mediterranean climate areas, and to a lesser extent in tropical areas. Most of the increases in production have been due to the growth of the areas of the orange crop, and to the fact that productivity has increased, thanks to the improvement of the exploitation practices; by applying fertilizers and irrigation, controlling pests and diseases, grafting trees, replacing poorly located orchards and planting the varieties with the highest resistance ([Hernández, 2015](#)).

Valencia orange (*Citrus sinensis* var. valencia), is one of the most consumed products worldwide, and just over 10% of total production, approximately 6.5 million tons, is exported to other countries, such as: France, United Kingdom, Germany, Russia, Saudi Arabia, among others. It is one of the world's most consumed products and a little more than 10% of total production ([Gómez et al., 2019](#)). In Mexico, citrus production is destined

for domestic consumption (88%), and the rest is mainly exported to the United States (Valencia and Duana, 2019).

Oranges rank fifth on the list of most produced or exported agricultural products, surpassed only by bananas, apples, tomatoes and onions, in terms of international trade. Mexico is in twenty-fifth place with \$ 19,449 and contributes 0.4% of total exports (Triana *et al.*, 2014).

The state of Veracruz has almost 50% of the country's harvested area (Barrón and Hernández, 2014) and produces 50% of the juice orange nationwide (SADER, 2018). Álamo municipality of, located in the north of the state of Veracruz, is considered the capital of the orange; producing variety of late valence, super late valence and early valence; as well as the table ones (zarzuma, monica and tangerines), among others. It also has juicers that process the orange and that add value to the derived by-products (Sarah *et al.*, 2018), such as the pulp or citrus waste; composed of the juice, bagasse, seeds and the husk (Espinoza *et al.*, 2019) to produce silage.

Fresh bagasse, due to its high water content and its potential for polluting the environment, generates a problem at the level of industrial plants, but at the same time offers an opportunity for supplementary feeding for ruminants, especially cattle (Bermúdez *et al.*, 2015).

Derived from the high production of orange in the area, these by-products come to be supplied by the owners of cattle ranches in times of high production. A large part of these citrus fruits are destined for the production of juice, obtaining annually about 70,000 tons of pulp that are discarded by the juicer.

Due to the above and due to the high demand for by-products of the orange, this work aimed to prepare a food concentrate with by-products of Valencia orange (*Citrus sinensis* var. Valencia) as a supplement for fattening young bulls in the north of Veracruz state.

MATERIAL AND METHODS

Experimental place

This investigation was developed in a cattle ranch in the municipality of Álamo-Temapache, Veracruz; located on the meridians North Latitude 20° 55'19 "and a West Longitude 97° 41' 44"; at a height of 40 m a.s.l and ambient temperature 19 to 38 °C (Solano, 2006).

Treatments

40 Zebu x Swiss young bulls were used, weighing approximately 300 kg assigned under a completely randomized design in four treatments and ten repetitions per treatment.

Determination of nutritional values of orange peel

Nutritional values (crude protein %, ether extract %, ash %, crude fiber % ([Van Soest and Wine, 1968](#)), nitrogen-free extract %, total digestible nutrients (Mcal) and net energy of production (Mcal) in the orange peel; they were analyzed prior to the elaboration of concentrates in the Laboratory of Animal Bromatology of the Faculty of Biological and Agricultural Sciences of the Veracruz University, Tuxpan campus.

Ruminant management

The management of the housed animals consisted of vaccination, deworming, tag identification and application of vitamins A, D and E, intramuscularly. The concentrate feed was offered twice a day, considering 3% of the live weight of the young bull (NRC, 2007) during the 90 days that the experiment lasted. Treatments were fresh forage (control T1), concentrate formulated on the basis of orange bagasse + fresh forage (T2), concentrate formulated on the basis of orange peel + fresh forage (T3) and concentrate formulated on the basis of orange silage + fresh forage (T4).

Manufacture of concentrates

To carry out the elaboration of the food concentrate, for the T2 and T3 treatments, it was necessary to collect by-products that were discarded such as orange peel and bagasse in the juicers of Álamo, Veracruz. In relation to the T4 treatment, a pastel-type silo was developed, located in an elevated site with a slight slope, building a border around it to prevent the entry of water, as the only ingredient; the oranges were chopped into small pieces of 3-6 cm; Those that accumulated by layers with 20 cm thickness and rammed with a tractor on top. Later it was covered with polyethylene plastic, and on it a uniform layer of 10-15 cm of earth, six meters wide and one meter high; which was used one month later to discover only the quantity to be provided per day.

To facilitate the mixing of the ingredients, each of the treatments was added on spread canvas and separately: T2: 50 kg orange bagasse; T3: 50 kg orange peel and T4: 50 kg orange silo. With this, the concentrate was made, adding broken corn (25 kg.), Ground sorghum (20 kg.), Vitamins and minerals (5 kg.). The ingredients were mixed daily and carefully, to have a homogeneous feed in the different rations to be supplied morning and afternoon to the cattle (tables 1, 2 and 3).

Table 1. Ingredients used for the preparation of food concentrate based on orange bagasse.

Ingredients	kg	PC%	TOTAL PC%
Orange bagasse	50	10	5.10
Broken corn	25	12	2.75
Ground sorghum	20	12	2.45
Vitamins and minerals	5	-	-
TOTAL	100		10.3

PC (Crude Protein).

Table 2. Ingredients used to make concentrated food based on orange peel

Ingredients	kg	PC%	TOTAL PC%
Orange peel	50	10.0	5.10
Broken corn	25	12	2.75
Ground sorghum	20	12	2.45
Vitamins and minerals	5	-	-
TOTAL	100		10.3

PC (Crude Protein).

Table 3. Ingredients used for the preparation of food concentrate based on orange silo.

Tabla 3. Ingredientes utilizados para la elaboración de concentrado alimenticio a base de silo de naranja

Ingredients	Kg	PC%	TOTAL PC%
Orange silo	50	16.0	8.10
Broken corn	25	12	2.75
Ground sorghum	20	12	2.45
Vitamins and minerals	5	-	-
TOTAL	100		13.3

PC (Crude Protein).

Weight estimation

Changes in animal weight were recorded at the beginning and end of the study (90 days). Once the evaluations were completed, the animals were sacrificed on a Federal Inspection Type (TIF) cold store, determining the performance of the cold carcass (RCF).

Analysis of data

An analysis of variance and Duncan's test were performed to compare the treatment means ($P < 0.05$), with the SPSS statistical package (SPSS, version 10).

Estimación de peso

Los cambios en el peso de los animales fueron registrados al inicio y término del estudio (90 días). Una vez finalizadas las evaluaciones los animales fueron sacrificados en un rastro frigorífico Tipo Inspección Federal (TIF), determinándose el rendimiento de la canal fría (RCF).

Análisis de datos

Se realizó un análisis de varianza y prueba de Duncan para comparar las medias de tratamientos ($P < 0.05$), con el paquete estadístico SPSS (SPSS, versión 10).

RESULTS

Regarding the nutritional recommendations indicated by the National Research Council (NRC, 2001), the values between 10-18% of Crude Protein (PC) and 65% of Total Digestible Nutrients (TND), are considered desirable (Table 4). Therefore, in this investigation, these parameters were met, intended for the stalled bulls of 300 kg, with values of 10.0 -13.0 % PC provided in the ration.

The productive behavior of the animals in the different treatments, related to weight gain (kg/day) was significantly different ($P < 0.05$), between the treatments (T2, T3 and T4), with respect to the control (2.66, 2.70 and 2.97 kg.) (Table 5).

Table 4. Nutritional value of orange by-products.

Indicator	Orange bagasse	Orange peel	Orange silage	Fresh forage
Crude Protein %	10.0	10.0	16.0	5.67
Ethereal Extrac %	3.20	4.96	9.22	3.79
Ashes %	3.30	7.92	7.93	3.02
Crude Fibe %	14.92	30.80	33.40	36.43
Nitrogen free extract %	64.51	67.18	77.58	56.78
Total digestible nutrients (Mcal)	60.39	63.78	64.56	55.67
Net Production Energy (Mcal)	22.60	26.87	27.89	29.30

PC (Crude Protein). Mcal (megacalories).

Table 5. Productive levels with orange by-products

	T1	SD	T2	SD	T3	SD	T4	SD
Initial weight (kg)	300.1 a	33.11	300.2 a	33.11	300.1 a	32.99	300.1 a	33.11
Final weight (kg)	439.8 a	28.19	540.3 b	28.19	543.5 b	11.00	567.5 a	6.80
Kg gained/animal 90 days/group	139.7 a	-	240.1 b	-	243.4 b	-	267.4 b	-
Weight gain/day (kg)	1.55 a	0.32	2.66 b	0.53	2.70 b	0.40	2.97 b	0.38
Concentrate consumption (kg)	-	-	16.20 b	-	16.30 b	-	17.02 b	-
Metabolizing energy consumption (Mcal)	10.30 a	-	27.89 b	-	27.92 b	-	27.94 b	-
Cold carcass yield (%)	50.0 a	-	54.5 b	-	54.8 b	-	55.3 b	-

Averages with different letters within the same row are statistically different ($P < 0.05$).

T1 (control) fresh forage; T2 concentrate formulated with orange bagasse + fresh forage;

T3 concentrate formulated with orange peel + fresh forage;

T4 concentrate formulated with orange silage + fresh forage.

SD standard deviation of mean starting and ending weights (kg) and weight gain/day (kg).

DISCUSSION

The orange pulp from the juicer presented a protein value of 10-13 %; These crude protein (PC) values could be increased and improve daily weight gain, by adding medium quality protein, such as urea, chicken manure, chicken manure or some bypass protein; such as soybean paste, harinoline, cottonseed, among others ([Lagos and Castro, 2019](#)). In feed rations with citrus by-products for ruminants ([Hernández *et al.*, 2015](#)), it has been observed that the gain in weight, quality of the carcass and the content of milk fat increases, which gave similar results with the supply of cereals in the food ration provided in this study. The difference in feed consumption resulted in T1 animals consuming 12.6 Mcal; while the animals that consumed orange by-products (T2, T3 and T4), ingested between 27.89 and 29.9 Mcal of net energy of production/day (table 5).

It is highlighted that the animals that received only energy nutrients presented higher kilograms gained/animal to the addition of the orange by-product (240.1, 243.4 and 267.4 kg, for T2, T3 and T4, respectively), compared to the treatments supplemented only with fiber (T1), those with a significantly lower response ($P < 0.05$). Likewise, the performance of the cold carcass (55.3%) is notable, which was significantly higher in the animals supplemented with corn silo. The above is related to what was reported by [Cury *et al.* \(2017\)](#), who recognize that the daily production per animal is determined by the combination of effects between the availability and quality of the food (energy-protein supplementation); as well as the animal's appetite and genetic potential.

Currently, in the field of nutrition of meat-producing cattle, protein is not only important, since the level and quality of protein is fundamental in the productive response of animals, and is the key to achieving the highest profits in any livestock production unit, under confinement conditions and the productive behavior of animals in the different treatments.

In relation to the total weight gain/day, there were increases of 2.66, 2.70, 2.97 kg for T2, T3 and T4, in the young bulls that received orange by-products with respect to the control treatment. The difference in feed consumption (T1: grass) was 10.30 Mcal of metabolizable energy/day. While the young bulls supplemented with orange by-products, consumed 27.89, 27.92 and 27.94 Mcal (T2, T3, T4, respectively); equivalent to a difference of 40%, which is reflected in the same proportion on the live weight gain between the treatments. These differences were due to a better nutritional contribution and the effect that the inclusion of an energy source in the rumen has for the production of volatile fatty acids (VFAs), such as acetic acid, propionic acid, butyric and valeric, essential on feed intake, daily live weight gain, and increased meat and conformation production ([Jarvis and Moore, 2010](#)).

Regarding the quality of the orange silo (T4), good quality silage was obtained; Due to its yellowish green and light brown color, a slightly acidic, ripe fruit smell and a firm texture, without deforming when pressed with the fingers; which indicates that the adequate

management of the silo increased the nutritional and organoleptic properties of the food. It should be noted that the amount of food offered to treatment animals 2, 3 and 4, was totally consumed; this due to the palatability of the orange by-product, which was demonstrated by not leaving residues inside the feeders. Therefore, it could be attributed that the consumption of dry matter is total in all the treatments, except in T1 (fresh forage), in this it was observed that, although it was consumed, it was not attractive, compared to the orange by-products. This may be due to the increase in digestible sugars that stimulate palatability, compared to green or dry forages, as they have more carbohydrates. Lactic acid bacteria generate a greater amount of biochemical compounds that enrich the substrate, improving taste conditions and sensory stimulating through their characteristic lactic acid odor and the sensitive organs of animal smell ([Wadhwa et al., 2015](#)).

The results of the present work were similar to those reported by [Triana et al. \(2014\)](#), who worked with Valencia orange by-products, appreciating in the silo a light brown and light mustard color through fermentation times. The silo produced in this study complies with the organoleptic characteristics associated with high-quality silages; in this case an aromatic, sweet, pleasant fermented wine smell that characterizes lactic acid. This could be attributed to the fact that the orange peels, in addition to the natural fragrance of essential oils, have acids that generate a pleasant odor that, accompanied by the increase of lactic bacteria in the fermentation process, gave the silage a slightly pleasant odor.

Currently, in the field of nutrition of meat-producing cattle, protein is not only important, since the level and quality of energy is fundamental in the productive response of animals and is the key to achieving the highest profits in any livestock production system, under confined conditions. Importantly, energy provides the body with the ability to do work. In rations for fattening cattle, energy is required for activities such as growth and maintenance; so energy is a nutrient required by livestock in large quantities. The primary sources of energy in forage are cellulose and hemicellulose, and in grains starch. Fats and oils have a higher energy content, but are usually added in small amounts in the diet.

CONCLUSIONS

It was very notable that the stalled bulls that received the orange silo by-products had a daily weight gain of 2.97 kg. The accumulated weight gain at 90 days was 267.4 kg and the treatment for the young bulls with fresh fodder from African star grass was lower, with 139.7 kg. The low price and easy elaboration of concentrates with orange by-products is attractive and a viable option, as a complement for ruminants in periods of low water (drought and winter), given the availability of citrus in the north of Veracruz state.

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