RABBIT PRODUCTION IN LATIN AMERICA

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Summary

In Latin America, highlands and higher latitude areas can be viewed as the most favorable for rabbit production, whereas the more hot and humid regions such as the Amazon, Central America and the Caribbean are the most limiting for rabbit production. Rabbit meat production was over 1.8 million ton in the world in 2008, showing a 42.4% increase relative to year 2000, when it was around 1.3 million ton. A 10.8% production decrease was observed in Europe but a 118.2% increase was observed in the estimated production of the Americas over that period. Seven Latin American, six of which were South American countries, produced over 1,000 ton of rabbit meat each in 2008: Venezuela, Argentina, Mexico, Colombia, Peru, Brazil, and Ecuador. From 2000 to 2008, production increased in Peru, Ecuador, Venezuela, and Colombia, whereas Argentina, Brazil and Mexico showed little or no change in this period. Argentina is the only Latin American country that exported considerable amounts of rabbit meat between 2000 and 2007. The lack of support from government programs and technical assistance for the rabbit production sector was pointed out as one of the limiting factors for the development of rabbit meat production in Latin American countries. In the majority of countries in which a commercial-scale rabbit production has been established, the production chain is underdeveloped and often characterized by advancement and regression cycles. Cooperative organization and various forms of contract farming should be encouraged for the rabbit meat production sector to reduce transaction costs to access high quality inputs, credit, technology, and market information. A high dependence on export markets may not be the best way to expand commercial rabbit meat production in Latin American countries. More attention should be devoted to the internal growing markets.

Introduction

Latin America spans an area of approximately 21,069,501 km², comprising almost 3.9% of the Earth´s surface or 14.1% of its land surface area. The overall population was estimated at 579.8 million and the combined GDP (Gross Domestic Product) at 4.21 trillion USD [USAID, 2009]. Expected economic growth for the region is at about 4% in 2010, but Latin America has the most unequal income distribution in the world; therefore inequality and poverty are the region's main challenges. Nearly 25% of the population lives on less than 2 USD a day.

Evidence suggests that in developing countries, poor people, especially young children and their mothers are victims of malnutrition and undernutrition [FAO, 2009]. A striking example is provided by a recent study involving Brazilian Indians [FUNASA, 2010] that revealed that in a typical Indian family, the mother is obese, and yet anemic, and her kids are also anemic. Poor nutrition impairs children growth and cognitive development besides increasing vulnerability of women, men and children to infectious diseases. Foods of animal origin, especially meat, can provide high quality protein and six micronutrients that are difficult to obtain in adequate amounts from foods of plant origin alone. They are: vitamins A, B12 and B2, calcium, iron and zinc. Small quantities of animal-origin foods, added to a plant-based diet can substantially enhance nutritional adequacy [FAO, 2009].

The recent global food crisis has revealed the fragility of the global agricultural system. Today, the number of people suffering from chronic hunger in the world is 1.02 billion [FAO, 2009]. Besides providing food security to these one billion people, doubling food production

is needed in order to feed a population projected to reach 9 billion in 2050. It is recognized that agricultural and livestock production development is crucial to alleviate poverty and food insecurity.
A large demand increase for livestock derived products has occurred in the fast growing economies in the last past decades due to population growth, increasing income and rapid urbanization. This demand was met by commercial livestock production systems and associated food chains through a “livestock revolution” supported by technological innovations and structural changes in the sector [FAO, 2009]. Nevertheless, government policies and regulations did not keep pace with these rapid changes, therefore, a number of issues confronting the sector have recently emerged. Pressure on ecosystems and natural resources, animal rights activism, and risk of spreading animal diseases and animal-related human diseases can be pointed out. The social implication of the structural change in the sector should also be of concern. Although millions of rural people are still involved in traditional livestock production systems ensuring households and local population food security, an increasing marginalization of the smallholders is taking place. There is no simple solution to this situation, but it is possible that rabbit meat production could contribute to minimize negative environment, health and social impacts of livestock production.
Based on geography, Latin America can be subdivided into four main subregions: North America (one country: Mexico), Central America (seven countries: Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama), the Caribbean (13 independent countries plus five British, four French, two US and two the Netherlands possessions) and South America (13 countries: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Uruguay and Venezuela plus one French and two UK possessions). Due to its large latitudinal range, varied topography and rich biodiversity, Latin America and the Caribbean have the most diverse and complex range of farming systems of any region in the world. In the coming decade, growth in agricultural production is projected to be rapid in Latin America, while slowing in the industrialized countries [FAO, 2009]. By 2018 agriculture output in the region is projected to be 75% higher than in 2000, compared to only 12% increase in industrialized economies.
Most of Latin American territory is located in the equatorial and tropical zones, except for the Southern portion of South America and Northern Mexico. It is known that at temperatures above 30^{o}.C, rabbit production can be severely limited [Cheeke, 1986; Chiericato et al., 1993], especially if associated with high relative humidity. Therefore, the Amazon, Central America and the Caribbean are the most limiting regions for rabbit production, whereas highlands, higher elevation and higher latitude areas can be viewed as the most favorable for rabbit production.

Statistics on rabbit Meat Production in Latin America

According to FAO estimates [FAOSTAT, 2010], rabbit meat production was over 1.8 million ton in the world in 2008, showing a 42.4% increase relative to year 2000, when it was around 1.3 million ton. The evolution, however, was not homogeneous among continents: whereas a 10.8% production decrease was observed in Europe, a traditional rabbit meat producer and consumer, important increases were observed in the estimated productions of Asia and the Americas (76.5 and 118.2%, respectively, Figure 1).

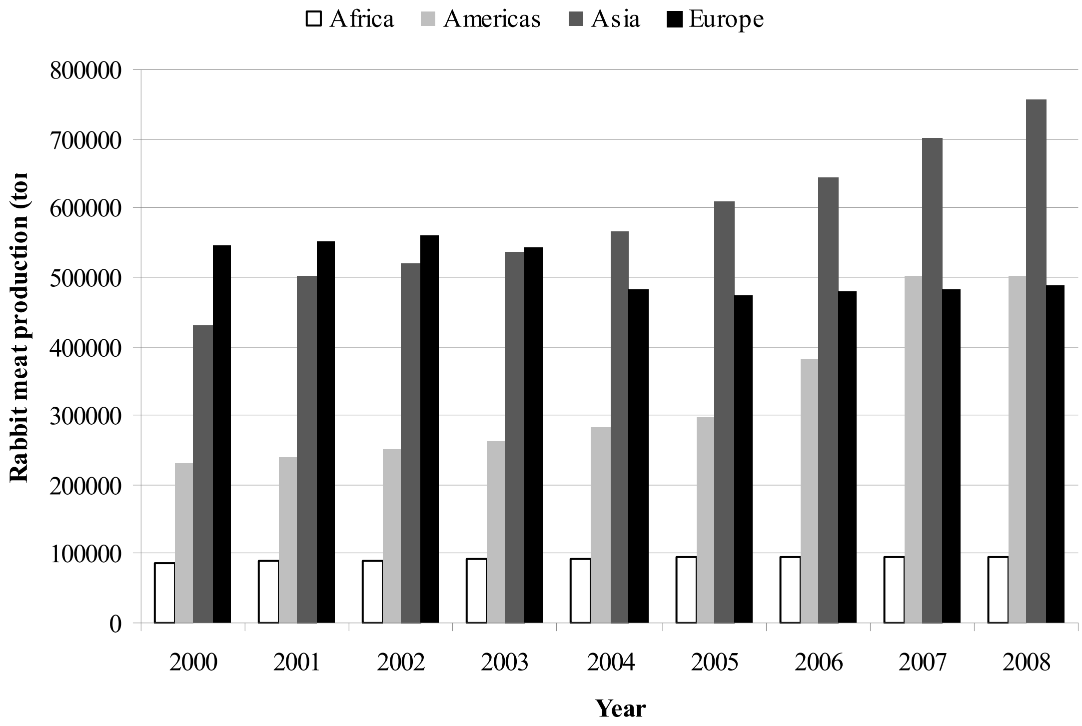

Figure 1. Evolution of rabbit meat production in the World from 2000 to 2008 (FAOSTAT, 2010)

A comprehensive survey of rabbit population and rabbit meat production and trade was conducted back in 1995 for 186 countries [Colin&Lebas, 1996]. At that time, Mexico appeared as the greatest rabbit meat producer and, consequently, as having the largest rabbit population in Latin America, followed by Brazil, Colombia, Venezuela, Argentina, Peru, Chile, Ecuador, Porto Rico and Uruguay (Table 1). Except for the small amounts exported by Uruguay, Argentina and Brazil, no other rabbit meat trades were recorded. In French Guiana, Guadeloupe and Martinique consumption per capita exceeded 1 kg. Ethnic minorities were reported to be the main consumers of rabbit meat in South America.

Recent survey data on rabbit population, number of rabbit does, number of farms producing rabbits and statistics on rabbit meat production do not exist for most Latin American countries. FAO estimates are probably the only source of data on rabbit meat production and trade in the region (Tables 2 and 3). Because small-scale rabbit keeping is believed to represent an important portion of the sector (30 to 50% overall) in Latin American countries, these figures could be underestimated.

According to FAO estimates, seven Latin American, six of which were South American countries, produced over 1,000 tons of rabbit meat each in 2008: Venezuela, Argentina, Mexico, Colombia, Peru, Brazil, and Ecuador (Table 2). From 2000 to 2008, production increased over 20% in Peru, Venezuela, and Colombia, and by 16% in Ecuador, whereas Argentina, Brazil and Mexico showed little change during this same period. It is possible that the recent shortage of animal food in Venezuela has stimulated rabbit meat production, but the absolute numbers presented for rabbit production for that country are very high and should be viewed with caution.

Table 1. Technical and economical data on rabbit meat production

Country	Production x 1000 t	Exports x 1000 t	Imports x 1000 t	Number females x 1000	Consumption kg per capita	Number females 1000 inhabitants
Argentina	4.00	.05	.00	119	.121	3.63
Bolivia	1.00	.00	.00	64	.131	8.36
Brazil	12.00	.05	.00	475	.078	3.10
Chile	1.00	.00	.00	31	.075	2.33
Colombia	8.00	.00	.00	357	.238	10.62
Ecuador	1.00	.00	.00	61	.093	5.62
Fr. Guiana	.10	.00	.02	5	1.200	54.44
Guyana	.10	.00	.00	8	.123	10.48
Paraguay	.50	.00	.00	19	.114	4.33
Peru	4.00	.00	.00	207	.182	9.42
Surinam	.10	.00	.00	8	.233	19.73
Uruguay	1.00	.20	.00	31	.257	9.95
Venezuela	6.00	.00	.00	367	.297	18.12
South America	38.80	.30	.02	1,753	0.127	5.79
Antigua	.03	.00	.01	2	.500	20.83
Bahamas	.05	.00	.00	3	.200	10.55
Barbados	.10	.00	.02	5	.462	20.98
Belize	.01	.00	.00	<1	.053	3.03
Costa Rica	.20	.00	.00	11	.065	3.51
Cuba	.50	.00	.00	18	.047	1.65
Dominican Rep.	.30	.00	.00	16	.041	2.24
El Salvador	.33	.00	.00	19	.065	3.70
Grenada	.04	.00	.01	2	.556	25.25
Guadeloupe	.20	.00	.20	6	1.143	18.48
Guatemala	.60	.00	.00	31	.063	3.26
Haiti	.30	.00	.00	23	.045	3.40
Honduras	.36	.00	.00	20	.068	3.88
Jamaica	.50	.00	.00	26	.204	10.43
Martinique	.20	.00	.20	6	1.081	17.48
Nicaragua	.30	.00	.00	17	.075	4.33
Panama	.15	.00	.00	8	.061	3.26
Porto Rico	1.00	.00	.20	36	.333	10.12
St Lucia	.06	.00	.01	3	.467	22.22
Trinidad Tobago	.40	.00	.05	21	.360	16.61
Central America and Caribbean	5.63	.00	.70	274	5.333	205.21
Mexico	15.00	.00	1.00	1,018	.182	11.60

Adapted from Colin & Lebas, 1996

Table 2. Rabbit meat production (ton) in Latin American countries from 2000 to 2008

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008
Venezuela	210,000	220,000	230,000	240,000	260,000	276,542	356,000	548,000	244,000
Argentina	7,150	7,150	7,150	7,150	7,150	7,150	7,150	7,300	7,260
Colombia	3,255	3,281	3,307	3,570	3,700	3,875	3,875	3,900	3,900
Peru	2,442	2,538	2,580	2,628	2,760	2,916	2,916	3,000	3,000
Brazil	2,100	1,950	2,100	2,025	2,025	2,025	2,040	2,040	2,040
Ecuador	921	924	931	1290	1306	1320	1029	1050	1050
Uruguay	354	390	390	390	390	390	390	390	405
Bolivia	135	135	135	139	139	139	139	139	139
South America	226,357	236,368	246,593	257192	277,470	294,357	373,539	565,819	261,794
South America *	16,357	16,368	16,593	17,192	17,470	17,815	17,539	17,819	17,794
Puerto Rico	0	0	0	357	164	141	141	150	158
Martinique	60	60	60	60	60	60	60	60	60
Guadeloupe	52	52	52	52	52	52	52	52	60
Central America and Caribbean	112	112	112	469	276	253	253	262	278
Mexico	4,160	4,190	4,190	4,220	4,220	4,220	4,220	4,250	4,250
Latin America	230,629	240,670	250,895	261,881	281,966	298,830	378,012	570,331	266,322
Latin América *	20,629	20,670	20,895	21,881	21,966	22,288	22,012	22,331	22,322

* Excluding Venezuela
Adapted from FAOSTAT, 2010

Table 3. Rabbit meat exports (ton) in Latin America from 2000 to 2007

Country	2000	2001	2002	2003	2004	2005	2006	2007
Argentina	3,410	3,384	3,612	3,443	4,584	6,166	4,444	3,628
Chile	332	195	1	169	145	105	126	136
Uruguay	0	0	312	185	300	329	303	274
Venezuela	0	0	0	0	0	0	0	0
Brazil	0	0	0	0	0	0	0	0
Peru						0	0	0
South America	3,742	3,579	3,925	3,797	5,029	6,600	4,873	4,038
Costa Rica						20	0	0
Honduras	2	2	0	0	0	0	0	0
Central America	2	2	0	0	0	20	0	0
Mexico	0	89	10	0	0	0	0	0
Latin America	3,746	3,672	3,935	3,797	5,029	6,640	4,873	4,038

FAOSTAT, 2010

Comparing FAO estimated production levels in 2008 with those from 1995 [Colin&Lebas, 1996], we realize that rabbit meat production have increased in Venezuela and Argentina, remained stable in Ecuador, but have decreased in some degree in most Latin American countries. Brazil and Mexico showed the most important decreases. In fact, large rabbit commercial operations have closed in Brazil during the nineties. But there has been a new impulse for rabbit meat production in Brazil beginning in 2009. The advent of avian influenza (H5N1) and the outbreak of A (H1N1) influenza caused by a virus containing genetic material from human, swine and poultry viruses, may have contributed to this renewed interest in rabbit meat production in Brazil, along with an increased consumer concern with the nutritional value and safety of meat products [Hernández, 2008].

When we consider exports estimates, Argentina is the only Latin American country that exported significant amounts of rabbit meat between 2000 and 2007 (Table 3). It is worth noting that, although Chile was not listed as a rabbit meat producer in FAO's estimates, it appeared along with Uruguay as a small exporter.

For the purpose of this paper, searches were carried out (on June 6th., 2010) at the Ministry of Agriculture websites of the seven greatest Latin American rabbit meat producer countries according to FAO estimates, for which the words "*conejo/ coelho*" and "*cunicultura*" were employed. No match was found for five (Venezuela, Colombia, Brazil, Ecuador and Peru) out of seven countries. Argentina and Mexico were the only two exceptions. Five documents related to rabbit production were found at the "*Portal de la Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación de México*" (SAGARPA). They included a Rabbit Raising Guide, minutes from a National Committee for Rabbit Production Systems, and news on balanced diets and on an epidemiological surveillance. Statistics on rabbit production and trade were found exclusively at the "*Ministerio de Agricultura, Ganadería y Pesca de la Nación Argentina"* website, along with a complete set of documents on legislation and from a national rabbit production committee (*la Comisión Nacional de Cunicultura*). Although this paper should not focus on any particular country, since we will have specific presentations later on today, I cannot refrain from showing a summary of these data (Table 4).

The figures presented in Table 4 do not reflect the overall amount of rabbits slaughtered in Argentina, because county slaughterhouses, which are not certified for export, were not included. But the numbers reflect a clear picture: there was an increase from 2000 to 2003, which became explosive between 2003 and 2005. But the rapid increase was followed by an equally rapid decrease thereafter, such that the graphical representation of the data would generate a bell shaped curve. Export figures follow a similar trend. Destinations of Argentina's exports were the European countries the Netherlands, France, Belgium, Spain, and Swiss, in a decreasing order of imported amount [Vitelleschi, 2009]. The vertiginous success was attributed to an abrupt increase in the demand of European Union, due to circumstances of the commercial relations with other suppliers (China), but that was followed by a retraction of the demand after 2005.

Table 4. Number of slaughtered rabbits and rabbit meat exports in Argentina from 2000 to 2009

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Slaughter (nr. heads)*	99,664	130,362	250,491	457,048	1,702,557	2,618,727	1,531,753	820,612	560,707	241,040
Exports (ton)			127	382	1482	2890	1929	791	595	336
Thousands US$			517	1752	7879	12385	7212	4725	3225	1845
US$/ton			4071	4586	5291	4285	3739	5974	5420	5491

* Does not include local slaughter houses

Ministerio de Agricultura, Ganadería y Pesca, Presidencia de La Nación Argentina, 2010

Potential and limitations for rabbit meat production development in Latin America

Rabbit production systems have often been classified into two categories: small-scale family units and commercial scale units [Finzi, 2000; Becerril-Perez, 2006; Lukefahr, 2007]. The first is essentially a low input and sustainable system, with five to ten does from local breeds, that uses on-farm feedstuffs, local materials for cage building, and family labor [Finzi, 2000; Lukefahr, 2007]. In this system, one or two rabbits are slaughtered every week to attend family needs and the exceeding rabbits or carcasses are sold in the local market, generating some income. Rabbit manure can be used as compost for vermiculture, forage and garden plots, while their fresh-cut feedstuffs could be fed to rabbits and other livestock [Lukefahr, 2007].

Characteristics such as small body size, rapid growth, high reproductive rate, small generation interval, large genetic diversity and the ability to use forages and agriculture by-products make rabbits suitable as meat producing small livestock in developing countries [Cheeke, 1986]. Some other features could be added to these, such as its quiet nature and the excellence of rabbit meat, low in fat and cholesterol [Samkol&Lukefahr, 2008]. In contrast, the relative complex management skills required, cultural barriers and the low thermo tolerance of the species were pointed out as limitations to the introduction of this activity in non-traditional areas [Cheeke, 1986; Finzi, 2000].

Small-scale familiar rabbit production is the most prevalent system in Latin America and the only system present in some countries [Salas, 2006]. An example of successful rabbit meat production project involving women, elderly people and indigenous populations, some of which organized in small cooperatives, was reported in the semi-desert *Queretano* region in Mexico [Gómez-Gallegos, 2008]. It started a decade ago in that region where natural resources are very limited and the rate of children malnutrition is high. State and federal government institutions subsidized the establishment of infrastructure and technical assistance. The training program and supervision was a very important component of this project and included not only rabbit raising techniques, but also meat and skin processing and marketing [Gómez-Gallegos, 2008]. Several other government programs for rural development were initiated in Mexico to stimulate small-scale rabbit production [Becerril-Perez, 2006], but the degree of success of those programs was restricted because, in many cases, actions were limited to distribute livestock in rural communities, without the formal training of farmers and on-farm supervision of the activities. The lack of support from government programs and technical assistance for the rabbit production sector was also reported in Uruguay [Denes, 2006], Colombia [Cortazar&Martinez, 2006], Brazil [Ferreira&Machado, 2007] and Ecuador, where small livestock experimental stations were shut down, and the technical support and training programs for the producers were suppressed [Salas, 2006].

Commercial-scale rabbit production, on the other hand, is characterized by a substantial initial investment in physical structure (building, caging system and equipment) and by continuous high inputs for hired labor, commercial feed, and hybrid genetic material. Production is directed to urban markets and exports [Finzi, 2000; Lukefahr, 2007]. Unfortunately, in the majority of Latin American countries in which a commercial-scale rabbit production has been established, such as in Argentina, México, Brazil and Uruguay, the production chain is underdeveloped and often characterized by advancement and regression cycles [Denes, 2006; MAGP, 2010]. The most recent examples are those of Argentina and Uruguay, but analogous crisis had occurred in Brazil in the nineties. The possible causes for the regression cycle differed somewhat from country to country. In Brazil, macroeconomic factors such as high inflation and interest rates, low access to credit and export markets, were the main causes for the decrease in rabbit meat production, which went from estimated 12,000 to 2,000 ton/year in the nineties [Ferreira&Machado, 2007]. In Argentina, a recent retraction of demand from European countries was the main cause for the decrease in production, whereas in Uruguay an outbreak of the Viral Hemorrhagic Disease triggered a recent crisis [Denes, 2006].

Studies on rabbit meat demand in Latin America are very scarce, but a market research was conducted in the state of Trujillo in Venezuela [Osechas&Sanchez, 2006]. Almost half (45%) of the interviewed persons manifested their disposition in consuming rabbit meat, which was interpreted as interest in buying it, whereas the remaining 55% showed no interest in buying it. When inquired about the reasons why they did not consume it, less than one third (27%) declared that rabbit meat was not attractive to them; 24% argued that they had not yet tried it, 17% could not find it, and 32% did not consume it because it was too expensive. In this particular case the rejection level seems to be rather low and the lack of knowledge about the nutritional value of rabbit meat or the high retail prices were the main reasons for not consuming it. It is important to mention that when interviewed, the retailers declared that all the rabbit meat offered was sold and they often did not have enough to satisfy consumer demand. This comment is an indication that the demand exceeded the supply of rabbit meat in that area.

Technological constraints such as reproduction seasonality, which results in inconstant supply; lack of high quality adapted genetic material, specialized equipment and commercial feed are problems common to several countries [Becerril-Perez, 2006; Cortazar&Martinez, 2006; Ferreira&Machado, 2007]. Moreover, sanitary problems with the Rabbit Hemorrhagic Disease (RHD) and Mixomatosis have caused important losses in the rabbit production sector. Cuba faced several outbreaks of RHD from 1993 to 2004, which lead to the massive slaughtering of rabbits [Cuttis&Ponce de León, 2006]. Recent outbreaks of Mixomatosis were reported in Rio de Janeiro [Bruno et al., 2008] and São Paulo [unpublished data] states in Southeast Brazil, but the corresponding vaccine cannot be found in the country market [Ferreira & Machado, 2007; Bruno, 2008].

Conclusions and strategies to develop the rabbit meat production chain

Undoubtedly, the development of small-scale rabbit projects can contribute to food security and poverty alleviation, especially when only plant resources are available [Finzi, 2000; Samkol&Lukefahr, 2008] or where social-political conflicts affect the rural population, such as in Colombia [Cortazar&Martinez, 2006]. But, as indicated by Lukefahr [2007], to develop successful programs, farmer selection and training and early on-farm supervision and latter multiplication effect are essential. Training of extension specialists should probably be a preceding step, since the number of rabbit specialists can be reduced and sometimes restricted to the universities [Ferreira&Machado, 2007].

Collective action like cooperative organization and various forms of contract farming should be encouraged for rabbit commercial-scale producers to reduce transaction costs to access high quality inputs (especially feed), credit and technology [FAO, 2009]. Other benefits include the arrangements for selling live animals, accessing slaughtering and processing facilities and export markets.

A high dependence on export markets may not be the best way to expand commercial rabbit meat production in Latin American countries. More attention should be devoted to the internal growing markets. The interest in sustainable or organic production has increased in developed countries [McNitt, 2006], with products being offered for sale in local farmers' markets. This could be an alternative strategy to develop local markets in Latin American countries. There is an increasing concern among consumers in relation to food quality and safety due to recent threats of spreading animal-related human diseases and the presence of chemical contaminants in food products. Rabbit meat has a good reputation regarding healthiness and safety, but product quality certification could be a step forward to meet the new consumer's requirements.

In fact, we need to fully understand the consumers' profile in order to satisfy their tastes and preferences. Since rabbit meat, in most cases, cannot compete with chicken or pork regarding retail prices, marketing programs based on the promotion of the high nutritional quality of rabbit meat could be directed to doctors and nutritionists. A differentiation, showing the product "value" is essential, as well as the creation of value-added products such as special cuts and prepared meals. Rabbit meat consumption could also be promoted in connection to tourism and country cooking [Becerril-Perez, 2006]. And, why not think about a healthy Latin American fast foods franchise named "Señor Conejo" or even a McRabbit?

Acknowledgments

The author acknowledges the valuable contribution of Mario Tavares Moura, DVM, MSc, for his revision of and suggestions to a preliminary version of this manuscript.

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THE RABBIT PRODUCTION IN BRAZIL

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SUMMARY

Rabbit population in Brazil becomes shorter every year. There are many reasons to explain such a trend, most of them said to be cultural. Usually rabbits are thought as pet so, there is little tradition en consuming rabbit meat, and thereafter a restricted number of slaughterhouses cause incipient meat distribution and market alternatives. The Brazilian rabbit production is carried out through small/average farms. Few large commercial farms raise crossbred animal, mainly involving New Zealand White breed with Californian, French Spot and Chinchilla. Recently a flagrant demand from high cuisine and touristic industry claimed market organization and suggest production growth. Also, rabbits have been used as laboratory animals and even pets, which caused new breeds introduction and new production goals in some regions of the country.

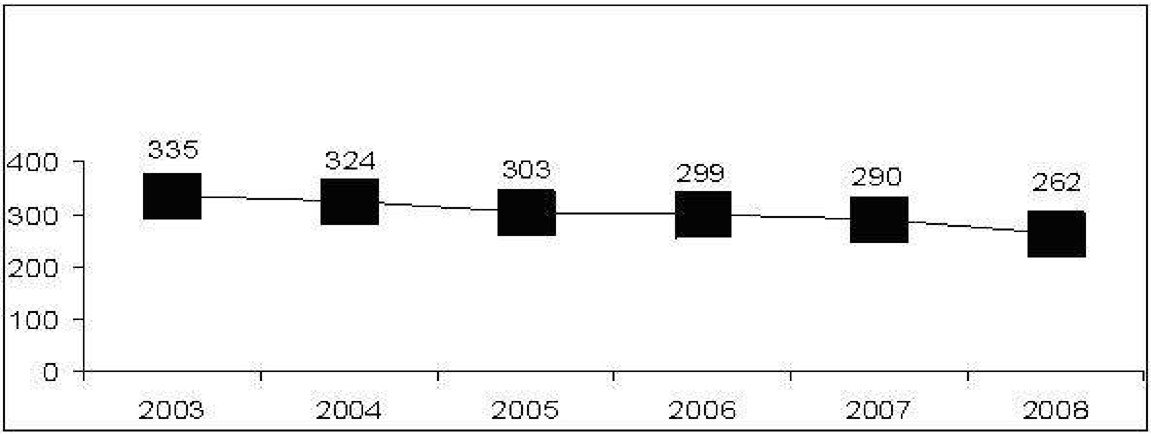
1. Introduction

Brazil presents an immense territory (8.500.000 km^2) and an expressive farming activity, being one of the greater producers and exporter of grains and products of animal origin. As far as animal production is involved, it has biggest commercial bovine population in the world, is one of the greater exporters of cattle, pig and chicken meat. However, the country still presents typical problems of the developing countries like the precarious production infrastructure and logistic, transport and storage problems which increase the cost of product distribution, and an incipient processing net to improve their byproducts. Another serious problem spread out in all over the country in related to social inequality, defining good part of the population to live in poverty conditions. Such population group has animal protein ingestion below of the expectations.

The rabbit production in Brazil is an activity that faces some problems like the little tradition of the producers to raise this animal and to consume its meat, and the fact of considering the animal as pet. Consequently governmental organizations are not support research eager to neither to improve commercialization. On the other hand, poultry products present low cost for the consumer, whereas rabbit meat is usually commercialized as an exotic alternative, casting a high price in the market, for a selected and restricted public. Rabbit meat production unpopularity can be realized when the number of bovines, 190 million of animals is compared to the number of rabbits, 262 thousand (data of 2008).

The lack of official slaughterhouses is another reason for the unexpressive rabbit meat commercialization. The producers feel discouraged to invest in the activity. The absence of an efficient productive chain causes small or average producers (around 150 females) to commercialize their products in informal markets, offering products which usually present low quality and sanitary risks. To overcome this risk Brazilian government is trying, throughout the years, to increase fiscalization and to control the illegal trade which, in its turn, provides more restriction for development of rabbit meat local farms.

This entire conjuncture comes leading to the fall of the number of rabbits in Brazil, as it can be seen in Graph 1. This reduction was considerable, presenting around 22% between the years 2003 and 2008.



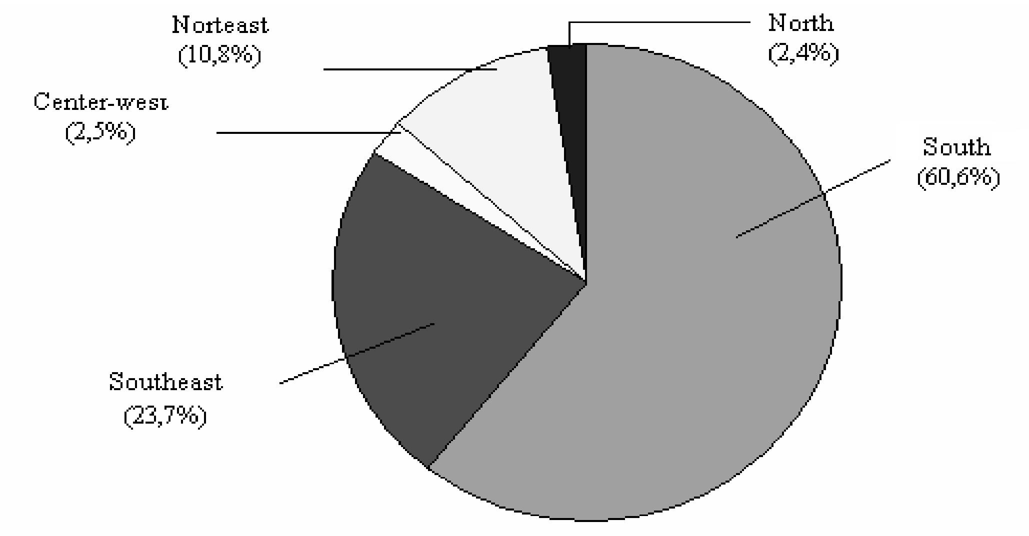
Graphic 01: Evolution of the population of rabbits in Brazil.
Source: Adapted of www.sidra.ibge.gov.br. Access in 23/03/2010

Attention should be called to the lack of tanneries industries which could be benefiting slaughtered rabbits the leathers or skins. This situation makes some producers to discard or to inadequately manufacture even realizing the excellent value that these products present.

2. Space division of the population of rabbits in Brazil

Brazil is a country of continental dimensions, presenting great social inequality between its regions, being this differences present also in the space distribution for rabbit population, as shown in graphic 2.

It can be observed that more than 80% of rabbits population is found in regions South and Southeastern, which are characterized by moderate climates (except in the coast), fertile ground and agriculture based in small properties, predominantly familiar. There an expressive European colonization can be found, showing a high human development index (HDI). Amongst the South states, the biggest producers of rabbits are Rio Grande do Sul and Paraná. The Southeastern region is more industrialized, presenting as the biggest HDI in Brazil. The animals of the Southeastern region are meant destined, in its majority to the meat production while in the South region, beyond the cited activity, the producers also produce animals to pet market.



Graphic 02: Distribution of Brazilian Rabbit Population.
Source: Adapted of IBGE (2006)

It can be said that all over Brazil particularly in South and Southeastern, there are many universities that which offer graduate courses in agrarian sciences, in special animal science, and within it, courses on production, which somehow keeps production knowledge in this area. The majority of the Brazilian researchers that have interest in rabbit production has published locally a substantial amount of information, essentially on rabbit nutrition and feeding, considering the reduction of the production cost. There also exist a few studies of sanitary defense and genetic improvement of these animals. In Brazil the occurrence of diseases that currently worry European or Asian researchers is not noticeable. Currently some rabbit producer associations and cooperatives try to organize expositions and sales of their products, seeking to decrease production costs, and turning it as a popular activity.

Data of the 2006 Brazilian Agricultural Census show a total of 17.615 establishments in the Country, presenting in average 16 rabbits for establishment. Although there are a few rabbit farms of great expression (above of 1.000 rabbit does) the more organized national producers keep 25 - 50 rabbit does in production. The majority of these producers is landowner (84.43%) and produced 89.11% of nation production. Amongst them 52,61% also work with other animals and 66% of them within 20 ha of land.

3. Characterization of the rabbit production in Brazil

The Brazilian rabbit production is characterized by being carried through in small or average farms. The commercials animals are, in its great majority, crossbred products where the breed New Zealand White predominates, with less participation of the breeds Californian, French Spot and Chinchilla. Currently the interest in Champagne D'Argent breed has grown, due to the characteristics of productive performance and high quality skins. There are at least thirty different breeds of rabbits in Brazil.

The rabbit production in Brazil presents good results that can be considered very good, comparable to the European production in average. The great majority of the farms work with steel galvanized cages installed in half-open laterally sheds and with control of curtains. The table 01 presents the average productive levels of the Brazilian rabbit production.

4. News perspectives

Despite all the effective problems it is perfectly possible to exceed the current barriers starting with marketing politics for the sector and quality product improvement in the market, with added information for cooking. Rabbit production should be recognized as an activity with low ambient impact and that can be associated to other productive activities using agro industry residues and other agricultural byproducts. In change it will provide high speed of weight gain and expressive reproductive indices. So rabbit production can be brought to an important platform in the national agricultural scenery.

Brazil has a great potential to supply the worldwide meat market. New alimentary security policies are been required within this context. This situation requires producers and industries to search for diagnostic tests that prove the sanitary status of the animals, for vaccines or the development and manufacture of these.

In Brazil, well as in other countries, the standard animal for the diagnostic tests or the tests of new lots of vaccines or new vaccines is the rabbit. So, with the search for vaccines and diagnostic test, rabbits can supply a clear demand for the market. The sales of adult animals to the laboratories represent a good trade opportunity the rabbit producers for the laboratories pay more for the animal at slaughter time.

Table 01 - Average productive levels of the Brazilian rabbit production and other physiological data of rabbits*

Productive level/physiological data	**Indicating value**
Insemination/crossing after birth	11 –12 days
Birth/ Female per year	6 – 7
Number of rabbits per birth	7 – 8
Weigth at the born	55 – 60 grams
Weigth at weans	500 – 600 grams
Age at weans	28 – 35 days
Weight at slaughter	2000 grams
Age at slaughter	65 – 75 days
Food conversion by weans at slaughter	2,3 – 2,8 : 1
Carcass efficiency (with head)	55%

**Data gotten for the authors from questions with rabbit producers with even 200 rabbit does*

Another market that comes growing is the commercialization of rabbits as company animal (pet). This is a trend that in a long time is verified in developed countries and that recently is observed in Brazil. The consumer of the market “pet” very well to producer that will be able to negotiate the animals after wean, reducing the production costs. In Brazil, the sales of small size breeds or dwarfs like the Rex and varieties, Dutch, Polish and the Lop Mini, Lop Fuzzy and Mini Lion Head is increasing. To give supported for this situation, the ration of rabbits is commercialized in supermarkets and easily found in all the types of agricultural stores.

Due the population growth, better education and income levels, Brazilian legislation is requiring high quality protein from animal meat in general. Market logistic distribution is also sought. On the other hand, climatic conditions, water and soil limitation and inadequate technologies come along to decrease animal productivity, especially, for large animals.

Thereafter it is important to count on alternatives which use animals with high reproduction levels, high productivity using smaller areas and lower environmental impact. The rabbit can present all those characteristics and may fit pretty well present world demand high quality protein.

5. Conclusions

Rabbit production has been experiencing dramatic changes in Brazil, although decreasing rabbit population, trough the possibility of producing high quality protein in smaller areas, at the price of low environment contamination levels. Laboratory and pet animals are other situations where producers will certainly get profit in the years to come.

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APPARENT DIGESTIBILITY OF THE SIMPLIFIED AND SEMI-SIMPLIFIED DIETS ON THE BASIS OF FORRAGE CROPS AND NUTRITIONAL VALUE OF FIBROUS SOURCES FOR RABBITS[1]

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Abstract

The simplified and semi-simplified diets are a new technology that associates the proportionate economy due the high inclusion of a forage crops with a satisfactory performance, providing better intestinal health to the rabbits. The objective of this work was to evaluate the digestibility of the nutritional principles of simplified and semi-simplified diets, on the basis of the mixture of forage crops, for rabbits in fattening. The tested foods had been: alfalfa hay (ALH), cassava upper third foliage hay (CUTFH) and cassava leaves flour (CLF). The treatments had consisted of REF: reference diet ; SFA: simplified diet on the basis of mixture of CLF and ALH; SSM: semi-simplified diet on the basis of CUTFH; SSA: semi-simplified diet on the basis of ALH; SSF: semi-simplified diet on the basis of CLF; SSFA: semi-simplified diet on the basis of the mixture of CLF and ALH; SSMA: semi-simplified diet on the basis of the mixture of CUTFH and ALH, being used a completely randomized design with 7 treatments and eight repetitions. It was observed that the digestibility of the nutritional principles of the diets was influenced by the type of studied food ($p<0,05$) where the REF diet presented betters results. It was also observed that great part of the crude protein of the CLF is complexed in reason of the high temperature used in its processing. The nutritional value found for fibrous sources had been 1822,7 kcalDE/kgDM and 12.26% of digestible protein (DP) in the DM for the CUTFH, 2232,5 kcalDE/kgDM and 15.54% DP in the DM for ALH and 1888,9 kcalDE/kgDM and 7.36% DP in the DM for the CLF.

Introduction

It is very important, in the current models of animal nutrition, to count with options of foods that do not concur with the feeding human or that can be used like industrial sub-products. The simplified and semi-simplified diets are a new technology that associates economy, proportionate for the high inclusion of a forage crop, with the satisfactory performance, providing better intestinal health for the animals (Machado et al., 2007; Fernandez-Carmona et al., 1998).

This assay objectified to evaluate the digestibility of the simplified and semi-simplified diets and the nutritional value of the fibrous sources for rabbits in fattening.

Material and methods

This work was lead in the laboratory of animal metabolism, located in the department of Animal Science of the UFMG, Brasil. The average temperature, during the four days of collection was of 23,6°C.

The evaluated foods had been the alfalfa hay (*Medicago sativa*), cassava upper third foliage hay (*Manihot sculenta*, Crantz), variety GRAVETINHO, harvested at the 12 months of age and the cassava leves flour (CLF), variety JACARE, harvested at the four months of age. The basal diet was formulated to take care of the requirements proposals for De Blas and Mateos (1998). Oil was added to increase the energy density of the ration, beyond of the positive contribution in the digestibility of the others nutrients (Fernandez-Carmona et al., 1998). It was also added, to the semi-simplified diets, at least 5% of a starch source and amounts of a protein source of recognized nutritional quality, for improvement of all the digestive process. It was pursued, to the maximum, the approach of the energy requirement proposal for De Blas and Mateos (1998) and when it was not possible to adjust the digestible energy (DE), if searched for to adjust to the minimum of 2200kcalDE/kgDM.

The treatments had consisted of REF: reference diet; SFA: simplified diet on the basis of the flour mixture of cassava leaves flour (CLF) and alfalfa hay (ALH); SSM: semi-simplified diet on the basis of cassava upper third foliage hay (CUTFH); SSA: semi-simplified diet on the basis of ALH; SSF: semi-simplified diet on the basis of CLF; SSFA: semi-simplified diet on the basis of the mixture of CLF and ALH; SSMA: semi-simplified diet on the basis of the mixture of CUTFH and ALH. The experimental diets can be visualized in Table 01. The used methodology was based on (Perez et al., 1995). For elaboration of the diets had been used data gotten of the analysis of the fibrous sources, and data extracted of literature.

	Experimental diets						
Ingredients (%)	REF (T1)	SFA (T2)	SSM (T3)	SSA (T4)	SSF (T5)	SSFA (T6)	SSMA (T7)
Alfalfa hay	37,735	47,000	-	83,759	-	41,039	40,095
Cassava leaves flour	-	41,826	-	-	78,410	40,000	-
Cassava upper third foliage hay	-	-	70,329	-	-	-	37,282
Maize	7,548	-	8,000	5,000	5,000	5,000	5,000
Soybean meal	4,184	-	10,000	0,043	6,874	5,525	6,020
Wheat bran	25,000	-	-	-	-	-	-
Soybean oil	-	5,327	5,961	5,363	4,282	4,811	6,000
Disintegrated maize with straw and slough	20,000	-	-	-	-	-	-
Vitamin/mineral mixture	0,500	0,500	0,500	0,500	0,500	0,500	0,500
Monoammonium phosphate	0,979	0,571	0,578	0,647	0,434	0,534	0,603
Salt	0,500	0,500	0,500	0,500	0,500	0,500	0,500
Molasses in dust	2,000	3,000	3,000	3,000	3,000	3,000	3,000
Bentonita	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Limestone	0,544	-	-	0,187	-	0,091	-
Methionine	0,011	-	-	-	-	-	-
Lysine	-	0,276	0,133	-	-	-	-
Analysed composition (MN)							
Nutrient (%)							
Dry matter	91,31	91,12	91,12	91,18	90,17	90,26	90,89
Crude protein	15,15	17,13	17,42	16,41	17,76	19,55	17,47
NDF	36,35	32,95	46,53	42,16	31,26	33,71	41,30
ADF	16,46	23,76	27,71	25,52	23,74	23,83	26,67

Lignified protein (%)[2]	4,58	15,12	16,14	9,30	15,76	17,03	15,38
ADL	2,71	8,17	8,79	7,05	8,86	8,16	8,78
Cálcium	0,91	1,40	1,42	1,34	1,09	1,32	1,35
Phosphorus	0,69	0,47	0,47	0,43	0,38	0,45	0,48
Crude energy (kcal/kg)	3945	4391	4356	4214	4524	4294	4327
Digestible energy[1] (kcal/kg)	2519	2394	2156	2204	2453	2326	2196

[1]DE (kcal/kgDM) = CE (kcal/kg DM) x (84,77 - 1,16 X %ADF DM) /100 (De Blas and Mateos, 1998)
[2] If is calling of lignified protein to that fraction of the crude protein contained in the ADF residue.

The coefficients of apparent digestibility (ACD) of the dry matter (DM), organic matter (OM), crude protein (CP) and crude energy (CE) had been calculated. The methodology for determination of the digestible energy (DE) and digestible protein (DP) of the fibrous sources followed the direct method, after the determination of the ACD of diets SSM, SSA and SSF. The animals had been distributed in a completely randomized design, with seven treatments and eight repetitions, being the experimental unit consisting of a cage with one rabbit. The values of ACD of the different nutritional principles had been submitted to the variance analysis, using the resources of computational program SISVAR and the averages had been compared by the Scott-Knott Test, at the level of 5% of probability.

Results and discussion

The digestibility of the nutritional principles was influenced by the type of studied diet ($p<0,05$). The ACD of the experimental diets and the consumption of ration are presented in Table 02.

Table 02
Coefficients of apparent digestibility and daily average consumption of the experimental diets

Diet	Coefficients of digestibility CP (%)	CE (%)	DM (%)	OM (%)	Average consumption (g)
REF	78,34 a	66,38 a	65,57 a	67,25 a	99,93a
SFA	58,01 e	50,86 d	53,91 d	54,13 d	91,38a
SSM	68,10 c	53,45 c	54,23 d	54,28 d	94,73a
SSA	72,23 b	56,67 b	56,94 c	56,69 c	99,78a
SSF	45,48 f	48,84 d	53,07 d	52,75 d	78,15b
SSFA	62,79 d	54,03 c	57,29 c	56,98 c	98,50a
SSMA	72,89 b	56,89 b	57,52 c	56,82 c	94,38a

Averages followed of different letters differ between itself for the Scott-Knott test to the level of 5,0% of probability

The reference diet presented the biggest coefficients of digestibility ($p<0,05$) for all the nutritional principles evaluated, in function mainly of the lesser content of ADF, presenting lesser rate of passing, what favors the digestion and absorption. It can be observed that all the diets that contained CLF had presented low digestibility of the CP. In the dehydration process, the material was submitted to the temperatures superior at the 100°C, occurring complexation of amino acids with carbohydrates (reaction of Maillard).

Evaluating the digestibility of the CE, is observed that SFA and SSF diets had presented the worse results, following of diets SSM, SSFA, SFAE and SSME. Considering the DM consumption, it can be observed that SSF, SFAE and SSFE diets had presented inferior results ($p<0,05$), suggesting that diets with high concentration of CLF are also little savouries.

Making the linear regression with the values of the ACD of the CE of the experimental diets and the content of ADF of the same diets, the following equation could be created: $y = -0{,}9367x + 80{,}013$ ($R^2 = 0{,}44$); where: y = coefficient of digestibility of the CE, x = value of ADF (%DM). It is verified that this equation presented low R^2 due mainly to some antinutritional factors inside of the CLF that depreciates the digestibility of the energy and is not quantified by the ADF analysis. Thus, from the elimination of the diets that contain the CLF, if had been able to consider the following equation: $y = -0{,}962x + 83{,}805$ ($R^2 = 0{,}97$), where: y = coefficient of digestibility of the CE, x = value of ADF (%DM). In the same way, inverse relation can also be considered enters the digestibility of the CP and the lignified protein, which is contained in the ADF residue. From the data of lignified protein and digestibility of the CP verified for the experimental diets, the linear equation was gotten: $y = -1{,}4808x + 85{,}145$ ($R^2 = 0{,}38$) ; where: y = coefficient of digestibility of the CP, x = lignified protein (% of the CP). In the same way considered for the prediction of the digestibility of the CE, disrespecting the diets with high inclusion of CLF, if considered the new equation: $y = -0{,}6555x + 80{,}33$ ($R^2 = 0{,}7223$), where: y = coefficient of digestibility of the CP, x = lignified protein (% of the CP). New experiments must be carried through for evaluation of these equations.

The nutritional values found for the fibrous sources had been of 1823 kcalDE/kgDM and 12.3% of DP for the CUTFH, 2233 kcalDE/kgDM and 15.54% of DP for ALH and 1889 kcalDE/kgDM and 7.36% of DP for the CLF.

Conclusions

The semi-simplified diets provide, in general, intermediate coefficients of digestibility between the traditional diets and the simplified diets. Diets with high inclusion of cassava leaves flour, above of 40%, present inferior values of digestibility for its nutritional principles, when compared with the traditional diets.

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EFFECT OF THE LIQUID VINASSE ON GROWING RABBIT PERFORMANCE

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ABSTRACT

This experiment was carried out to evaluate the effects of liquid vinasse inclusion in diets for growing rabbits on the productive performance. The experimental design was in casualized blocks with five treatments and four blocks. Each replicate consisted of two male and two female. The treatments consisted of inclusion levels of liquid vinasse in the commercial ration for rabbits, based on the weight. The studied levels were 0.0, 2.5, 5.0, 7.5, and 10.0%. Each rabbit received 70, 90, 110, 130, 140, and 150g of the ration in a day, at the 1st, 2nd, 3rd, 4th, 5th, and 6th week, respectively. From this amount, it was deducted the liquid vinasse amount. The liquid vinasse was weighed and distributed on the ration, being mixed to the ration for total incorporation to the pellets. Animals and rations were weighed at 35 and 70 days of age in order to obtain the body weight (BW), daily weight gain (DWG), daily ration consumption (DRC), and feed: gain ratio (FGR). Economic viability was also calculated. There was no effect ($P>0.05$) due the vinasse inclusion on BW and DWG, however, the DRC reduced ($P<0.01$) and the feed: gain ratio was improved ($P<0.04$) due the vinasse inclusion at levels of 5, 7.5 and 10%, but the best gross margin was obtained with the sale of live animals that was fed with diets containing 7.5% of liquid vinasse. It was concluded that liquid vinasse can be added to growing rabbit diets up to the level of 7.5%.

Key words: ethanol by-product, productive performance, rabbit nutrition

INTRODUCTION

Vinasse is the major effluent of the ethanol production from sugar cane and has, approximately, 93% of water and 7% of solid compounds, dark color, sweetish smell, acid pH, and high salt levels. This effluent also has high potassium, calcium, magnesium, sulphur and nitrogen concentrations. The low pH can favor the presence of saprophyte intestinal flora and to prevent diarrheas (Hidalgo, 2009).

The vinasse has being used in the liquid form in the animal feeding as an addictive in different species due its probiotic properties, at the rate of 1 to 3% in non-ruminants (Hidalgo, 2009). However, vinasse has a high potassium level that be considered toxic for rabbits (Morisse et al., 1983).

The interest in the vinasse is due its nutritive value and its beneficial properties. However, Maertens et al. (1994), used vinasse in diets for rabbits from 35 to 69 days of age, and noticed that the 0, 4 and 8% of inclusion did not affect the productive performance and carcass characteristics of the animals.

This experiment was carried out to evaluate the effects of liquid vinasse inclusion in diets for growing rabbits on the productive performance and economic viability of liquid vinasse use.

MATERIAL AND METHODS

This experiment was carried out on the Cunicultura Sector of Rio Verde University. Eighty New Zealand White rabbits, male and females, mean initial weight of 572.67±13.67g, weaned at 35 days of age were used.

The experimental design was in casualized blocks with five treatments and four blocks. Each replicate consisted of two male and two female. The treatments consisted of inclusion levels of liquid vinasse in the commercial ration for rabbits, based on the weight. The studied levels were 0.0, 2.5, 5.0, 7.5, and 10.0%.

Each rabbit received 70, 90, 110, 130, and 140g of the ration in a day, at the 1^{st}, 2^{nd}, 3^{rd}, 4^{th}, and 5^{th} week, respectively. From this amount, it was deducted the liquid vinasse amount. The liquid vinasse was weighed and distributed on the ration, being mixed to the ration for total incorporation to the pellets.

Animals and rations were weighed at 35 and at 70 days of age in order to obtain the body weight, daily weight gain, daily ration consumption, and feed: gain ratio. When the animals reached 70 days of age, they were weighted and, after a 12 hours fasting, they were slaughtered. After the slaughter, the carcass with no offal, was weighed too.

Economic viability was calculated based on the price of live animal sale (US$2.51/kg) and the ration price (US$0.31/kg). The gross margin was obtained by the difference between the gross profit (live animal weigh (kg) x US$2.51) and the ration cost (amount of ingested ration in the experimental period of 35 days (kg) x US$0.31). In ration price is already included the vinasse price (US$ 0.01/L).

Statistical analysis of the results was performed using the SAEG software - Statistical and Genetics Analysis System, and means were compared by Duncan test at 5% of probability.

RESULTS AND DISCUSSION

There was no effect (P>0.05) of vinasse inclusion on body weight and daily weight gain (Table 1), however, the daily ration consumption was reduced and the feed: gain ratio was improved when 5, 7.5 and 10% of liquid vinasse was included in the diet. Since the vinasse has a low digestible energy (6 MJ/kg) according to Maertens et al. (1994), the reduction in ration consumption and in feed: gain ratio is probably due the probiotics properties of the vinasse. Vinasse has also organic acids that increase the nutrients use, the digestion, vitamins synthesis and minerals absorption, improving the feed metabolism in the animal (Hidalgo, 2009).

Different results were obtained by Maertens et al. (1994) that did not notice effects of 4 or 8% of vinasse in the diet on the weight gain and ration consumption, but the feed: gain ratio was increased at 8% of inclusion.

Table 1 – Productive performance of growing rabbits fed diets containing liquid vinasse levels

Parameters	Liquid vinasse levels (%) 0.0	2.5	5.0	7.5	10.0	CV(%)
Body weight (g)	1866	1870	1810	1840	1779	4.37
Daily weight gain (g/d)	37.09	37.10	35.23	36.17	34.45	6.41
Daily ration consumption (g/d)	123.31a	123.11a	103,14b	105,47b	100.32b	8.65
Feed: gain ratio	3.32a	3.32a	2,93b	2,93b	2,92b	7.18

CV = coefficient of variation.

The best gross margin (Table 2) obtained with the live animal sale was obtained with rabbits fed diets containing 7.5% of liquid vinasse. Since the feed cost is almost 65% of the production cost, the use of agricultural byproducts can reduce this production cost and increase the profit.

Table 2 – Economic viability of liquid vinasse use in diets for growing rabbits

	Live animal sale			
Liquid vinasse inclusion levels (%)	Animal weight (kg)	Live animal price ($US)	Ingested ration cost ($US)	Gross margin ($US)
0.0	1.866	4.68	1.33	3.35
2.5	1.870	4.69	1.33	3.36
5.0	1.810	4.54	1.12	3.42
7.5	1.840	4.61	1.14	3.47
10.0	1.779	4.46	1.08	3.38

CONCLUSIONS

It was concluded that liquid vinasse can be added to growing rabbit diets up to the level of 7.5%.

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EFFECT OF LIQUID VINHACE ON CARCASS AND VISCERA OF RABBITS

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ABSTRACT

This experiment was carried out to evaluate the effects of liquid vinasse inclusion in diets for growing rabbits on the relative weight of carcass and viscera. The experimental design was in casualized blocks with five treatments and four replicates. Each replicate consisted of two male and two female. The treatments consisted of inclusion levels of liquid vinasse in the commercial ration for rabbits, based on the weight. The studied levels were 0.0, 2.5, 5.0, 7.5, and 10.0%. Each rabbit received 70, 90, 110, 130, 140, and 150g of the ration in a day, at the 1st, 2nd, 3rd, 4th, 5th, and 6th week, respectively. From this amount, it was deducted the liquid vinasse amount. The liquid vinasse was weighed and distributed on the ration, being mixed to the ration for total incorporation to the pellets. When the animals reached 77 days of age, they were weighted and, after a 12 hours fasting, they were slaughtered. After the slaughter, the carcass, edible viscera, and spleen were also weighed, and the relative weight were calculated. There was no effect ($P>0.05$) due the vinasse inclusion on the absolute and relative weight of carcass, liver, kidneys, heart, and spleen from growing rabbits. It was concluded that liquid vinasse can be added to growing rabbit diet up to the 10% level.

Key words: ethanol by-product, growing rabbits, rabbit nutrition

INTRODUCTION

Vinasse word is derived from Latin *vinacaeus,* known as fermented wine. It is used in several tropical countries and in Europe as a feeding supplement for ruminants and non-ruminants animals (Hidalgo, 2009).

According to Leite (1999), vinasse composition, in g/L, is 2.70 of organic matter, 0,68 of nitrogen, 0.15 of phosphorus, 4.92 of potassium, 2.08 of calcium, and 0.49 of magnesium. Following Albers (2009), vinasse, *in nature,* present the characteristics: 4.4 to 4.6 pH, 470 to 710 mg/L of nitrogen, 9 to 200 mg/L of phosphorus, 3340 to 4600 mg/L of potassium, 1330 to 4570 mg/L of calcium , and 580 to 700 mg/L of magnesium.

The nutritive value of vinasse can vary depending on the production process of the ethanol, on the raw material used, on the climate conditions, and on the soil and technologies used, which does not allow give rigid values for each parameter. The low fiber values consist, almost totally, of glucans and mannans in the cell wall of the yeast used in the process (Hidalgo, 2009).

This experiment was carried out to evaluate the effects of liquid vinasse inclusion in diets for growing rabbits on the relative weight of carcass and viscera.

MATERIAL AND METHODS

This experiment was carried out on the Cunicultura Sector of Rio Verde University. Eighty New Zealand White rabbits, male and females, mean initial weight of 572.67±13.67g, weaned at 35 days of age were used.

The experimental design was in casualized blocks with five treatments and four replicates. Each replicate consisted of two male and two female. The treatments consisted of inclusion levels of liquid vinasse in the commercial ration for rabbits, based on the weight. The studied levels were 0.0, 2.5, 5.0, 7.5, and 10.0%.

Each rabbit received 70, 90, 110, 130, 140, and 150g of the ration in a day, at the 1^{st}, 2^{nd}, 3^{rd}, 4^{th}, 5^{th}, and 6^{th} week, respectively. From this amount, it was deducted the liquid vinasse amount. The liquid vinasse was weighed and distributed on the ration, being mixed to the ration for total incorporation to the pellets.

When the animals reached 77 days of age, they were weighted and, after a 12 hours fasting, they were slaughtered. After the slaughter, the carcass, edible viscera, and spleen were also weighed, and the relative weight were calculated considering the slaughter weight.

Statistical analysis of the results was performed using the SAEG software - Statiscal and Genetics Analysis System.

RESULTS AND DISCUSSION

There was no effect ($P>0.05$) of liquid vinasse inclusion on absolute and relative weight of carcass, edible viscera, and spleen of growing rabbits.

Table 1 – Absolute and relative weight of carcass, edible viscera, and spleen of growing rabbits fed diets containing liquid vinasse levels

	Liquid vinasse levels (%)					
	0.0	2.5	5.0	7.5	10.0	CV(%)
			Absolute weight (g)			
Slaughter weight	2107	2007	2014	2074	1907	6.76
Carcass	1087	1064	1087	1134	954	7.90
Liver	54.37	42.53	47.85	49.25	43.47	8.21
Kidneys	13.86	13.28	12.62	14.21	11.90	6.59
Heart	4.46	4.35	4.83	4.72	4.35	7.56
Spleen	0.86	0.84	0.78	0.84	0.87	4.82
			Relative weight (%)			
Carcass	51.55	52.96	53.96	54.66	49.54	3.94
Liver	2.60	2.12	2.38	2.38	2.27	6.26
Kidneys	0.66	0.67	0.63	0.68	0.62	4.12
Heart	0.21	0.22	0.24	0.23	0.23	6.80
Spleen	0.040	0.042	0.039	0.041	0.046	4.71

CV = coefficient of variation.

This probably happened due the beneficial properties of vinasse. Its low pH can favor the presence of a good intestinal flora. Its organic acid also helps to increase the nutrient use, keeping the balance of the intestinal flora, avoiding the presence of intestinal pathogens (Hidalgo, 2009). All of these help the metabolism and the use of nutrients for organ and muscle growth. Similar results was found by Maertens et al. (1994) who use 4 and 8% of vinasse inclusion and did not observe differences in carcass characteristics.

CONCLUSIONS

It was concluded that liquid vinasse can be added to growing rabbit diet up to the 10% level.

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SEMI-SIMPLIFIED DIET FORMULATED WITH CASSAVA BY-PRODUCTS ON RABBIT SEMEN PRODUCTION

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ABSTRACT: This study was conducted with 20 breeder New Zealand White rabbits, with seven months of initial age, in order to evaluate semen quality. The animals were housed individually and allotted in a randomized experimental design, consisting of two treatments (one reference diet and one semi-simplified diet based on cassava by-products) and ten replications. It were taken ten collections of semen per animal, once per month, evaluating the following parameters: gel-free semen volume and gel volume, semen color, pH, sperm progressive motility, sperm vigor, sperm concentration, number of spermatozoa per ejaculate, normal and abnormal spermatozoa, and primary and secondary abnormalities. No effect of diets was observed on gel-free semen volume and on primary and secondary abnormalities. However, gel volume, semen color, pH, sperm progressive motility, sperm vigor, sperm concentration, number of spermatozoa per ejaculate, and total abnormalities were higher in the animals that received the semi-simplified diet. The results demonstrate that it is possible to use a semi-simplified diet with cassava by-products in the feeding of breeders, since cassava variety and reduced levels of hydrocyanic acid are observed.

Keywords: *cassava meal, hay from the upper third of cassava foliage, reproduction*

Introduction

Feeding accounts for approximately 70% of production costs. The inclusion of ingredients such as corn and soybean meal, despite their nutritional qualities, increases these costs (Borges et al. 2006). Thus, the use of cassava by-product meal and cassava foliage hay may be a viable alternative in animal production, by replacing at least partially the more expensive items and possibly reducing production costs (Michelan et al. 2006).

Mello & Silva (2003) commented that spermatozoa production, in rabbits, starts when the animals reach 70 to 80 days of age. According to the authors, production varies between 50 and 350 million spermatozoa (SPTZ) per mL of semen, reaching maximum production between seven and eight months of age.

The objective of this work was to evaluate the efficiency of a semi-simplified diet based on cassava byproducts on the semen quality of New Zealand white breeder rabbits.

Material and Methods

The experiment was performed at the Experimental Farm of the State University of Maringá (UEM), state of Paraná, between March and December 2007. Twenty New Zealand White breeder rabbits were used, with average initial age of seven months, housed individually in galvanized wire cages featuring provided with an automatic water dispenser and semi-automatic feeder, set inside the storage shed covered with shingle roof.

The animals were allotted in a randomized experimental design, consisting of two treatments – a reference diet with corn, wheat bran, soybean meal, alfalfa hay, coast-cross hay, and supplemented with minerals and vitamins; and a semi-simplified diet based on cassava by-products, containing 40% cassava meal (CM) and 40% hay from the upper third of cassava foliage (HUTCF), plus minerals, vitamins and soybean meal, both diets were formulated to meet nutritional requirements for breeders (De Blas & Wiseman 1998) and ten replications.

The cassava cultivar used was “Fécula Branca”, considered low toxic level, and with roots appropriate for human consumption, due to the low levels of hydrocyanic acid (Vidigal Filho et al. 2007).

Semen collections were performed using an artificial vagina, once a month, totaling 10 collections per animal. The vagina consisted of a non-lubricated condom and a graduated collecting cup, using an estrous female rabbit as a mannequin.

Immediately after each collection, a visual evaluation was made of gel-free semen volume, gel volume, and color. Semen color was classified in scores ranging from 1 to 4, as follows: (1) milky white; (2) watery white; (3) yellowish; and (4) brown - “1” indicates the best semen color and “4” the worst. pH was determined with pH paper, where a drop of semen was placed on the strip and the pH was red on a scale of 0 to 14. Then, the semen was placed in a water bath at 37^oC, and sperm progressive motility and sperm vigor were analyzed placing in a microscope slide a drop (0.03 mL) of semen with five drops (0.03 mL) of sodium citrate dehydrate at 2.94%. One drop of this dilution was placed in another slide which was examined with a phase contrast microscope, at 400X magnification by a subjective method for both variables. Sperm progressive motility was determined as a score of 0 to 100%, and the sperm vigor with score 0 to 5 points, where the higher score corresponded to spermatozoa with greater sperm progressive motility and sperm vigor, respectively.

Sperm concentration was determined from a 0.02 mL semen sample, diluted at 1:100 in Hancock solution (1957), using a Neubauer chamber. The count and determination the number of SPTZ per mm^3 of semen were performed according to Sorensen (1979). In order to obtain SPTZ quantity per ejaculate, the semen volume of each collection was multiplied by the SPTZ concentration per mL. The percentage of sperm abnormalities was obtained by observing 100 SPTZ in a phase contrast microscope, from which the percentage of total, primary and secondary abnormalities was obtained.

The general linear models of the SAS (2000) were used for the statistical analysis of the results, with the means of the studied traits compared by Analysis of Variance f-test ($P<0.05$).

Results and Discussion

The estimated means, standard errors and coefficients of variation (CV) of the characteristics of semen from breeder rabbits fed the reference and semi-simplified diets are shown on Table 1.

Table 1 - Estimated means, standard errors and coefficients of variation (CV) of the characteristics of semen from breeder rabbits fed the reference and semi-simplified diets

Parameters	Diets		CV (%)	(p<0.05)
	Reference	Semi-simplified		
Gel-free semen volume (mL)	1.42 ± 0.09	1.31 ± 0.07	56.3	0.3064
Gel volume (mL)	1.67 ± 0.17b	2.37 ± 0.24a	64.9	0.0002
Semen color (points)[a]	1.71 ± 0.10b	1.41 ± 0.08a	55.8	0.0108
pH	8.41 ± 0.06b	8.03 ± 0.07a	7.7	0.0001
Sperm progressive motility (%)	34.02 ± 3.16b	51.22 ± 2.76a	72.4	0.0001
Sperm vigor (points)[b]	2.45 ± 0.16b	3.5 ± 0.14a	52.3	0.0001
Sperm (SPTZ) concentration[c]	226 ± $0.18x10^8$b	339 ± 0.25 $x10^8$a	74.5	0.0001
Number of SPTZ per ejaculate (millions)	283 ± 0.24 $x10^8$b	438 ± $0.38x10^8$a	83.6	0.0002
Normal (%)	39.12 ± 1.49	42.47 ± 1.62	37.2	0.0838
Abnormal (%)	60.88 ± 1.49a	56.92 ± 1.71b	26.7	0.05
Primary abnormalities (%)	22.75 ± 1.15	20.98 ± 1.06	49.2	0.2101
Secondary abnormalities (%)	38.12 ± 1.37	36.54 ± 1.17	33.1	0.3120

ab Means, in each row, for each variable, followed by different letters, are different (p<0.05); [a]1 point indicates milky white color; 2 points, watery white; 3 points, yellowish; 4 points, brown. [b]0 points indicates absence of vigor; 5 points, maximum vigor. [c]Million of SPTZ /mL.

Gel volume was greater in animals fed the semi-simplified diet. Mataveli (2008) observed that gel is an individual trait, related to good semen production in rabbits, which is in accordance with the results of this work, as the animals that received the semi-simplified diet showed greater gel production, and consequently higher progressive sperm motility and vigor than animals fed the reference diet (Table 1). One of the factors that improved semen quality for animals that received the semi-simplified diet may have been the increase in vitamin C in the semi-simplified diet. According to Ortega-Flores et al. (2003), the leaves and aerial part of the cassava plant show high levels of this vitamin and as Aitken et al. (1989) acts as an antioxidant.

Semen color was better in the animals fed the semi-simplified diet, which was close to milky white. As semen color became more watery (1.71 points, reference diet), SPTZ concentration was lower (226 million SPTZ) than for those fed the semi-simplified diet (Table 1).

There was a difference with regard to semen pH, being lower (P<0.05) in those fed the semi-simplified diet, coming close to neutral pH, which is the most desirable for best SPTZ survival.

The number of SPTZ per ejaculate is related to semen volume and sperm concentration/mL. However, there were no differences (P>0.05) in the semen volume of rabbits, and sperm concentration was higher (P<0.05) in animals fed the semi-simplified diet; consequently, the number of SPTZ in ejaculate (438 million) was also higher (Table 1).

The use of the semi-simplified diet did not influence (P>0.05) the percentage of normal SPTZ, primary and secondary abnormalities; however, the percentage of abnormal SPTZ was higher (P<0.05) in the animals that received the reference diet. However, it should be emphasized that total abnormalities were above the acceptable rate of 20% (CBRA, 1998), which may be related to the genetics of the animals, feeding or climate conditions.

HUTCF used in diet showed 103.2mg hydrocyanic acid/kg after drying, a level that was reduced in the diets following dilution with other ingredients and even with the heating during the pelleting process, as Otsubo (2004) comments that hydrocyanic acid is volatile in temperatures above 27ºC.

Conclusion

The results indicated that it is possible to use a semi-simplified diet based on cassava by-products for breeder feeding, without adverse effects on semen characteristics.

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VEGETAL SEMIPURIFIED GLYCERIN ON THE FEEDING OF GROWING RABBITS

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Abstract

The present work aimed to determine glycerin digestible energy through a digestibility assay and evaluate different inclusion levels of vegetal semipurified glycerin from soybean oil on rabbit diets as a replacement for corn in a performance assay. In the digestibility assay, 60 New Zealand White rabbits were utilized, 45 days of age, assigned in a completely randomized design into five treatments with one reference diet and four test diets, where glycerin was included at 4, 8, 12 and 16% replacing the reference diet volume, with 12 replications. The digestible energy and digestible dry matter values of the glycerin were, respectively, 3,974 kcal/kg of dry matter and 93.96%. In the performance assay, 100 New Zealand White rabbits were utilized, 32 days old, distributed in a completely randomized design into five treatments with diets containing increasing levels of glycerin (0, 3, 6, 9 and 12%) in replacement of corn, 10 replications and two animals per experimental unit. The data were submitted to polynomial regression while the differences from the data obtained with the reference diet were compared by Dunnett's test ($P<0.05$). A quadratic effect was verified for the variables LW 70 at days, DWG from 32 to 70 days, FC from 32 to 50 days, FC from 32 to 70 days of age, and CW, with the worst results provided by diets with, respectively, 7.08, 7.09, 7.46, 6.85 and 7.26% of glycerin inclusion. Only CW of the animals fed with the diets containing 6 and 9% of glycerin were lower than those obtained with the reference diet. It is concluded that the maximum level studied of vegetal semipurified glycerin (12%) can be included in partial substitution of the digestible energy from corn, without impairing performance and carcass of growing rabbits.
Keywords: digestible energy, glycerin levels, corn replacement.

Introduction

The variations related to enzymatic activity during the postnatal life of rabbits, especially until 40 to 50 days of age, are related to nutritional standards, both qualitatively and quantitatively, and with the maturation of digestive processes (GIDENNE, 1997). Starch is digested almost in its totality in the small intestine, and pancreatic amylase is the major enzyme involved in this process. Therewith, fecal excretion of starch is usually lower than 2% of the ingested total, although in some cases the excretion can represent 10 to 12% of the ingested total, depending on starch source and rabbit age (BLAS & GIDENNE, 1998). Therefore, up to 50 days of age of the rabbit, it is necessary to reduce the level of this ingredient in order to avoid digestive disorders. According to the Agência Nacional do Petróleo (2009), Brazilian biodiesel production in 2008 was 1.2 billion liters, of which approximately 10% consisted of glycerin (DASARI et al., 2005). Glycerin, a by-product of the biodiesel industry, also known as glycerol, it is an organic compound with alcohol function that shows a great energetic value. The present work aimed to determine the glycerin digestible energy through a digestibility assay and evaluate different inclusion levels of vegetal semipurified glycerin, from soybean oil, as a replacement for corn in the diet of growing rabbits.

Material and Methods

The trial was accomplished in the rabbit sector located at the Iguatemi Experimental Farm of the State University of Maringá, Paraná State, Brazil, from April to June 2009. For the digestibility assay, 60 New Zealand White rabbits were utilized, males and females, 45 days old, allocated in individual metabolism cages. The design was completely randomized with five treatments (one reference diet plus four test diets), and 12 replications. The reference diet was formulated based on corn, wheat bran, soybean meal, alfalfa hay (*Medicago sativa*), stargrass hay (*Cynodon nhenfluensis*), soybean oil and supplemented with vitamins and minerals. For test diets, vegetal semipurified glycerin was included at levels of 4, 8, 12 and 16%, replacing the natural matter of the reference diet. All diets were dry pelleted. The assay was conducted according to the European Reference Method for *in vivo* digestibility trials (PEREZ et al., 1995).

The apparent digestibility coefficients of glycerin dry matter and gross energy were calculated using the regression method (VILLAMIDE, 1996). In the performance trial, 100 New Zealand White rabbits were used, 32 days old, distributed into five treatments (0, 3, 6, 9 and 12%) of glycerin inclusion replacing part of the corn digestible energy and ten replications, with two animals per experimental unit. The diets (Table 1) were isonutritive with levels of crude protein, methionine+cystine, lysine, calcium, phosphorus, neutral detergent fiber, acid detergent fiber and digestible energy, respectively, of 16%, 0.60%, 0.76%, 0.80%, 0.50%, 41%, 21% and 2,650 kcal/kg of dry matter. The levels of starch, however, decreased with the inclusion of glycerin, with values of 26, 24, 21, 19 and 17%, respectively, for the five diets.

Table 1 – Percentage and chemical composition of the experimental diets

Ingredientes	Reference Diet	Inclusion Levels of Vegetal Semipurified Glycerin			
		3	6	9	12
Stargrass	22.60	22.65	22.70	22.75	22.80
Alfalfa hay	15.00	15.50	16.00	16.50	17.00
Corn	22.10	19.08	16.05	13.01	10.00
Wheat bran	23.00	22.00	21.00	20.00	19.00
Soybean meal	13.00	13.75	14.50	15.25	16.00
Limestone	0.80	0.75	0.70	0.65	0.60
Dicalcium phosphate	0.40	0.46	0.52	0.58	0.64
Salt	0.40	0.37	0.35	0.33	0.30
Premix[1]	0.50	0.50	0.50	0.50	0.50
Methionine	0.09	0.09	0.09	0.10	0.10
Lysine	0.05	0.04	0.03	0.02	0.00
Cycostat®[2]	0.06	0.06	0.06	0.06	0.06
Soybean oil	2.00	1.75	1.50	1.25	1.00
Inert	0.00	3.00	6.00	9.00	12.00

Total	100.00	100.00	100.00	100.00	100.00

[1]Nuvital, composition per kg of product: vit. A – 600,000 UI; vit. D – 100,000 UI; vit. E – 8,000 mg; vit. K3 - 200 mg; vit. B1 - 400 mg; vit. B2 - 600 mg; vit. B6 - 200 mg; vit. B12 – 2,000 mcg; pantothenic acid – 2,000 mg; choline – 70,000 mg; Fe – 8,000 mg; Cu – 1,200 mg; Co - 200 mg; Mn – 8,600 mg; Zn – 12,000 mg; I - 64 mg; Se - 16 mg; Methionine – 120,000 mg; antioxidant – 20,000 mg; [2]Robenidine-based active principle (6.6%).

The animals were housed in galvanized wire cages, with automatic water dispenser and semi automatic feeders, with free access to feed and water. The rabbits were weighed at 32, 50 and 70 days of age, along with the feeds and leftovers, in order to calculate feed intake, weight gain and feed conversion. At slaughter, weight and carcass yield were evaluated. Hot carcass with head and without edible viscera was considered in order to determine carcass weight.

Performance data and animal carcass characteristics were submitted to polynomial regression analysis, while the differences with the data obtained with the reference diet were compared by Dunnett's test ($P<0.05$).

Results and Discussion

The digestibility coefficients of vegetal semipurified glycerin gross energy and dry matter were, respectively, 97.20% and 98.27%. Applying these percentages to the chemical composition, the values of digestible energy and dry matter of the glycerin for rabbits were, respectively, 3,974 kcal/kg and 93.96%.

Quadratic effects ($P<0.05$) were observed for variables LW at 70 days, DWG from 32 to 70 days, FC from 32 to 70 days, and CW, with the worst results provided by diets with, respectively, 5.73, 5.73, 3.12 and 6.76% of glycerin inclusion. However, when applying Dunnett's test, only CW of the animals fed with the diets containing 6 and 9% of glycerin inclusion was lower ($P<0.05$) than the reference diet. SIMON et al. (1996), evaluating 5, 10, 15, 20 and 25% of pure glycerin in the diet, concluded that the inclusion of 10% of this product can be utilized without affecting animal performance. The same was found by BERENCHTEIN (2008), who observed that semipurified glycerin can be used as energetic ingredient in diets of nursery and finishing pigs up to the level of 9%, without significantly affecting performance, carcass characteristics and meat quality of the animals.

Table 2 – Estimated means and coefficient of variation (CV) of live weight (LW) from 50 to 70 days (d), daily weight gain (DWG), daily feed intake (DFI), feed conversion (FC), carcass weight (CW) and carcass yield (CY) of rabbits fed, from 32 to 70 days of age, with diets containing different levels of vegetal crude glycerin inclusion replacing corn, as basis of digestible energy.

Characteristics	Reference Diet	Inclusion Levels of Vegetal Semipurified Glycerin				Mean	CV
		3	6	9	12		
LW 50d (g)	1,497	1,496	1,469	1,452	1,515	1,486	6.84
LW 70d (g)[1]	2,079	2,080	2,051	2,014	2,126	2,070	6.18
DWG 32-50d (g)	39.42	39.38	37.89	36.93	40.40	38.81	14.55
DWG 32-70d (g)[1]	34.00	34.03	33.25	32.28	35.24	33.76	9.98
DFI 32-50d (g)	112.14	107.00	108.63	108.41	107.90	108.82	7.76
DFI 32-70d (g)	123.13	118.85	118.67	116.96	117.90	119.10	5.50

FC 32-50d	2.84	2.72	2.87	2.94	2.67	2.80	17.22
FC 32-70d[1]	3.62	3.49	3.57	3.62	3.34	3.53	9.91
CW (g)[1]	1,200	1,157	1,099*	1,097*	1,176	1,146	4.49
CY (%)	55.94	55.62	54.57	55.21	56.34	55.64	3.22

[1] Quadratic effect; LW 70d: $y= 2{,}095.31-19.5528(X)+1.7068(X)^2$, $R^2=0.49$; DWG 32-70d: $y= 34.4214-0.5145(X)+0.0449(X)^2$, $R^2=0.49$; FC 32-70d: $y=3.5995+0.0156(X)-0.0025(X)^2$, $R^2=0.47$; CW: $y= 1{,}210.23-32.1651(X)+2.3776(X)^2$, $R^2=0.89$.
Means followed by "*", in the row, differ from those obtained with the reference diet by Dunnett's test ($P<0.05$).

Conclusions

Vegetal semipurified glycerin provided 3,974 kcal/kg of digestible energy for rabbits, demonstrating is it a great source of energy value. The data suggest the inclusion of 5,73 % vegetal semipurified glycerin on the diet in partial replacement of digestible energy from corn, without reducing performance and carcass of growing rabbits.

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VEGETAL SEMIPURIFIED GLYCERIN ON THE FEEDING OF GROWING RABBITS

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Abstract

The present work aimed to determine glycerin digestible energy through a digestibility assay and evaluate different inclusion levels of vegetal semipurified glycerin from soybean oil on rabbit diets as a replacement for corn in a performance assay. In the digestibility assay, 60 New Zealand White rabbits were utilized, 45 days of age, assigned in a completely randomized design into five treatments with one reference diet and four test diets, where glycerin was included at 4, 8, 12 and 16% replacing the reference diet volume, with 12 replications. The digestible energy and digestible dry matter values of the glycerin were, respectively, 3,974 kcal/kg of dry matter and 93.96%. In the performance assay, 100 New Zealand White rabbits were utilized, 32 days old, distributed in a completely randomized design into five treatments with diets containing increasing levels of glycerin (0, 3, 6, 9 and 12%) in replacement of corn, 10 replications and two animals per experimental unit. The data were submitted to polynomial regression while the differences from the data obtained with the reference diet were compared by Dunnett's test ($P<0.05$). A quadratic effect was verified for the variables LW 70 at days, DWG from 32 to 70 days, FC from 32 to 50 days, FC from 32 to 70 days of age, and CW, with the worst results provided by diets with, respectively, 7.08, 7.09, 7.46, 6.85 and 7.26% of glycerin inclusion. Only CW of the animals fed with the diets containing 6 and 9% of glycerin were lower than those obtained with the reference diet. It is concluded that the maximum level studied of vegetal semipurified glycerin (12%) can be included in partial substitution of the digestible energy from corn, without impairing performance and carcass of growing rabbits.
Keywords: digestible energy, glycerin levels, corn replacement.

Introduction

The variations related to enzymatic activity during the postnatal life of rabbits, especially until 40 to 50 days of age, are related to nutritional standards, both qualitatively and quantitatively, and with the maturation of digestive processes (GIDENNE, 1997). Starch is digested almost in its totality in the small intestine, and pancreatic amylase is the major enzyme involved in this process. Therewith, fecal excretion of starch is usually lower than 2% of the ingested total, although in some cases the excretion can represent 10 to 12% of the ingested total, depending on starch source and rabbit age (BLAS & GIDENNE, 1998). Therefore, up to 50 days of age of the rabbit, it is necessary to reduce the level of this ingredient in order to avoid digestive disorders. According to the Agência Nacional do Petróleo (2009), Brazilian biodiesel production in 2008 was 1.2 billion liters, of which approximately 10% consisted of glycerin (DASARI et al., 2005). Glycerin, a by-product of the biodiesel industry, also known as glycerol, it is an organic compound with alcohol function that shows a great energetic value. The present work aimed to determine the glycerin digestible energy through a digestibility assay and evaluate different inclusion levels of vegetal semipurified glycerin, from soybean oil, as a replacement for corn in the diet of growing rabbits.

Material and Methods

The trial was accomplished in the rabbit sector located at the Iguatemi Experimental Farm of the State University of Maringá, Paraná State, Brazil, from April to June 2009. For the digestibility assay, 60 New Zealand White rabbits were utilized, males and females, 45 days old, allocated in individual metabolism cages. The design was completely randomized with five treatments (one reference diet plus four test diets), and 12 replications. The reference diet was formulated based on corn, wheat bran, soybean meal, alfalfa hay (*Medicago sativa*), stargrass hay (*Cynodon nhenfluensis*), soybean oil and supplemented with vitamins and minerals. For test diets, vegetal semipurified glycerin was included at levels of 4, 8, 12 and 16%, replacing the natural matter of the reference diet. All diets were dry pelleted. The assay was conducted according to the European Reference Method for *in vivo* digestibility trials (PEREZ et al., 1995).

The apparent digestibility coefficients of glycerin dry matter and gross energy were calculated using the regression method (VILLAMIDE, 1996). In the performance trial, 100 New Zealand White rabbits were used, 32 days old, distributed into five treatments (0, 3, 6, 9 and 12%) of glycerin inclusion replacing part of the corn digestible energy and ten replications, with two animals per experimental unit. The diets (Table 1) were isonutritive with levels of crude protein, methionine+cystine, lysine, calcium, phosphorus, neutral detergent fiber, acid detergent fiber and digestible energy, respectively, of 16%, 0.60%, 0.76%, 0.80%, 0.50%, 41%, 21% and 2,650 kcal/kg of dry matter. The levels of starch, however, decreased with the inclusion of glycerin, with values of 26, 24, 21, 19 and 17%, respectively, for the five diets.

Table 1 – Percentage and chemical composition of the experimental diets

Ingredientes	Reference Diet	Inclusion Levels of Vegetal Semipurified Glycerin			
		3	6	9	12
Stargrass	22.60	22.65	22.70	22.75	22.80
Alfalfa hay	15.00	15.50	16.00	16.50	17.00
Corn	22.10	19.08	16.05	13.01	10.00
Wheat bran	23.00	22.00	21.00	20.00	19.00
Soybean meal	13.00	13.75	14.50	15.25	16.00
Limestone	0.80	0.75	0.70	0.65	0.60
Dicalcium phosphate	0.40	0.46	0.52	0.58	0.64
Salt	0.40	0.37	0.35	0.33	0.30
Premix[1]	0.50	0.50	0.50	0.50	0.50
Methionine	0.09	0.09	0.09	0.10	0.10
Lysine	0.05	0.04	0.03	0.02	0.00
Cycostat®[2]	0.06	0.06	0.06	0.06	0.06
Soybean oil	2.00	1.75	1.50	1.25	1.00
Inert	0.00	3.00	6.00	9.00	12.00

Total	100.00	100.00	100.00	100.00	100.00

[1]Nuvital, composition per kg of product: vit. A – 600,000 UI; vit. D – 100,000 UI; vit. E – 8,000 mg; vit. K3 - 200 mg; vit. B1 - 400 mg; vit. B2 - 600 mg; vit. B6 - 200 mg; vit. B12 – 2,000 mcg; pantothenic acid – 2,000 mg; choline – 70,000 mg; Fe – 8,000 mg; Cu – 1,200 mg; Co - 200 mg; Mn – 8,600 mg; Zn – 12,000 mg; I - 64 mg; Se - 16 mg; Methionine – 120,000 mg; antioxidant – 20,000 mg; [2]Robenidine-based active principle (6.6%).

The animals were housed in galvanized wire cages, with automatic water dispenser and semi automatic feeders, with free access to feed and water. The rabbits were weighed at 32, 50 and 70 days of age, along with the feeds and leftovers, in order to calculate feed intake, weight gain and feed conversion. At slaughter, weight and carcass yield were evaluated. Hot carcass with head and without edible viscera was considered in order to determine carcass weight.

Performance data and animal carcass characteristics were submitted to polynomial regression analysis, while the differences with the data obtained with the reference diet were compared by Dunnett's test (P<0.05).

Results and Discussion

The digestibility coefficients of vegetal semipurified glycerin gross energy and dry matter were, respectively, 97.20% and 98.27%. Applying these percentages to the chemical composition, the values of digestible energy and dry matter of the glycerin for rabbits were, respectively, 3,974 kcal/kg and 93.96%.

Quadratic effects (P<0.05) were observed for variables LW at 70 days, DWG from 32 to 70 days, FC from 32 to 70 days, and CW, with the worst results provided by diets with, respectively, 5.73, 5.73, 3.12 and 6.76% of glycerin inclusion. However, when applying Dunnett's test, only CW of the animals fed with the diets containing 6 and 9% of glycerin inclusion was lower (P<0.05) than the reference diet. SIMON et al. (1996), evaluating 5, 10, 15, 20 and 25% of pure glycerin in the diet, concluded that the inclusion of 10% of this product can be utilized without affecting animal performance. The same was found by BERENCHTEIN (2008), who observed that semipurified glycerin can be used as energetic ingredient in diets of nursery and finishing pigs up to the level of 9%, without significantly affecting performance, carcass characteristics and meat quality of the animals.

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LW 70d (g)[1]	2,079	2,080	2,051	2,014	2,126	2,070	6.18
DWG 32-50d (g)	39.42	39.38	37.89	36.93	40.40	38.81	14.55
DWG 32-70d (g)[1]	34.00	34.03	33.25	32.28	35.24	33.76	9.98
DFI 32-50d (g)	112.14	107.00	108.63	108.41	107.90	108.82	7.76
DFI 32-70d (g)	123.13	118.85	118.67	116.96	117.90	119.10	5.50

FC 32-50d	2.84	2.72	2.87	2.94	2.67	2.80	17.22
FC 32-70d[1]	3.62	3.49	3.57	3.62	3.34	3.53	9.91
CW (g)[1]	1,200	1,157	1,099*	1,097*	1,176	1,146	4.49
CY (%)	55.94	55.62	54.57	55.21	56.34	55.64	3.22

[1] Quadratic effect; LW 70d: $y= 2,095.31-19.5528(X)+1.7068(X)^2$, $R^2=0.49$; DWG 32-70d: $y= 34.4214-0.5145(X)+0.0449(X)^2$, $R^2=0.49$; FC 32-70d: $y=3.5995+0.0156(X)-0.0025(X)^2$, $R^2=0.47$; CW: $y= 1,210.23-32.1651(X)+2.3776(X)^2$, $R^2=0.89$.
Means followed by "*", in the row, differ from those obtained with the reference diet by Dunnett's test ($P<0.05$).

Conclusions

Vegetal semipurified glycerin provided 3,974 kcal/kg of digestible energy for rabbits, demonstrating is it a great source of energy value. The data suggest the inclusion of 5,73 % vegetal semipurified glycerin on the diet in partial replacement of digestible energy from corn, without reducing performance and carcass of growing rabbits.

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INFLUENCE THE TEMPERATURE-HUMIDITY INDEX SEMEN TRAITS OF RABBITS IN THE TROPICS

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Abstract

The aim of this work was to verify the THI (temperature-humidity index) in tropical environment and its effect on the vigor, motility and sperm concentration, also fructose, total cholesterol and total proteins in rabbit seminal plasma. Twenty male New Zealand White rabbits aged eight months were used in the study. The animals were reared in intensive system, housed individually in galvanized wire cages, arranged in flat-deck system and fed with commercial *ad libitum*. Samples were collected in the morning. The temperature and humidity were measured at the beginning and end of collection day. Semen samples were collected by means of an artificial vagina, the semen was extended 100-fold with physiological saline solution. Examination was carried out under the high power magnification (X 400). The residual semen was centrifuged at 2.500 g/ 20 min/ 5 ^{o}C and the supernatant, was removed and seminal plasma was kept in a refrigerator (-18^{o}C) until analyses for biochemical characteristics. Sperm and biochemical parameters were calculated by analysis of variance. We also calculated the Pearson correlations to verify the relationships among the variables. THI values increased in the same sequence of order from collection and, only in last collection was found moderate heat stress. The vigor, motility and sperm concentration were higher when the THI was between 25.5 and 27.4. The biochemical constituents ranged widely. The motility correlated with vigor only. The sperm concentration correlated moderate with THI, vigor, motility and fructose. We can conclude that seminal and biochemical traits of rabbits in this study were affected by THI even when they were not heat stress

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Key words: sperm concentration, vigor motility, environment, rabbit.

Introduction

The most obvious limitation to rabbit production in a hot climate area, is their susceptibility to heat stress that produces a series of drastic changes in the biological functions which in turn ends with impairment of production and reproduction (Marai et al., 1999). Among the climatic components that may impose influence on the animal are ambient temperature, humidity, air movement, radiation and photoperiod, of which the temperature is the most important. Optimal climatic conditions for rabbits would be: air temperature 13 to 20 °C, relative humidity 55 to 65% and wind velocity 5 to 18 km/h (Marai and Rashwan, 2004). Various studies had used the temperature-humidity index (THI) proposed by Marai et al. (2001) for verify the effects environmental temperature and relative humidity on reproductive traits in rabbit male and female (Marai et al., 2001; Marai et al., 2002).

The aim of this work was to verify the THI in tropical environment and its effect on the vigor, motility and sperm concentration, also fructose, total cholesterol and total proteins in rabbit seminal plasma.

Material and methods

The research was carried out on September 2009, in the Animal Science Department of the Federal University of Ceara (Fortaleza, Ceara, Brazil), at 3° 45' 02" S, 38° 32' 35" W and 15.5 m above sea level. The climate, according to the Koppen classification (1948), is AW, hot and humid. The average, maximum and minimum temperatures, respectively, are 26.5°C, 30°C and 19°C, and the relative humidity is 82%. Twenty male New Zealand White rabbits aged eight months were used in the study. The animals were reared in intensive system, housed individually in galvanized wire cages, arranged in flat-deck system and fed with commercial *ad libitum*. Samples were collected in the morning. The temperature and humidity were measured at the beginning and end of collection day. They were measured with digital thermo-hygrometer German-built model 7429.02.0.00, imported by Intercom.The Temperature-Humidity Index (THI) was calculated according to Marai et al. (2001), adapted for rabbit: THI = db°C – [(0,31 – 0,31 RH) (db°C – 14,4)], were db°C is dry bulb temperature in Celsius degree and RH = relative humidity as percentage. The THI values obtained were then classified as follows: < 27.8 = absence of heat stress, 27.8 to < 28.9 = moderate heat stress, 28.9 to < 30.0 = severe heat stress and 30.0 and over = very severe heat stress. Semen samples were collected by means of an artificial vagina using a female teaser rabbit. Semen ejaculate volume was measured in mL. The drop of semen was covered by a cover slip and immediately examined under the high power magnification (X 400) how much vigor and motility. Sperm concentration (X 10^6 sptz/ mL) was estimated using a hemocytometer. The semen was extended 100-fold with physiological saline solution. Examination was carried out under the high power magnification (X 400). The residual semen was centrifuged at 2.500 g/ 20 min/ 5 ^{o}C and the supernatant, was removed and seminal plasma was kept in a refrigerator (-18^{o}C) until analyses for biochemical characteristics. Fructose and total protein were estimated by the colorimetric method using commercial (In Vitro Diagnostic S/A®). Total cholesterol was estimated by the colorimetric method using chemical commercial kit (Labtest S/A®). Data were evaluated using the Statistical Analysis System, SAS v.8 (2000). Sperm and biochemical parameters were calculated by analysis of variance using the general linear model. When significant effects were detected (F test), averages were adjusted and compared using the Student t test (P<0.05). We also calculated the Pearson correlations to verify the relationships among the different traits when the variances of the pairs of observations were independent.

Results and discussion

The THI values increased in the same sequence of order from collection and, only in last collection was found moderate heat stress (table 1).

The other estimated THI values indicated absence of heat stress until fourth collection, because they were below 27.8 (Marai et al., 2001). Nevertheless, the different THI values affected seminal and biochemical parameters of the rabbits (table 1), which showed that despite THI indicate that the animals were not under heat stress, the comfort zone was not appropriate.

The comfort zone temperature for rabbits is around 21 °C. At either higher or lower temperatures, the animal has to spend energy to maintain its body temperature (Marai et al., 2002a). In this study, initial and final temperatures were 27.92 ± 0.81 and 29.10 ± 1.34 °C, respectively, in other words, they were above the comfort zone for the species. But, other studies suggested that disorders caused by high environment temperature stood out when relative humidity was high (Marai and Rashwan, 2004). In this work, the relative humidity was 67.80 ± 5.18%. Other studies showed that cold to moderate the affected also ejaculate parameters (García-Tomás et al., 2008).

Table 1: Mean ± and standard of vigor, motility, sperm concentration, total cholesterol, fructose and total proteins of rabbit semen under different values THI.

THI	Seminal traits			Biochemical traits		
	Vigor (0-5)	Motility (%)	Sperm concentration ($x10^6$ sptz/mL)	Total Cholesterol (mg/ dL)	Fructose (mg/ dL)	Total Proteins (g/ dL)
25.5	2.70 ± 0.81 ^{ab}	71.25 ± 19.32 ^{a}	1.17 ± 0.78 ^{a}	44.86 ± 7.53 ^{ab}	162.56 ± 75.63 ^{a}	1.01 ± 0.12 ^{b}
26.4	3.29 ± 0.65 ^{a}	78.68 ± 18.84 ^{a}	1.02 ± 0.59 ^{ab}	42.29 ± 9.71 ^{b}	118.52 ± 58.48 ^{b}	1.00 ± 0.18 ^{b}
27.3	1.95 ± 0.97 ^{c}	56.00 ± 25.21 ^{b}	0.68 ± 0.50 ^{bc}	46.03 ± 8.13 ^{ab}	132.56 ± 66.22 ^{ab}	1.04 ± 0.22 ^{ab}
27.4	2.76 ± 1.07 ^{ab}	69.47 ± 21.72 ^{ab}	1.03 ± 0.72 ^{ab}	49.55 ± 9.36 ^{a}	133.63 ± 75.63 ^{ab}	1.16 ± 0.17 ^{a}
27.8	2.45 ± 1.01 ^{bc}	65.00 ± 22.36 ^{ab}	0.55 ± 0.36 ^{c}	43.98 ± 11.45 ^{ab}	139.11 ± 56.12 ^{ab}	0.96 ± 0.21 ^{b}

Values followed by different letters among lines differ statistically (P< 0.05).

The vigor, motility and sperm concentration were better when the THI was between 25.5 and 27.4. Already the biochemical constituents ranged widely.

Sperm concentration, total cholesterol, fructose and total proteins concentrations in seminal plasma of rabbits were lower than the results found by Marai et al. (2002b), Salcedo-Baca et al. (2004) and, Holtz and Foote (1978). Some search found that cholesterol content of rabbit semen was 811 mg/10^9. Seminal plasma and droplets accounted for 73.7% of the total cholesterol (Castellini et al., 2006). The low total cholesterol concentration found in this experiment can be attributed to methodology used for determination the total cholesterol that did not allow the measurement of the cholesterol present in seminal drops.

Table 2: Association among seminal and biochemical traits of rabbits.

	Vigor	Motility	Sperm Concentration	Fructose	Total Cholesterol	Total Proteins
THI	-0.18134	-0.17482	-0.28553*	0.10806	0.10302	0.03863
Vigor		0.69513*	0.36486*	0.00279	0.08882	0.06761
Motility			0.36637*	-0.04739	0.13101	0.17653
Sperm concentration				-0.37758*	0.10100	0.11516
Fructose					0.29212*	0.01838
Total cholesterol						0.46062*

*p<0.01

In this study, the motility correlated with vigor only (table 2). The sperm concentration correlated moderate with THI, vigor, motility and fructose. It suggests that the sperm concentration is also under influence of the humidity and temperature. Some studies also found negative correlation between fructose and sperm concentration (ERB et al., 1956; LU et al., 2007). This indicated spent of energy for spermatozoa ejaculate, in other words, the higher the sperm concentration, the lower the fructose concentration.

The total cholesterol correlated moderately with fructose and total proteins (table 2). Components responsible for blocking the acrossome reaction and which might thereby have an effect on the fertilizing ability of spermatozoa were isolate in the seminal plasma of rabbit. Among them are particles of the lipid composition and occurrence of ecto-enzymes (Castellini et al., 2008). Indeed, seminal particles are characterized by large amounts of cholesterol and sphingomyelin (Castellini et al., 2006). It is believed that this explains the correlation between the cholesterol and others seminal components.

Conclusions

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Rabbits seminal parameters according to the period of collection

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Abstract

The aim of this study was to verify the effects of collection month and presence or absence of gel on seminal parameters of rabbits and THI. It was used 21 bucks rabbits of breed New Zealand White. The animals were reared in intensive system, housed individually in galvanized wire cages, arranged in flat-deck system and fed commercial feed. The ejaculates were obtained with use of artificial vagina. After collecting and removing the gel fraction of the ejaculate (if present) the volume of semen was measured, then was accomplished to the evaluation of seminal parameters. Based on the study of analysis of variance, it was found the effect of month of collection on seminal parameters of rabbits. Regarding the presence or absence of gel, there were no significant differences in this study. Given the above, it is possible to conclude that the rabbit semen parameters vary between the months of the year, and that this variation can be attributed to changes in thermal sensation perceived by animals throughout the experiment.

Key-words: *vigor, motility, sperm concentration, THI, rabbits.*

Introduction

The semen production and quality of ejaculate are not constant during the year when collected from rabbits living under natural environmental conditions (Marai et al. 2002). These seminal parameters may vary due to individual characteristics and environmental effects, such as temperature, humidity and ventilation. Therefore, to obtain the maximum reproductive efficiency is necessary to control the micro-climate in the buldings. The two principal parameters that interfere in environmental conditions are temperature and humidity. According to Marai et al. (2002), the rabbits need to be on a range of appropriate temperature, where they spend a minimum amount of energy to maintain homeothermy (Marai et al. 2002), the ideal temperature would be 20°C for thermal comfort, but they can support temperatures varying from 5°C to 30°C. The ideal air humidity is 65-70% in average, with 50% minimum and maximum 80%. Souza et al. (1990), studying the physiological behavior of New Zealand White and Butterfly rabbits, reared in semi-arid of Paraiba-Brazil, concluded that the stress observed in the afternoon was triggered by increased environmental temperature and reduction of relative humidity. Using the temperature and humidity index (THI), adapted to rearing rabbits for Marai et al. (2002), it was observed that THI high values had immediate negative effects on sperm concentration, total amount of spermatozoa, sperm motility and ejaculate viability. The aim of this study was to verify the effects of month collection and presence or absence of gel on seminal parameters of rabbits, such as volume of ejaculate, vigor, motility and sperm concentration considering the THI in each month.

Materials and methods

The experiment was conducted from September to December 2009, in the Animal Science Department of the Federal University of Ceara (Fortaleza, Ceara, Brazil), at 3° 45' 02'' S, 38° 32' 35'' W and 15.5m above sea level. The weather, according to the Koppen classification (1948), is A W, hot and humidity. The average, maximum and minimum temperatures, respectively, are 26.5°C, 30°C and 19°C. The relative humidity is 82%. Twenty one New Zealand White bucks rabbits was used with an average age of eight months and weighing 2.80 kg. The animals were reared in intensive system, housed individually in galvanized wire cages, arranged in flat-deck system and fed with commercial feed *ad libitum*. The semen collections were realized in the morning, the temperature and humidity were measured at the beginning and the end of collection day. To obtain these variables was used a digital thermo-hygrometer German-built model 7429.02.0.00, imported by Intercom. The Temperature-Humidity Index (THI) was calculated using the formula proposed by Marai et al. (2001), adapted for rabbits: ITU= db°C– [(0,31 – 0,31 RH) (db°C – 14,4)], where db°C is temperature in Celsius and RH = relative humidity in percentage/100. The THI values found were classified as: < 27,8 absence of heat stress, 27,8 - 28,9 moderate heat stress and more than 30.0 very severe heat stress (Marai et al. 2002). The ejaculates were obtained by artificial vagina in tempered glass, with the aid of a female in oestrus as mannequin to induce mating. After collecting and removing the gel (if present), the semen was measured by volume, classified as the presence or absence of gel and evaluated for vigor, motility and sperm concentration. A drop of semen was covered by a cover slip and immediately examined under the high power magnification (x 440) to observe vigor and motility. The vigor evaluation was based on the progressive rectilinear quality movement and speed of sperm, on a scale from 1 to 5. The motility was evaluated by the percentage of motile spermatozoas. The sperm concentration was determined by counting cells in a Neubauer chamber, after dilution of 20 µl of semen in 2mL of formalin-saline solution (1:100), using optic microscopy at 400 x magnifications. The experimental lineation was completely randomized. The variance analysis was made by Proc GLM of SAS statistical software version 9.1 (2003) to evaluate the effects of month collection and the absence or presence of gel in the ejaculate of rabbits. The means and standard errors of sperm concentration, vigor and motility, in each month, were compared by t-Student test at 5% probability.

Results and discussions

The average values found for THI during September, October, November and December were 26, 84 ± 0, 05, 27, 30 ± 0, 03, 27, 53 ± 0, 04 e 27, 88 ± 0, 03, respectively.

Table 1. Means and standard errors of the ejaculates volume, vigor, motility and sperm concentration of New Zealand breeders rabbits under the effects of month of collection and the presence or absence of gel.

Month	Gel	THI	Volume of semen (mL)	Vigor (0 - 5)	Motility (1 - 100%)	Concentration (x 10^6sptz/mL)
September	A/G	26,87±0,06^{c}	0,46±0,03^{c}	2,89±0,14^{c}	71±0,02^{b}	0,82±0,10^{d}
	P/G	26,77±0,08^{c}	0,49±0,03^{c}	2,97±0,17^{bc}	74±0,03^{ab}	0,98±0,13^{cd}
October	A/G	27,22±0,05^{d}	0,50±0,02^{ab}	3,36±0,12^{b}	77±0,02^{a}	1,14±0,08^{bc}
	P/G	27,39±0,06^{c}	0,49±0,02^{c}	3,36±0,12^{b}	78±0,02^{a}	1,11±0,09^{bc}
November	A/G	27,54±0,05^{b}	0,46±0,02^{c}	3,12±0,11^{bc}	70±0,02^{b}	1,24±0,08^{abc}
	P/G	27,50±0,05^{bc}	3,08±0,13^{bc}	3,08±0,13^{bc}	71±0,02^{b}	1,48±0,10^{a}
December	A/G	27,85±0,04^{a}	0,45±0,02^{c}	3,74±0,10^{a}	79±0,01^{a}	1,28±0,07^{ab}
	P/G	27,91±0,06^{a}	0,45±0,03^{c}	3,97±0,13^{a}	79±0,02^{a}	1,28±0,07^{ab}

Different letters in columns mean different values (p≤0,05)

According to THI classification, proposed by (Marai et al. 2001), during the months September to November, the animals were in the range considered as absence of heat stress (THI< 27,8), although it was observed significant difference in the same range. The value of THI had a gradual increase during the experimental period, presenting significant difference in all months analyzed. The highest level occurred in December, when the THI reached values greater than 27, 80, which was classified as the presence of heat stress by high temperature. It was observe a reduction in the volume of ejaculate in December, when compared with the month of October, when the animals were still in the zone with absence of heat stress. (García-Tomás et al. 2008) found a reduction in the volume of ejaculated of rabbits with an increase in THI. There were no significant differences for other parameters analyzed for the stress index, since there was an increase in the levels of vigor, sperm concentration and motility. These results also reported by (Roca et al. 2005) and (García-Tomás et al. 2008) within the same range of values observed. Regarding the presence or absence of gel, there were not significant differences in this study. However, their presence must be detected in the ejaculate to be held the removed avoiding any interference in sperm motility because of agglutinant effect that in mating prevents the reflux of semen (Alvariño et al. 1993).

Conclusion

According to this study, it is possible to conclude that the rabbit semen parameters vary between the months of the collect, and that this variation can be attributed to changes in thermal sensation perceived by animals throughout the experiment.

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WEIGHT AND MORPHOMETRIC MEASUREMENTS OF ORGANS IN GROWING RABBITS SUBMITTED TO FEED RESTRICTION

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ABSTRACT

This experiment was carried out to evaluate the effects of feed restriction on the morphometric measurements and weight of organs in growing rabbits. Sixty New Zealand White rabbits, male and females, mean initial weight of 636.76 ± 13.28g, weaned at 33 days of age were used. The experimental design was in casualized blocks with four treatments and five replicates. Each replicate consisted of two male and one female. The treatments were: 1) *ad libitum* feeding, 2) feed restriction from 33 to 40 days of age (50 g/d/rabbit), 3) feed restriction from 54 to 61 days of age (90 g/d/rabbit), and 4) feed restriction from 33 to 40 days (50 g/d/rabbit) and from 54 to 61 days of age (90 g/d/rabbit). Water was provided *ad libitum* and the pelletized commercial ration (17% CP, 15% CF, 2% Ca, 0.75% P, and 2300 kcal/kg DE) was provided following the dietary regimen of each treatment. When the animals reached 81 days of age, after a 12 hours fasting, they were slaughtered. After the slaughter, stomach, liver, kidneys, heart, lungs, and spleen were removed, weighed, and measured related to the length and width. There was effect ($P<0.04$) of the feed restriction only on the heart weight, that was lower in restricted rabbits. There was no effect ($P>0.05$) of the treatments on the length and width of the internal organs. It was concluded that the feed restriction from 54 to 61 days of age or from 33 to 40 and from 54 to 61 days of age caused a reduction in heart weight, but do no influence the other organs weight or organs measures.

Key words: feeding program, internal organs, organ measure,

INTRODUCTION

Several feeding strategies have been used to produce animals with maximum lean corporal mass, better feed: gain ratio, and maximum body weight. Feed restriction can result in metabolic changes that lead to lower body weight, reduced immunity, and altered functions in the digestive system, mainly in liver and gut. These changes has a great effect on the enzymes activities in the intestine, on the mucosa cell mass, on the protein and ADN content, and on the mucosa integrity (Ortega et al., 1996).

Re-feeding, however, can rapidly restore the morphology and functions in the gut, repairing the intestinal atrophy and normalizing the mucosa permeability. However, the extension of the changes depends on the amount of ingested feed and, in particular, on the amount and quality of dietary nitrogen (Poullain et al., 1991).

This experiment was carried out to evaluate the effects of feed restriction on the morphometric measurements and weight of organs in growing rabbits.

MATERIAL AND METHODS

This experiment was carried out on the Cunicultura Sector of IFGoiano, Campus Rio Verde. Sixty New Zealand White rabbits, male and females, mean initial weight of 636.76 ± 13.28g, weaned at 33 days of age were used.

The experimental design was in casualized blocks with four treatments and five replicates. Each replicate consisted of two male and one female. The treatments were: 1) *ad libitum* feeding, 2) feed restriction from 33 to 40 days of age (50 g/d/rabbit), 3) feed restriction from 54 to 61 days of age (90 g/d/rabbit), and 4) feed restriction from 33 to 40 days (50 g/d/rabbit) and from 54 to 61 days of age (90 g/d/rabbit).

Water was provided *ad libitum* and the pelletized commercial ration (17% CP, 15% CF, 2% Ca, 0.75% P, and 2300 kcal/kg DE) was provided following the dietary regimen of each treatment.

When the animals reached 81 days of age, after a 12 hours fasting, they were slaughtered. After the slaughter, stomach, liver, kidneys, heart, lungs, and spleen were removed, weighed, and measured related to the length and width.

Statistical analysis of the results was performed using the SAEG software - Statiscal and Genetics Analysis System, and means were compared by Tukey test at 5% of probability.

RESULTS AND DISCUSSION

There was effect (P<0.04) of the feed restriction only on the heart weight (Table 1). The organ growth can be affected by several factors and nutrition is the major factor. The internal organ and edible viscera, like kidneys and liver, can be reduced by the feed restriction. However, this effect was not observed in this research. Visceral organs exhibit quick responses to feed restriction by reducing their size and their metabolic activity and, according to Winter et al (1976), the heart can be considered as a source of labile protein in times of feed restriction.

Table 1 – Organ weight in rabbits submitted to feed restriction in different ages

	Treatments[1]				
Weight (g)	AL	R33-40	R54-61	R33-40/54-61	CV (%)[2]
Stomach	17.49	19.66	18.73	18.84	5.95
Liver	47.48	50.03	50.52	52.96	6.65
Kidneys	11.74	13.35	12.67	13.00	8.08
Heart	5.06a	4.75ab	4.43b	4.32b	6.93
Lungs	10.89	10.21	8.92	11.19	4.73
Spleen	0.64	1.01	0.68	0.66	4.67

Means followed by different letters, are different by Tukey test.
[1]AL = *ad libitum,*; R33-40 = feed restriction from 33 to 40 days of age; R54-61 = feed restriction from 54 to 61 days of age, and R33-40/54-61 = feed restriction from 33 to 40 and from 54 to 61 days of age. [2]CV = coefficient of variation.

There was no effect (P>0.05) of the treatments on the length and width of the internal organs (Table 2). Ledin (1984) reported that internal organs were affected by feed restriction and by re-feeding. According to the same author, after seven days of re-feeding, all of the internal organs, except the kidneys, had the same size or were bigger than the organs in the control rabbits. It is possible that in the re-feeding period, is given a priority to the development of internal organs that grow quickly than other parts of the body (Tumová et al., 2006).

Table 2 – Organ measure in rabbits submitted to feed restriction in different ages

	Treatments[1]				
Measure (mm)	AL	R33-40	R54-61	R33-40/54-61	CV (%)[2]
Stomach length	69.00	65.50	64.87	69.50	4.80
Stomach width	34.50	38.50	39.50	37.62	3.56
Liver length	101.66	100.87	106.00	103.62	8.15
Liver width	84.16	90.75	90.00	93.00	5.90
Kidneys length	29.91	30.12	30.75	30.00	5.45
Kidneys width	19.33	21.12	20.62	21.87	3.76
Heart length	31.00	27.25	27.87	26.75	7.48
Heart width	19.66	18.50	19.50	18.25	7.43
Lungs length	44.33	41.50	37.33	47.00	6.65
Lungs width	52.00	46.16	51.33	54.83	7.26
Spleen length	37.00	44.33	39.66	47.00	5.18
Spleen width	5.60	7.00	6.00	5.30	7.42

Means followed by different letters, are different by Tukey test.
[1]AL = *ad libitum,*; R33-40 = feed restriction from 33 to 40 days of age; R54-61 = feed restriction from 54 to 61 days of age, and R33-40/54-61 = feed restriction from 33 to 40 and from 54 to 61 days of age. [2]CV = coefficient of variation.

CONCLUSIONS

It was concluded that the feed restriction from 54 to 61 days of age or from 33 to 40 and from 54 to 61 days of age caused a reduction in heart weight, but does not influence other organs weight or measurements.

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RABBIT PRODUCTION PERFORMANCE FROM BACKYARD FAMILY SYSTEMS IN MINAS GERAIS, BRAZIL*

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ABSTRACT

The aim of this paper is to report rabbit raising performance in subsistence farming systems run by rural families involved in "Use of rabbit pelts and leather in local craftsmanship". The goal was to produce a regular supply of rabbit meat, but also, to increase family income by selling the hides. One bulk and three females does were weighted and provided for every family. Farmers, after one year, had to provide back to the program the same amount of animals given to them initially. Alternative rabbit housing systems, using local materials were encouraged, but use of wire cages was allowed. Diets should be based, mostly, on forages, garden wastes, grain by-products, crops, cassava, sugar cane, fruits or roots, and other available foods. Farmers were totally responsible for the routine activities (feeding, mating, cleaning and other required activities). During weekly routine visits, students weighed all animals (including the breeding stock), weaned the offspring, identified the fryers, collected data (mating, offspring, death and other relevant records), trained the family and organized meetings. Scarce variety and quality of the feed provided was the major problem and most likely had a negative impact on mating results. Average of conception rate (CR) was 79% and the kindling interval (KI) was 71 days. Average number of live born kits/kindling (AKBK) was 5.82 and number weaned per litter (AWL) was 3.63. Average daily weight gain (ADG) from birth to weaning was 14.43g and the average market age was 136 days. These results are similar to those reported from other developing country projects and indicate that rabbit raising may improve family income and quality of life as well as boost collective awareness.
***Key words**: alternative agriculture, sustainable development*
*Project sponsored by CNPq (CT-Agro)

INTRODUCTION

The project "Use of rabbit pelts and leather in local craftsmanship" was developed in Barroso, Minas Gerais, seeking to establish extensive rabbit raising in rural and peri-urban areas, becoming a good quality protein source for the population as well as providing extra income by commercialization of surplus meat and of by-products, such as pelt and hide, for handicraft work. For the population of Barroso, mostly of peasant origin, family sustainability programs are considered a priority for regional social balance re-establishment and its proximity to the cities of regional tourist centers, may assure rabbit meat, hide and pelt commercialization, strengthening the success of the Project.

This article has the objective of describing the activities developed by the families associated to the project, through the evaluation of their rabbit-raising performance under family based operation systems.

MATERIAL AND METHODS

Ten families were selected by regional research (EPAMIG) and extension agents (EMATER-MG) to participate in the Project, receiving each, a rabbit-raising technical bulletin prepared by the project Coordination and a Group of four adult rabbits (three does and one buck) bought from the Federal University of Lavras stock. Each family had the compromise of returning to the Project, at the end of the first year, the equivalent, in live or carcass weight, to the Group firstly received. Additionally, each family should build individual housing and manage the animals adequately. Five families (Groups 3, 4, 5, 8 and 9) opted to build a collective building on the property that received Group 3, sharing the necessary chores for the 20 housed rabbits. Families that failed to stay with the Project were required to pass the donated animals to the newcomer family.

During project implantation, families received visits from the trainees and from the coordinator for technical orientation and problem solving on nutrition, sanitary and reproductive management, general care, besides administration and economical advice. Feeding supplies and general sanitary conditions were checked, as well as, animal weights. Matings were assisted by the families, avoiding male-females interaction for more than 20 minutes. A female individual record sheet was adopted and all events were recorded. Kits were weaned when reaching 500g on average. Between weaning and slaughter, animals were weighed individually, allowing daily gain calculation, besides mortality and age at slaughter (between 2.0 and 2.5kg). Data are descriptive only, due to the limited number of animals and management practices.

RESULTS AND DISCUSSION

The rabbit raising training course included home hide tanning, nutrition aspects related to reproduction (diagnosed as the main problem faced by the families at the time), and options to increase rabbit-raising product and by-product values, was highly rated by the families. At that time, selling prices for carcass, live animal, recently weanlings and hide were suggested. In addition, to stimulate habit and teach some rabbit meat-processing options, three carcasses were smoked and offered to the participants. Even with the offering of another course on hide tanning, families still had difficulty performing this activity without the trainees and coordinator supervision.

Commercialization was also responsibility of the families, but the trainees and coordinator traveled to a tourist city, in order to promoted rabbit meat to restaurant owners, the Project objectives and importance.

Six families gave up on the project being replaced by new ones. Their main argument was lack of positive reproductive results. Weakly animal weighing was useful to indicate nutritional problems that resulted in poor reproductive performance. In general, all animals showed an initial weight loss, probably due to the shift from a pelleted commercial ration to a less balanced diet offered by the families. However, females that performed well reproductively, gained weight 14 weeks after arrival. Animals under the care of dropped-out families lost weight continuously after the adaptation period and did not reproduce.

Production indexes reached by seven animal Groups are presented on table 1, except for Groups 2, 7 and 10, which initiated too late in relation to the others. Since five Groups (3, 4, 5, 8 and 9) were housed and managed under the same conditions, although belonging to distinct families, their data were analyzed collectively.

Table 1. Productive and reproductive performance of rabbit Groups belonging to families associated to the Project

Group	CR^0 (%)	KI^1 (days)	Total kits /kindling /female		Mortality B-W (%)	Age at weaning (days)	Daily weight gain (g)		Mortality W-S (%)	Age at slaughter (days)
			B	W			B-W	W-S		
1	85.71	95	6.06	3.39	44.06	41	14.75	14.27	NE^2	NE^2
3,4,5, 8,9	57.45	65	5.00	3.13	37.40	52	5.93	9.42	66.67	144
6	93.33	53	6.40	4.36	31.87	41	22.62	21.20	10.00	127
Average	**78.83**	**71**	**5.80**	**3.63**	**37.78**	**44.67**	**14.43**	**14.96**	**38.33**	**135.5**

^{0}Conception rate; ^{1}kindling Interval; ^{2}not evaluated; B = birth; W = weaning; S = slaughter.

Average CR (79%) observed in the extensive systems investigated in this report, was superior to that registered (70%) for a semi-intensive system (Mello & Silva, 1989). The highest CR (93%) was observed in Group 6 females which also started to regain weight within the 14 weeks after females were given to the families, but the nutritional management included the use of pelleted ration for lactating females, besides leftover vegetables, fruits and grass. This diet probably contributed to the shorter kindling interval or KI (53 days). CRs were also superior (86%) for Group 1 does as compared to that (70%) related in the literature for semi-intensive systems. These results may probably be a consequence of the use of a homemade mixture in branny form (wheat bran and corn bran) and leftover vegetables and fruits offered *ad libitum*. In this case, by the owner's decision, a longer period was allowed before rebreeding the doe. Poorer results were found in Groups 3, 4, 5, 8 and 9. This result may have occurred due to constant changes on the diet. Afterwards a homemade meal-type mixture used for swine feeding was used. Lastly, a pelleted ration substituted the homemade concentrate. Elephant grass (Napier, for example), was offered on all occasions. Despite the low CR (57%), KI was acceptable (65 days). AKBK was higher in Group 6 (6.4) compared to the others (6.1 and 5.0, respectively). The AKBK of 5.8 was very close to that of 5.96, reported by Luckefahr & Cheeke (1991). During lactation, Group 6 animals gained 18g/day, while Groups 1 and 3 averaged 3.39 and 5.00 kits/fryer with ADGs of 14.71 and 5.93g, respectively. Milk production suffers the effect of various factors, but since these animals have the same origin, and therefore little genetic variability, it may be reasonable to associate the highly diverse diet in Group 6 with its greater fryer weight gain.

Luckefhar et al (2000) also related that 77% of producers from Cameroon, in Africa, assisted by the Heifer Project International, had from poor to adequate scores for nutrition management. These scores were, in part, a reflex of poor overall nutrition practices and resulted in lower growth rates, fertility and high litter mortality rates.

Despite the high fryer ADG from birth to weaning (18 g/day), resulting in more developed and stronger animals, a mortality rate of almost 32% in Group 6, was considered high for this phase. Rastogi (1988) registered 22.7% mortality rate from birth to weaning, when furnishing a pelleted swine diet (16% Crude Protein) and various grass species to lactating does. Mortality rates were also high in Groups 1 and 3 (44 e 37%, respectively). The AWL observed in the present project (3.63) was well below those reported from Africa (5.87), Asia (5.77) and Latin America (5.29) (Luckefahr & Cheeke, 1991). APWL in Group 6 (4.36) was the only closer to those values reported. Adequate fryer ADG from birth to weaning in Groups 1 (15 g/day) and 6 (18 g/day) resulted in lower weaning ages (41 days in both Groups) compared to the others Groups. Group 6 animals were slaughter earlier (127 days) compared to Group 3 (144 days) due to the higher ADG from weaning to slaughter (21.0 and 9.4g, respectively). Average age at slaughtering in developing countries is almost 120 days (Luckefahr & Cheeke, 1991), and ADGs of 22.0 (Rastogi, 1988) and 148.8 g/day (Berchiche et al, 1996).

Mortality rate from weaning to slaughter in Group 6, using a concrete floor building, was lower (10%) than in Group 3 (67%), which used wire cages in this phase and those observed by Rastogi (1988) (11,8%).

Finally, the main consequences of the nutritionally unbalanced or deficient diets observed in this Project, were poor reproductive indexes and low milk production. Avoiding excessive weight loss before does are first mated, appears to be the key point to improve reproductive performance. The presence of the team responsible for the Program interfered with families motivation, helped checking management practices, increased information exchange and showed whether established goals were being met. Indexes reported in this Project were, in general, adequate compared to indexes reported by other authors from extensive raising systems.

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Dressing Percentage and Meat Quality of Rabbits under Heat Stress

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Abstract: The objective was to evaluate the effects of heat stress on dressing percentage and carcass and meat quality traits of rabbits from two genetic groups. Ninety-six weaned rabbits were used; half were from the Botucatu genetic group and half were crossbreds between New Zealand White males and Botucatu females. They were assigned to a randomized design in a 2 x 3 factorial arrangement (genetic groups and thermal conditions: thermoneutral, moderate and intense heat stress). Slaughter took place at 10 weeks of age in two consecutive days (blocks) and meat quality traits were measured in the *longissimus* muscle. Average ambient temperature and relative humidity were 18.4°C and 63.9% (thermoneutral), 24.4°C and 80.2% (moderate heat stress) and 29.6°C and 75.9% (intense heat stress). No effect of the genetic group x thermal condition interaction was detected on dressing percentage, carcass or meat quality traits. The percentage of carcass forepart, of distal parts of legs and skin were higher in the crossbred rabbits and the percentage of thoracic viscera in the straightbreds. Lightness of the *longissimus* muscle was higher in the straightbred and redness in the crossbreds. Slaughter, commercial carcass and reference carcass weights were lower under intense heat stress. However, higher commercial and reference carcass yields were found under intense heat stress relative to thermoneutrality. The percentage of distal parts of legs was higher under intense heat stress and the percentage of skin under moderate relative to intense heat stress. The percentages of thoracic viscera, liver and kidneys were lower under intense heat stress. Yellowness was higher in thermoneutrality than under intense heat stress, whereas cooking loss was lower in thermoneutrality relative to intense stress. Heat stress resulted in lower slaughter weight and proportional reduction in organ weights, which contributed to a higher slaughter yield, but it seemed to have exerted a negative effect on meat quality regarding color and cooking loss.

Key words: *carcass, color, genetic group, stress*

Introduction

The zone of thermo neutrality for the rabbit is 21-25°C [4], but the recommended ambient temperature range under laboratory conditions is between 16 and 22°C with relative humidity around 60 to 70% [10]. The elevation of ambient temperature above this level influences the maintenance of thermal balance; leading the organism to physiological adjustments that may compromise performance, slaughter yield, and carcass and meat quality traits.

Enhanced knowledge on how heat stress impacts carcass and meat quality traits would be of great value for the advancement of rabbit meat production in tropical regions. Although meat sensory properties are crucial for the consumer's choice [5], little research was conducted so far on the effect of heat stress on those traits.

Therefore this study had the objective of investigating the effects of moderate and intense heat stress on dressing percentage, carcass and meat quality of rabbits from two genetic groups: straightbred and crossbred Botucatu rabbits.

Material and Methods

A total of 96 rabbits, males and females, half from the Botucatu genetic group and half crossbreds, were used in this study. The latter were products from New Zealand White bucks and Botucatu does. At weaning (35 d) they were housed in three identical chambers (5.0 x 3.0 x 2.65 m), except for the temperature at which they were maintained: the *Thermoneutral* at 18°C, the *Moderate Heat* chamber at 25°C and the *Intense Heat* chamber at 30°C. Sixteen cages (0.60 x 0.50 x 0.45 m) were housed in each chamber, with two animals from the same genetic group each. Average daily air temperature and relative humidity were computed based on values recorded at 9:00 am, 2:00 pm and 9:00 pm. A commercial pelleted diet and water were provided *ad libitum*. A 12L:12D photoperiod (from 9:00 am to 9:00 pm) was supplied.

Slaughter took place at 10 weeks of age when bleeding followed physical stunning. The distal parts of legs, skin, commercial carcass (includes head, thoracic viscera, liver and kidneys), thoracic viscera (heart, lungs, trachea, esophagus and thymus), liver, kidneys and dissectible fat (scapular, perirenal and inguinal deposits) were weighed [3]. Commercial carcass as percentage of slaughter weight (dressing percentage) was computed. After 24h at 4oC, reference carcass (no head or viscera) was weighed and its percentage relative to slaughter weight and the yield of technological cuts (forelegs plus thoracic cage, loin, and hindlegs) were also obtained.

Muscle pH was recorded 24h post-mortem on the carcass surface of the *longissimus* muscle and 48h post-mortem on the dissected muscle. Meat quality sensorial analyses were performed on the *longissimus* muscle. The objective color was recorded in two points using a Minolta colorimeter (CR-400) using the CIELAB system [12]. This was followed by measurements of water holding capacity [6], cooking loss [7] and Warner-Bratzler force of the cooked meat [1].

The animals were randomly assigned to a completely randomized design with a 2 x 3 factorial arrangement (two genetic groups and three temperatures: thermoneutral, moderate and intense heat stress) and eight replicates (cage with two rabbits from the same genetic group). Analysis of variance was conducted with the GLM procedure of SAS [11]. The fixed effects of the genetic group, ambient temperature and of the interaction were included in the model.

Results and Discussion

Average daily ambient temperature and relative humidity during the experimental period were 18.4°C and 63.9% in the *Thermoneutral* chamber, 24.4°C and 80.2% in the *Moderate Heat* chamber and 29.6°C and 75.9% in the *Intense Heat* chamber, thus they were maintained within narrow limits from the target values. No genetic group x ambient temperature interaction effects ($P>0.05$) was detected on dressing percentage, or any carcass or meat quality trait.

No effect of the genetic group was found on slaughter weight, carcass weight or carcass yield (Table 1), but a higher percentage of distal parts of legs and skin was found in the crossbreds. This could be attributed to breed differences, since the skin could be thicker in the crossbreds due to the New Zealand White breed contribution [9]. Thoracic viscera were heavier in the straightbred Botucatu rabbits. Increased panting when compared to the crossbreds, especially under heat stress (unpublished data), could partially explain this difference. Forepart percentage, on the other hand, was higher in the crossbreds, which combined with the already mentioned higher percentages of legs and skin, suggests a lower degree of maturity at slaughter in this group than in the straightbreds. No differences between genetic groups were found for liver, kidneys, dissectible fat, loin and hind part percentages.

Under intense heat stress, there was a reduction in slaughter weight and in the weights of commercial and reference carcass, as expected (Table 1). Percentage of skin was also reduced. As a consequence, dressing percentage was higher, despite the fact that the percentage of distal parts of legs were increased. The relative proportion of metabolically active organs such as thoracic viscera, liver, and kidneys were lower under intense heat stress. This may partially explain why reference carcass percentage was much higher under heat stress than with moderate heat stress or thermoneutrality. Percentages of dissectible fat and carcass parts were unaffected by ambient temperature.

Table 1. Least-squares means (standard-errors) of dressing percentage and carcass traits, according to genetic group and ambient temperature

Trait	Genetic group			Ambient temperature			
	Straightbred	Crossbred	p-value	Thermoneutral	Moderate heat	Intense heat	p-value
Slaughter weight (g)	2058 (23)	2000 (23)	0.080	2105 (28)[b]	2097 (28)[b]	1886 (28)[a]	<0.001
Commercial carcass (g)	1292 (16)	1257 (16)	0.136	1309 (20)[b]	1315 (20)[b]	1199 (20)[a]	<0.001
Dressing percentage (%)	62.76 (0.26)	62.85 (0.26)	0.813	62.19 (0.31)[a]	62.70 (0.31)[ab]	63.53 (0.31)[b]	0.015
Reference carcass (g)	1130 (14)	1104 (14)	0.203	1140 (17)[b]	1143 (17)[b]	1069 (17)[a]	0.006
Reference carcass (%)	54.94 (0.33)	55.28 (0.33)	0.472	54.19 (0.41)[a]	54.47 (0.41)[a]	56.66 (0.41)[b]	<0.001
Distal parts of legs (%)	3.31 (0.02)	3.40 (0.02)	0.010	3.24 (0.03)[a]	3.33 (0.03)[a]	3.49 (0.03)[b]	<0.001
Skin (%)	12.50 (0.09)	13.29 (0.09)	<0.001	12.95 (0.11)[ab]	13.05 (0.11)[b]	12.68 (0.11)[a]	0.045
Thoracic viscera (%)	1.97 (0.05)	1.81 (0.05)	0.023	2.01 (0.06)[b]	1.91 (0.06)[ab]	1.76 (0.06)[a]	0.007
Liver (%)	3.94 (0.07)	3.86 (0.07)	0.426	4.22 (0.09)[b]	4.01 (0.09)[b]	3.48 (0.09)[a]	<0.001
Kidneys (%)	1.72 (0.05)	1.60 (0.05)	0.098	1.79 (0.06)[b]	1.72 (0.06)[b]	1.46 (0.06)[a]	0.001
Dissectible fat (%)	2.20 (0.10)	2.15 (0.10)	0.714	2.30 (0.12)	2.19 (0.12)	2.03 (0.12)	0.297
Fore part (%)	29.00 (0.12)	29.34 (0.12)	0.047	29.43 (0.14)	29.01 (0.14)	29.06 (0.14)	0.090
Loin (%)	30.49 (0.16)	30.24 (0.16)	0.278	30.13 (0.20)	30.58 (0.20)	30.37 (0.20)	0.291
Hind part (%)	40.46 (0.14)	40.37 (0.14)	0.649	40.44 (0.17)	40.31 (0.17)	40.50 (0.17)	0.716

[1] a, b, c Means followed by different letters differ ($P<0.05$) according to Tukey's test.

Ultimate pH values of the *longissimus* muscle 24 and 48h pos- mortem fell within the normal range [8] in both genetic groups and under all three ambient temperatures (Table 2). Meat color differences were found between genetic groups (Table 2). Lightness was greater in straightbred Botucatu rabbits, whereas redness was greater in the crossbreds, indicating more colored meat in this group. The selection program to which the Botucatu rabbits were submitted may have influenced muscle metabolism [2] and, consequently, meat color. Line differences in respect to sensorial meat properties were reported, especially when selection for fast growth was practiced [5]. No genetic group effects were detected on any other meat quality traits (yellowness, water-holding capacity, cooking loss or shear force).
Intense heat stress reduced the yellowness of meat (Table 2) and increased cooking loss when compared to the thermo neutral temperature, therefore it had a negative impact on meat quality traits. Moderate heat stress was intermediate. Other meat sensory properties did not change significantly with heat stress.

Conclusion

Heat stress had similar effects on straightbred and crossbred Botucatu rabbits. It negatively impacted slaughter and carcass weights, but increased carcass yield, probably by reducing the relative weights of skin and of metabolically active organs. Small negative effects on meat color and cooking loss were also recorded. Therefore management and environmental measures should be taken to minimize the negative effects of heat stress during the pre-slaughter phase.

Table 2. Least-squares means (standard-errors) of meat quality traits, according to genetic group and ambient temperature

Trait [1]	Genetic group			Ambient temperature [2]			
	Straightbred	Crossbred	p-value	Thermoneutral	Moderate heat	Intense heat	p-value
Ultimate pH, 24h	5.92 (0.02)	5.90 (0.02)	0.500	5.88 (0.02)	5.93 (0.02)	5.92 (0.02)	0.193
Ultimate pH, 48h	5.93 (0.01)	5.95 (0.01)	0.175	5.92 (0.01)	5.95 (0.01)	5.95 (0.01)	0.358
Lightness (L*)	53.46 (0.35)	52.24 (0.35)	0.017	52.28 (0.42)	53.04 (0.42)	53.23 (0.42)	0.257
Redness (a*)	4.63 (0.24)	5.48 (0.24)	0.016	5.51 (0.29)	4.99 (0.29)	4.68 (0.29)	0.140
Yellowness (b*)	2.15 (0.16)	2.17 (0.16)	0.929	2.44 (0.20)[b]	2.30 (0.20)[ab]	1.74 (0.20)[a]	0.043
Water holding capacity (%)	59.48 (1.01)	59.56 (1.01)	0.958	58.77 (1.24)	60.19 (1.24)	59.60 (1.24)	0.716
Cooking loss (%)	35.63 (0.49)	35.46 (0.49)	0.816	34.31 (0.59)[a]	35.74 (0.59)[ab]	36.59 (0.59)[b]	0.032
Warner-Blatzer force (kgf/cm^2)	2.65 (0.12)	2.69 (0.12)	0.822	2.74 (0.14)	2.70 (0.14)	2.57 (0.14)	0.685

[1] Measured on the *longissimus* muscle
[2] a, b: Means followed by different letters differ (P<0.05) according to Tukey's test.

Acknowlegments

This project received financial support from FAPESP, Brazil. Ana S.A.M.T. Moura, José R. Sartori, and Cynthia P. Zeferino received scholarships from CNPq, Brazil. Claudia M. Komiyama received a scholarship from FAPESP.

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Physiological Responses of Growing Rabbits from two Genetic Groups to Heat Stress

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Abstract

The objective was to investigate the effect of moderate and intense heat stress on the physiological responses of straightbred and crossbred growing rabbits. Forty-eight weaned rabbits were involved; half were from the Botucatu genetic group and half crossbreds between New Zealand White males and Botucatu females. They were assigned to a completely randomized design in a 2 x 3 factorial arrangement (genetic groups and ambient temperatures: thermoneutral, moderate and intense heat stress) with repeated measures (weeks). Colonic temperature, ear temperature and respiratory rate were recorded weekly from 42 to 67 days of age. Average ambient temperature and relative humidity in the chambers were 18.4°C and 63.9% (thermoneutral), 24.4°C and 80.2% (moderate heat stress) and 29.6°C and 75.9% (intense heat stress). A slight decrease in colonic temperature over time was observed, whose intensity differed according to ambient temperature, but there was a sudden increase under intense heat stress over the last week (from 39.46±0.04°C at 60 d to 39.60±0.04°C at 67 d). Ear surface temperature was higher in Botucatu rabbits at week seven (29.0±0.2 *vs.* 28.4±0.2°C) and nine (29.8±0.2 *vs.* 29.1±0.2°C), which indicated higher sensible heat loss in this group. Respiratory rate showed an evident elevation trend over weeks in both genetic groups, but it was more pronounced in the straightbreds (31% *vs.* 18%), which may be an indication of a higher rate of heat dissipation in this group. There was a direct relationship of average ear surface temperature and of respiratory rate with ambient temperature. It should be investigated if the physiological differences between groups are translated into performance differences under heat stress.

Keywords: *colonic temperature, growth, respiratory rate, thermoneutrality*

Introduction

The scientific report from the European Food and Safety Authority [4] emphasized the need to investigate the ideal environmental conditions for weaned rabbits. Temperature, along with humidity, ventilation and photoperiod markedly influence rabbit's health, welfare and performance. Being an endotherm, the rabbit controls body temperature primarily through the generation of heat from metabolic processes [5], although behavioral responses are often used. The zone of thermo neutrality for the rabbit is 21 to 25°C [3], whereas the recommended ambient temperature range under laboratory conditions is between 16 and 22°C [8]. The rabbit is highly susceptible to high ambient temperature because it cannot sweat and panting is not efficient for cooling [2]. The ears are important heat-sensing organs in the rabbit because they represent about 12% of body surface area and are highly vascular [6].

The elucidation of thermoregulatory mechanisms and the identification of differences in physiological responses among genetic groups under heat stress are of extreme importance for the development of rabbit meat production in the tropics. Hence, this study aimed at investigating the effect of moderate and intense heat stress on some physiological responses of growing rabbits from two genetic groups.

Materials and Methods

A total of 96 weaned rabbits, males and females, half from the Botucatu Genetic Group and half crossbreds, were involved, but only 48 were used in this study. The crossbreds were products from New Zealand White bucks and Botucatu does. The *Botucatu* Genetic Group is a synthetic strain originated from Norfolk 2000 rabbits that has been selected for growth rate and litter size since 1992 [7] and had 37 years local adaptation by the time this study was initiated. At weaning (35 d), these rabbits were housed in three similar chambers (5.0 x 3.0 x 2.6 m), where they stayed up to 70 d of age: the *Thermoneutral* chamber was maintained at 18°C; the *Moderate Heat* chamber at 25°C and the *Intense Heat* chamber at 30°C. Rabbits were randomly assigned, two of the same genetic group per cage (0.60 x 0.50 x 0.45 m), 16 cages per chamber, half from each genetic group. A 12L:12D photoperiod (from 9:00 am to 9:00 pm) was supplied. Animals had free access to water and to a commercial pelleted diet. Air temperature and relative humidity were recorded daily at 9:00 am, 2:00 pm and 9:00 pm. Mean daily air temperature and relative humidity were computed.

Length of the right ear was recorded at 35 and at 70 d of age. Colonic temperature, ear temperature and respiratory rate were recorded weekly from one rabbit per cage. This rabbit was taken at random on the first day, but was the same during all the experimental period. The first week in the chambers was dedicated to acclimation. Physiological indicators were recorded in the following four weeks, three times a week. Wooden stocks were especially designed to restrain rabbits, allowing the use of probes for colonic temperature measurement. Colonic temperature was assessed with a three-channel digital thermometer (*Physitemp*®). Ear temperature was recorded with a pistol type laser sighting infrared thermometer (*Icel*®) positioned at approximately 25 cm. Respiratory rate was estimated by direct count during 15 seconds. The recorded value was subsequently multiplied by four. Averages of the three weekly measurements of colonic and ear temperatures and respiratory rate were computed as the weekly records for each individual rabbit.

A completely randomized design in a 2 x 3 factorial arrangement (two genetic groups and three ambient temperatures) with eight replicates was adopted. Analyses of variance were performed with the MIXED procedure of SAS [9], using models with repeated measures (weeks). The fixed effects of genetic group, temperature, weeks and all interactions were considered. Initial and final ear lengths were included as covariates, but were excluded from the final model if not significant ($P>0.05$).

Results and Discussion

Average daily ambient temperature and relative humidity during the experimental period were 18.4°C and 63.9% in the *Thermoneutral* chamber, 24.4°C and 80.2% in the *Moderate Heat* chamber and 29.6°C and 75.9% in the *Intense Heat* chamber. They were maintained within narrow limits from the target values in all three chambers (18°C, 25°C and 30°C, respectively). The relative humidity, on the other hand, oscillated due to the lack of resources for its control in the chambers.

Botucatu rabbits had longer ears than the crossbreds (83.6±0.5 *vs.* 81.7±0.5 mm at 35 d, P=0.0065; 108.9±1.2 *vs.* 103.2±1.2 mm at 70 d, P=0.0013, respectively). This difference was expected because New Zealand White rabbits have shorter ears than Botucatu rabbits.

An ambient temperature x week interaction effect (P=0.0014) was detected on colonic temperature. Average colonic temperatures ranged from 39.4 to 39.7°C across all treatments. These values are in the upper limit of normal core temperatures of adult New Zealand White rabbits at rest, which ranged from 38.5 to 39.5°C [2]. An increase in colonic temperature was observed during the last week of the trial under intense heat (from 39.46±0.04°C at 60 d to 39.60±0.04°C at 67 d), suggesting that the animals were becoming more sensitive to heat stress as they aged. If that had persisted, animals could have had experienced hyperthermia.

Genetic group x week (P=0.0418) and ambient temperature x week (P<0.0001) interaction effects were found on ear surface temperature. An evident rise in ear temperature was noticeable in both genetic groups between week six and eight followed by a slight drop thereafter, which was steeper in the crossbreds (Figure 1). Ear surface temperature was higher in Botucatu rabbits at week seven (29.0±0.2 *vs.* 28.4±0.2°C) and nine (29.8±0.2 *vs.* 29.1±0.2°C). This could be an indication of increased body heat production and sensible heat loss in this group. Apart from representing about 12% of body surface, the ears have the largest arteriovenus anastomotic system in the rabbit body, facilitating heat exchange through a countercurrent system [2, 6].

Ear surface temperature showed a direct relationship with ambient temperature (Figure 2). In the *Thermoneutral chamber*, ear surface temperature increased from 21.4±0.2°C in week six to 25.1±0.2°C in week eight, possibly reflecting an increasing thermogenic activity with growth. Under moderate and intense heat stress, ear surface temperatures were higher, but did not change as much along weeks. It could be hypothesized that the *Thermoneutral chamber* was, in fact, below the thermoneutral zone for six-week-old rabbits.

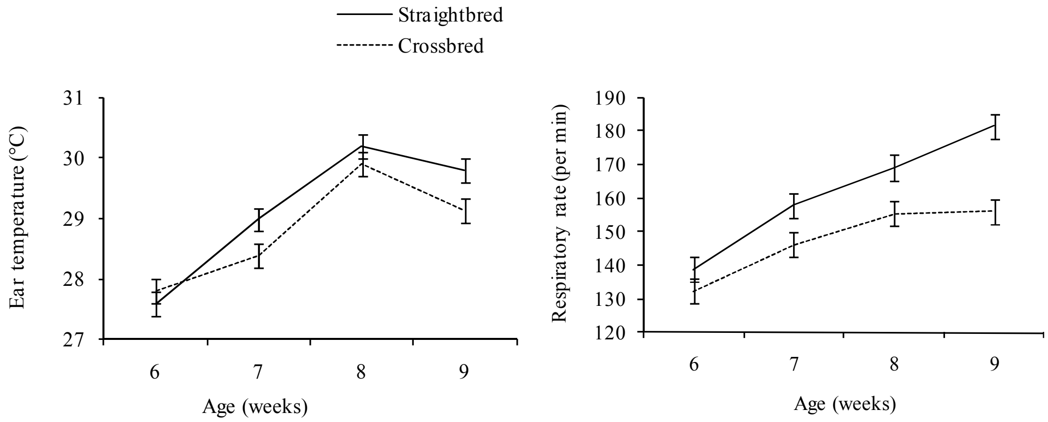

Figure 1. Effect of the genetic group x week interaction on ear surface temperature and respiratory rate of rabbits

Genetic group x week (P=0.0250) and ambient temperature x week (P<0.0001) interaction effects were found on respiratory rate. Final ear length also affected (P=0.0076) this trait: for each additional mm in ear length, there was a reduction of 0.99±0.35 respiratory movements/min. Respiratory rate of both genetic groups increased over time from six to nine weeks of age (Figure 1). Straightbreds showed higher respiratory rate than crossbreds from week seven on, and the difference between groups was amplified across weeks. Thus, in the straightbreds, respiratory rate increased 31% from week 6 to 9 (from 138.7±3.7 to 181.5±3.7), whereas in the crossbreds, the increase corresponded only to about 18% in the same period (from 132.3±3.7 to 156.1±3.7). Although panting is not an efficient mechanism for cooling, this result indicated that Botucatu rabbits have a higher rate of heat dissipation through respiratory evaporative heat loss.

The effect of ambient temperature on respiratory rate was not uniform over time (Figure 2). In thermoneutrality, respiratory rate changed little between weeks 6 and 9 (101.2±4.6 to 110.5±4.6 respirations/ min). Under moderate heat stress, a slight increase in respiratory rate was found between weeks 6 and 7, a more pronounced increase in the subsequent week, and stabilization in the final week. Under intense heat stress, respiratory rate increased especially in the last week up to 227.3±4.5 respirations/min. Values that were even higher than these (246.8±3.5 respirations/min) were reported for New Zealand White rabbits in the afternoon during the summer (24°C average daily temperature and 63.9% relative humidity) in Maringá, Brazil [1].

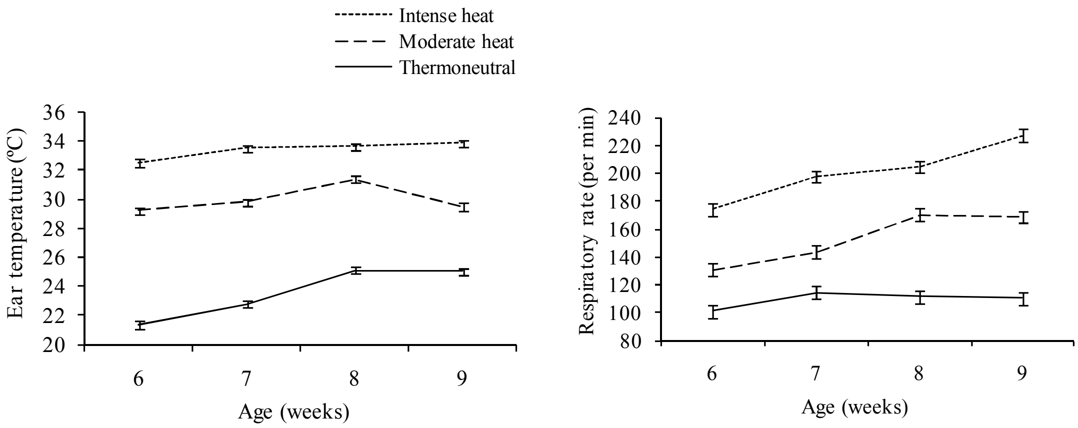

Figure 2. Effect of the ambient temperature x week interaction on ear surface temperature and respiratory rate of rabbits

Conclusion

Rabbits from both genetic groups became less tolerant to heat stress as they aged from six to nine weeks. Straightbred Botucatu rabbits showed longer ears and increased sensible and respiratory evaporative heat loss than crossbred New Zealand White x Botucatu rabbits. It should be investigated if these physiological differences between groups are translated into favorable performance differences under heat stress.

Acknowledgements

This project received financial support from FAPESP, Brazil. José R. Sartori, Cynthia P. Zeferino and Juliana S. Kanayama received scholarships from CNPq, Brazil.

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Evaluation of aerial part f cassava varieties, performance and digestibility in simplified and semi-simplified diets with or without enzymatic supplementation for fattening rabbits

Luiz Carlos Machado

ABSTRACT

Cassava consists of major source of food for many communities worldwide. The aerial part of this plant, however, is not employed for human feeding. Animals, in contrast, eat that part of cassava, although it is not largely used for animal feeding. The rabbit production is a strategic activity due the animal high prolificacy and its excellent meat quality. Besides, rabbit demand relatively small areas to be raised, accept diets with great content of fibrous ingredients, and cause low environmental impact, an important question for sustainable development of the modern society. The main objectives of this work were to select a variety of cassava adequate for feeding farmed rabbits, to evaluate the digestibility of the nutritional principles of simplified and half-simplified diets for rabbits, as well as the performance of the animals fed these diets, and to evaluate *in vitro* digestibility methods for rabbits. In the first trial, 12 cassava varieties developed by EMBRAPA Mandioca e Fruticultura research station, harvested 10 months after planting and made into cassava hay, had evaluated their chemical composition, cianidric acid (HCN) content and *in vitro* digestibility with gas production. In the second trial, it was investigated the potential of the fractions (1 to 5) of the aerial part cassava processing. In the third trial, the productivity of both parts, the cassava root and the upper third foliage hay (CUTFH), were studied. The CUTFH had studied its chemical composition, and its production cost was estimated. A fourth trial was set up to compare with a reference diet the i*n vitro* digestibility of the simplified and half-simplified diets, with basis of the mixture of forage crops, with or without exogenous enzymes. The following types of food were tested: CUTFH, alfalfas hay (ALH), and cassava leaves flour (CLF), being utilized a completely randomized design, with 11 treatments and eight replications. Carbohydrase (xylanase, beta glucanase, alpha galactosidase and galactomanase) and phytase enzymes were also added. The productive performance and digestive parameters had been evaluated also from the diets previously cited, being the animals weighteds to each five days. In the last two assays, the *in vitro* digestibility methods with gas production and Tiley e Terry had been used for evaluation of the

experimental diets being the second method modified on the time of incubation and the second stage (enzymatic digestion). KIRIRIS, GRAVETINHO and CIGANA cassava varieties showed better chemical composition, no presence of HCN, as well as a high degradability and gas production. Therefore, those varieties were selected for the productive performance trial (trial 4). Fraction 1 of the processing seemed favorable for use in the feeding of the rabbits, as it characteristics were very similar to the ALH. GRAVETINHO variety was chosen since it yielded greater productivity of root (19 t/ha) as well as a high productivity of CUTFH. Production cost for cassava upper third foliage hay was R$0.36/kg. While digestibility of the nutritional principles of the diets was negatively influenced by the type of food ($p<0.05$), the exogenous enzymes improved it. It was also observed that a large amount the crude protein (CP) of the CLF was conjugated, since it was undergone high temperatures during its processing. Fibrous ingredients had 1822.7 kcal DE/kg DM and 12.26% CP in the DM for the CUTFH, 2232.5 kcal DE/kgDM and 15.54% DP in the DM for ALH and 1888.9 kcal/kg DE/kg DM and 7.36% DP in the DM for the CLF. Feed consumption was affected by the type of food ($p<0.05$). Treatments with higher inclusion of CFL resulted in lower feed conversion and lower carcass yield. For daily weight gain (DWG) the best results were obtained in the treatment reference, the half-simplified CUTFH and half-simplified on the basis of the mixture of ALH and CLF ($p<0,05$). In contrast, no significant positive effect of exogenous enzymes was observed for DWG ($p>0.05$). The not linear models of Logistic, Gompertz and Von Bertalanffy adapted to the growth of the animals while Brody model did not. Diets with greater fiber content allowed greater development of the gastrointestinal tract. For the economic view, the simplified diet on the basis of the CUTFH seemed interesting, since it made possible a 4% reduction in the cost for production of 1 kg of rabbit. Regarding to the digestibility methods tested in this experiment, a excellent correlation was found between data obtained *in vitro* and data obtained *in vivo.*

PROCESSING RABBITS' SKIN: TECHNOLOGY FOR SKIN AND LEATHER

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Among the animal sub products used for the production of meat, the rabbit skin may be processed to obtain, after the tanning process, soft, flexible and beautiful leather. The skin's fibrous nature is maintained but fibers are previously separated when interfiber matter is removed and chemical products are applied. After the separation of fibers and removal of the interfiber matter, skins are treated with tanning compounds that transform them into leather or processed skins. Skin undergoes certain processes by chemical or vegetal products which preserve it from putrefaction brought about by autolytic processes (skin's enzymes affect its decomposition) of skin or bacteria. Skin is transformed into leather or processed skin with hair (for skin production), a non-putrefying product characterized by softness, elasticity, flexibility, traction resistant. It has physical and mechanical characteristics that make the skin useful for several clothing sections. Skins undergo two types of processing, with or without hair. In case of skin with hair products may be used for the manufacturing of clothes in general, such as coats, ornaments in cloths and wool blouses, bedspreads, carpets, and caps. Leather may be used in handbags, wallets, souvenirs, gloves, belts, fine shoes, and jackets. Both processing types may be used in the decoration of homes.

To better understand the process of tanning skins, it is important to make some considerations about the races that allow obtaining better quality, size of slaughter skins, as well as the characteristics observation on the skin itself (layers, constitution, flower design), slaughter and extraction of the skin (skinning). And also methods of conservation and care in storage, possible defects of the hair and hairless furs, as well as the parameters for the classification before and after the tanning process and the full tanning process related to both forms of processing (with and without hair).

The rabbits' breeds can be classified according to the interest of producing meat, skin or hair. Although there is the possibility of using any kind of rabbit fur or originated from any race, for application in the form of leather or fur is preferable to work with specific breeds and among them, the animals of short hair, like Rex variety. It is also possible the use of animals for meat production, as the rabbits of Chinchilla, New Zealand Red, Blue Vienna, Silver Champagne breeds among others, that have a natural and distinct coat color. These varieties provide a skin often unique due to its natural pigmentation related to race. A major drawback is that the races for meat production are usually slaughtered earlier, around 70-90 days, while for the use of skins to the fur, requires animals slaughtered after this period or preferably between 4-6 months of age. This is because during this period has already occurred to completion of molting and maturation of skin, when the animal presents every type of hair that is part of the coat, as well as completes its full growth.

The rabbit's skin is composed of various overlying adherent layers or is composed of three layers: epidermis, dermis and hypodermis or subcutaneous layer. Seen from the outside to the interior they are called epidermis, dermis (Figure 1a,b) and hypodermis. According to Duarte and Carvalho (1979), each layer presents different thickness according to age and sex, nutrition condition and anatomical site. Moreover, they may be subdivided into various sub-layers. The first layer, close to the surface and in direct contact with the external environment, is the epidermis which is very thin in rabbits. This layer is composed of epithelial, covering, layered, keratinized tissue formed by basal or germinative, thorny, granulous sub-chambers and by the cornea. The germinative layer consists of a simple chamber of cylindrical cells which are accountable, by division, for the constant reposition of surface epithelial layers (Kolbe, 1987). According to authors the germinative and the thorny layers are the sites in which pigment corpuscles, made up of melanin, meet. Hair color is caused by a pigment, called melanin, in the medullar cells within each hair and is produced by melanocytes from tyrosine.

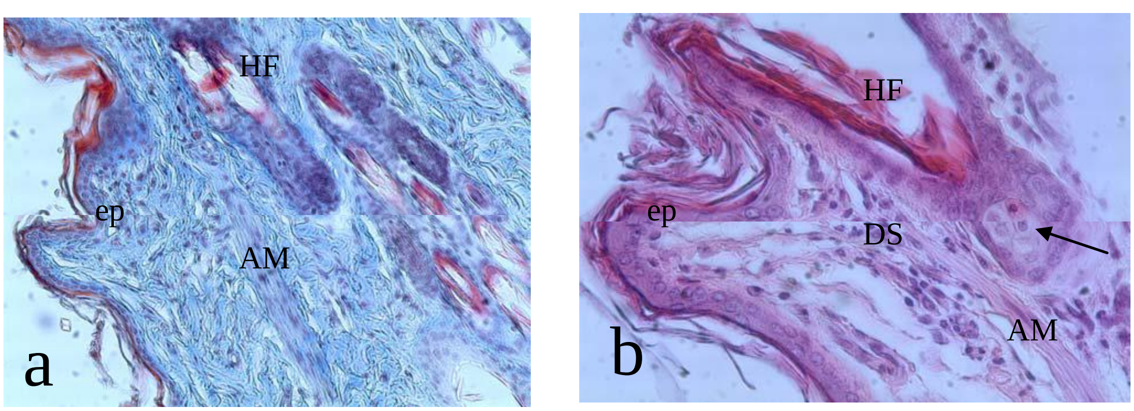

Figure 1 – Photomicrography of rabbit skin showing (a and b) epidermis layers (ep), dermis surface (ds), hair follicle (HF), the sebaceous gland (arrow), and the erector pili muscle (AM) are directly associated with the guard hairs (place).

According to Hoinacki *et al.* (1994), the pigment rate of the epidermis decreases in the direction of the corneal layer. The pigmentation of the surface layers of the skin is not identical to the color of the covering hairs. Many white hair animals have dark pigments in their epidermis. This fact may be observed in the skins of white New Zealand rabbits after the removal of hair in the tanning process when patches are evidenced in certain areas, mainly in the central dorsal area remain. This is especially true when the skin has not reached maturity, or rather, the entire development of all types of hair normally found in the fur. During the tanning process, or rather, before the strictly tanning stage and before the end of the pickling stage, skin starching is frequently necessary so that blemishes in the leather do not occur after coloring. Otherwise, a darker coloring occurs in these sites.

The dermis is composed of three structures, the sweat gland, the sebaceous gland, and the erector pili muscle, directly associated with the guard hair (Cheeke *et al.,*1982). The Figure 1a and 1b show two structures, the sebaceous gland and the erector pili muscle around hairy follicle. When the erector pili muscle contracts, it changes the position of the hair so that it stands vertically when the animal is frightened or feeling cold and also helps to constrict the superficial blood vessels of the skin. The hairs of the underfur do not generally have these three accessory structures. The hairs consist of central core of cells, called the medulla, which is surrounded by the cortex (Figure 2).

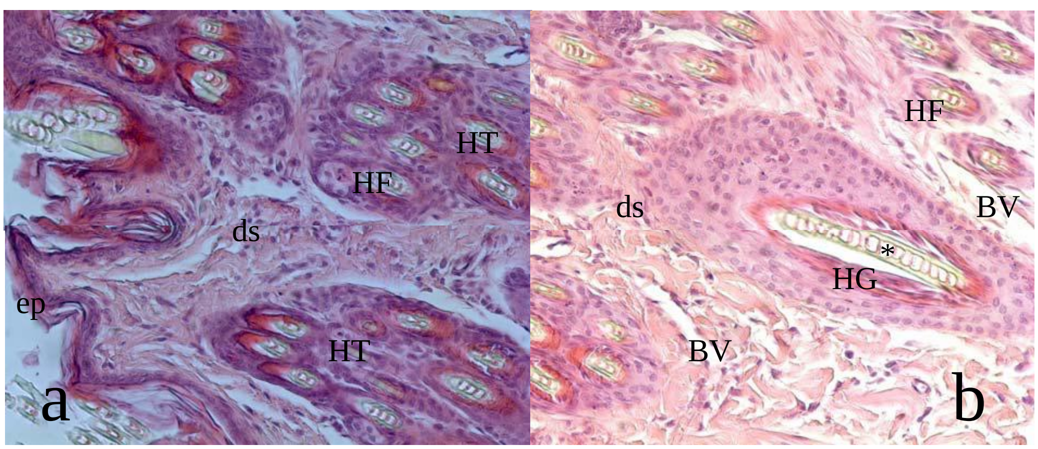

Figure 2 – Photomicrography of rabbit skin showing (a and b) epidermis layers (ep), dermis surface (ds), hair follicle (HF), the sebaceous gland (arrow), guard hairs (HG) with air chamber (*) and superficial blood vessels (BV). Showing dermis layers with the hairs tufts (HT).

The skin morphology provides the histological architecture of collagen fibers since they are basic structures that react with the tanning material and determine the skin's resistance

(Hoinacki, 1989). According to Junqueira *et al*. (1983), the structural arrangement of collagen fibers of the compact dermis and the extract's thickness cause high resistance in the skin to different traction forces. This is the reason why the skin of certain fish may be deployed commercially in the manufacture of leather artifacts (Souza, 2003).

According to Souza (2003), within the context of the organization and the disposition of its collagen fibers, analysis of skin morphology and of the dermis structure during tanning is of paramount importance for the investigation of skin resistance. At a certain stage during the tanning process and due to the use of certain chemical products, difference in composition favors the destruction of the structure's upper layer, while the intermediate one undergoes modifications without disaggregation. According to Frankel (1991), liming destroys the epidermis by alkaline products: it eliminates hairs; destroys the sweating glands, nerves and blood vessels; swells the conjunctive tissues to facilitate the opening of the fibrous material with a greater release or removal of interfiber material; destroys the interfiber tissues for a better penetration of tanning agents.

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The dermis may be found below the epidermis composed of conjunctive tissues with saliencies called dermal papillae (Figure 1a) that follow the epidermis's contours, and give it a greater adhesion. The dermis is composed of two layers, or rather, the papillary and the reticular layers. Papillary layer is thin and made up of a loose conjunctive tissue. It lies immediately below the epidermis although separated by the basal lamina. Blood vessels that nourish the epidermis without penetrating it may be seen. The reticular layer is thicker and composed of the nonpatterned thick conjunctive tissue. Hair and glands of the skin may be observed in this layer (Figure 1b).

Collagen fibers may be observed among the fatty glands. Fibers in the papillary dermis are thinner and shorter, whereas collagen fibers in the reticular dermis are thicker, wavy and longer. When compared to certain animal species, fish for instance, collagen fibers (Figures 1, 2 and 3) of the reticular and papillary dermis lack any pattern in orientation and disposition. Layers of stripes of collagen fibers in fish overlie one another.

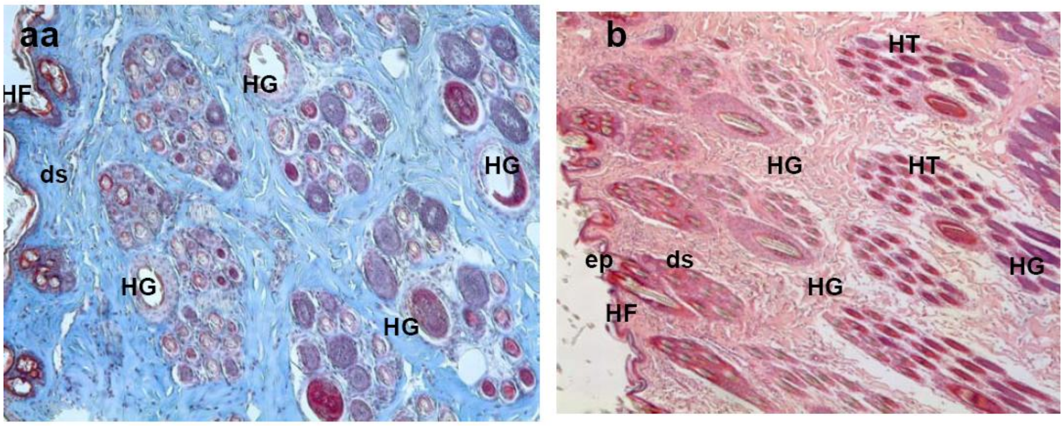

Figure 3 – Photomicrography of rabbit skin showing epidermis layers (ep), dermis surface layers (ds) with hair follicle (HF), hairs conductor, guard or clutch (HG) and the other hairs surround the latter, but always in tufts (HT).

Transversal and tangential cross sections of the hair follicles in the dermis, associated or not to the erector muscle of the hairs (smooth muscle), and few sebaceous glands may be observed (Figures 1b, 2a). Rabbit's hair follicles may be seen in the transversal cross section, grouped in characteristic arrangements (Figures 2 and 3), with different thicknesses. Hair may be seen within these follicles. According to Cheeke *et al.* (1982), hair may be classified according to their thickness (diameter) and length according to their distribution in the fur. The thickest and longest hair in lesser proportions in the fur, are the conductor, guard or clutch hair; the other hair surround the latter, but always in tufts (Figure 2 and 3). Hairs properly so called are more numerous and proportionally occupy a larger area in the animal's fur (Figure 3a). Their shape is similar to that of the conductor hairs but they are shorter and have a smaller diameter (Figure 3b). They are strongly colored and determine the rabbit's fur color. According to Lleonart *et al.* (1980), there are also intermediary hairs, shaped like the above, but in a smaller number. Their size is smaller than those strictly at the tip. Down hair are the shortest and the thinnest measuring 20-30mm in length and 0.015-0.02 mm in diameter. The above authors note that two subtypes exist, or rather, a thin and colorless type and a thick and slightly colored one. The quantity of this type of hair varies according to race and is more abundant in young animals and during the cold seasons. This corroborates to their protecting and isolating characteristics.

The skin presents the drawing of a flower observed on the surface of the skin, which is unique and delicate, as well as thin and presents softness characteristic (Figure 4b). According to Hoinacki (1989), the drawing of a flower is a composition formed by the opening of the hairy follicles and the pores, giving a unique characteristic for each type of skin, and consequently for the leather (Figure 4b).The skin's transversal cross section shows repartitions in the air chamber which, according to Cheeke *et al.* (1982), give excellent isolation and warmth to the skin without being too heavy.

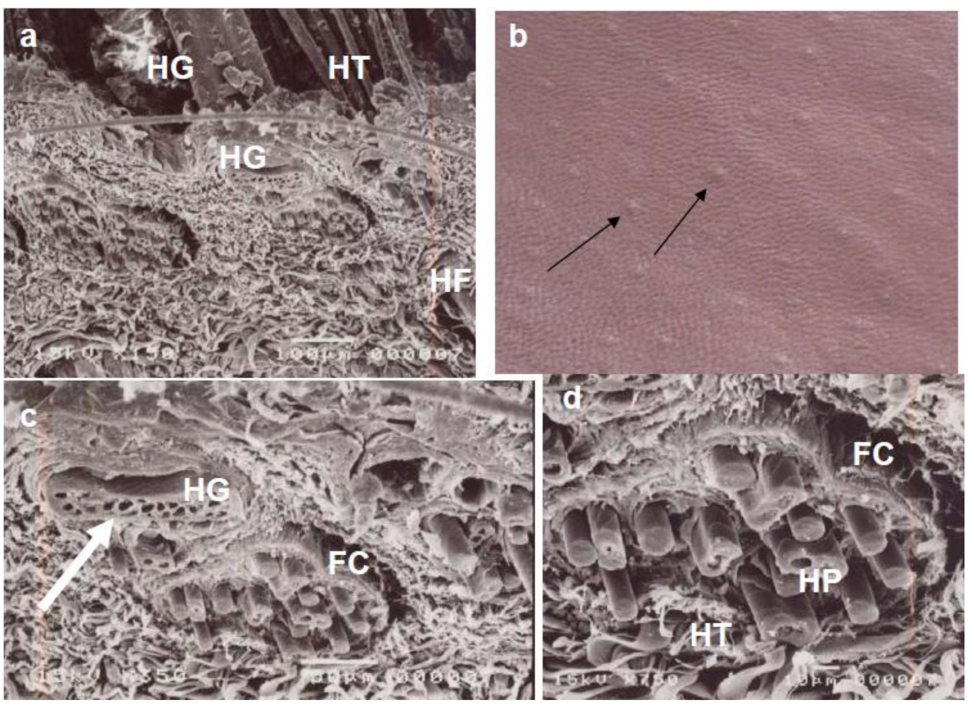

Figure 4 – Electron micrography of rabbit skin showing (a,c and d) dermis with hair follicle, air chamber (arrow) in the hairs, distribution of collagen fibers and hair guard or conductor (HG); hair follicle with cortex of hairs (FC); hairs tufts (HT) with hairs properly so called (HP); (b) The rabbit surface skin showing drawing of a flower on the surface of the skin (place of the hair guard or conductor - arrow).

The hypodermis or the loose conjunctive tissue layer that joins the skin to deep structures lies beneath to the skin (epidermis and dermis). High amounts of fatty tissues may be found in this layer. Morphological differences between the skins of males and females have not been observed. However, according to Lleonart *et al.* (1980), the rabbits' skin is very resistant whose characteristic increases with the age and indeed is more noticeable in male than in female animals.

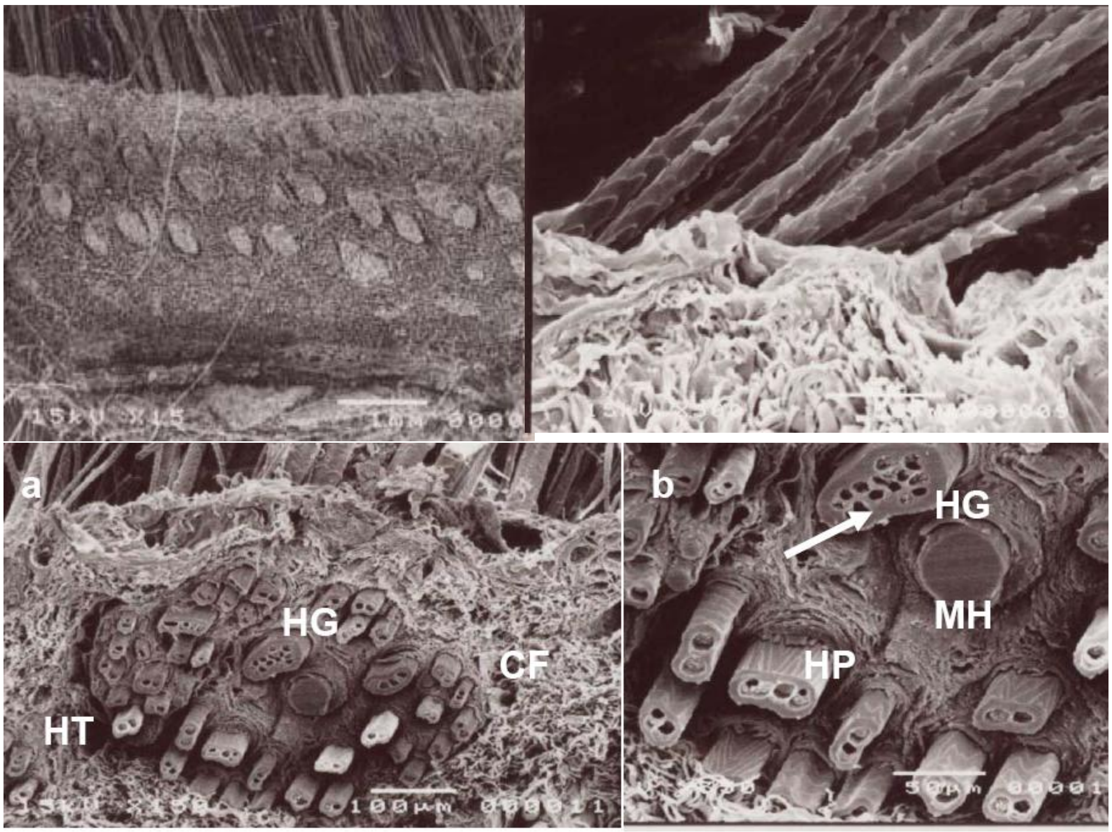

Figure 5 - Electron micrography of rabbit skin showing dermis with hairs tufts and hair follicle, air chamber in the hairs (arrow), hair guard or conductor (HG); distribution of thinner collagen fibers (CF) and hairs tufts (HT) with hairs properly so called (HP) and medulla of hair (MH)

Further studies should be undertaken in rabbits of different ages to analyze whether the development of the dermal may mark sex differences in rabbits. This is important since the tanned skins of old animals, matrixes and reproducers are different for males and females, on the touch, with regard to the elasticity and softness of the leather. This is chiefly the case when skins are processed without hair removal for skin production. The skins were submitted to the tanning procedure steps according to Hoinacki (1989) and Souza (2004), with modifications to rabbits' skins. The steps of this procedure with their aims are followed bellow:

Tanning procedure with chrome salts and four techniques of retanning

Soaking: Hydration and washing of skins to remove fat and blood.

Fleshing: hypoderm, adhered matter to meat side as meat and fat pieces removing. The removal was made using a bank of fleshing (Figure 6).

Soaking: washing of skins to remove fat.

200% water -0,5% tensioactive Nocotex NG 30 – while was being fleshed – wash.

Liming: Removal of furs and promotion of swallowing of the fibrous structure, providing an opening of the collagen fibers, preparing the skin to the successive mechanical operations.

40% water, 3% Sodium Sulphide and 4% of calcium carbonate – 60 minutes

150% water – 30 minutes – bath during the night.

Decalcining: removal of the calcium carbonate and sodium sulphide, which are found, reposed connected to the fibers of the dermal matter. It provides a loosening of the fibrillar structure too.

Purge: cleaning of fibrous structure as keratinous matter, fats, pilous bulbs and other unde retained among the collagen fibers when applying proteolytic substances.

Degreasing: removal of fat excess persisted in the dermal structure.

Pickling: acidify collagen fibers to react with the tannishes.

T**anning**: provides stability of all collagen system, increase retraction temperature, reduce swallowing of collagen, and stabilize due to enzymes. (7% of chromosal B – 60 minutes)

Basification: increase pH of skins, which were submitted to acidification in previous procedures, to fixate tannish to the collagen fibers. In addition, this process controls the pH to next step.

Neutralization: eliminates the excess of acidity of the leather.

Retanning and dyeing: proportionate more softness to the leather and determinates the final color of leather. Bellow there are the products and the quantity of them used of the tanning step.

- used tannishes

4% Chrome salts - 40min

6% tannin (Mimosa) - 40min

6% Synthetic tannin (Relugan 50%) - 40min

3% Vegetable tannin (Mimosa) + 3% synthetic tannin (Relugan) - 40min

Greasing – the addition of an oil emulsion that involves the collagen fibers promoting the lubrication of fibers. The grease furnishes more resistance to tearing, softness and elasticity to the leather. (9% of oils-60 minutes)

Fixing: To fixate oils and dyes in the fibers of the leather.

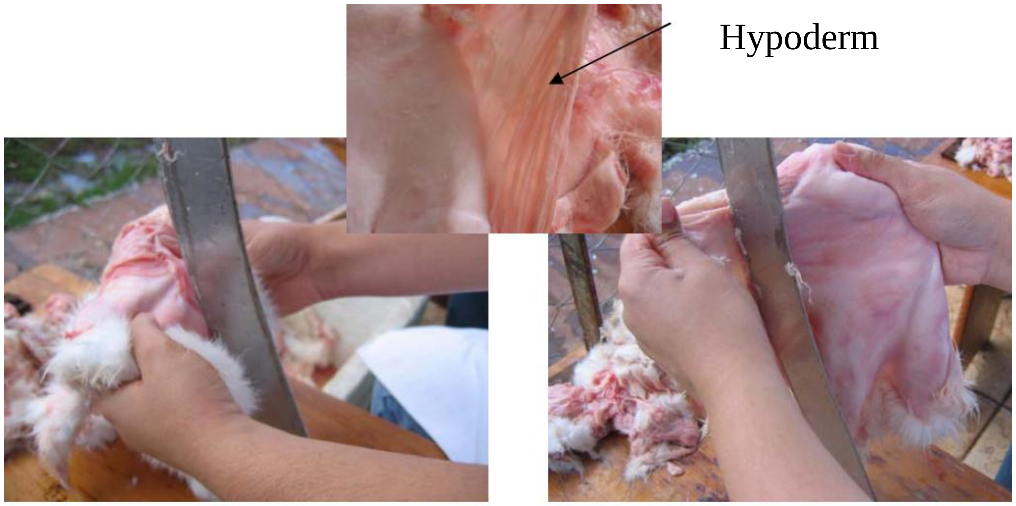

Figure 6 – . The removal of the hypoderm of the skin was made using a bank of fleshing

For the fur, those furs with hair are not submitted to stages of liming deliming and purging. The remaining steps are performed and during the step of dyeing, water should be prepared in a high temperature (60-80°C), and to the leather, the temperature should be normal. At the end of the process the skin should be submitted to the degreasing to make the hair free from oil.

After skin tanning it was removed the sampling to tests in order to determine the resistance to traction and elongation (ABNT-NBR 11041, 1997) and progressive tearing (ABNT-NBR 11055, 2005). The bodies-of-test were removed from the leather using the shuttle and then they were bring to the laboratory in an acclimatized environment around 23ºC and relative air moisture of 50%, during 48 hours according to ABNT (NBR 10455, 2006). To the tests of resistance it was used an EMIC dynamometer.

According to the rules, leather must need a body-of-test removed from the side of the parallel length to the dorsal line. The body-of-test must be removed in the parallel direction and perpendicular to the dorsal line.

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USE OF SOYBEAN HULLS IN THE REPLACEMENNT OF ALFAFA HAY IN NON PELLETED DIET FOR GROWING RABBITS

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Abstract

The present work was conducted in Rabbit Laboratory of Animal Science Department at the Federal University of Santa Maria, in the period among November 16th and December 28th, 2009, totalizing 42 days. It was used 36 animals distributed into three groups of 12 repetitions each, in experimental design completely randomized. The treatments consisted of TA = diet without inclusion soybean hulls (SH); TACS = diet with inclusion of 50% of soybean hulls and TCS = diet with 100% inclusion of soybean hulls as a replacement for alfafa hay. Isonutritive diets were formulated to meet the needs of the corresponding category, according to the AEC (1987). It was evaluated data of animal performance and carcass characteristics. The results were submitted to analysis of variance and means compared by Tukey test, at 5% significance level, with the aid of the statistical package SAS (2003). There were differences for feed intake and feed conversion, where the animals fed with TCS consumed less food than those of TA, and showed better conversion. For carcass characteristics, there was no difference between treatments, except for the weight of skin, which was higher for animals fed with the TA. We conclude that soybean hulls can replace 100% alfafa hay.

Keywords: Soybean hulls, animal performance, carcass, growing rabbits

Introduction

The rabbit is an animal that has the ability to benefit from foods relatively rich in fiber, competing to a lesser extent with mans than poultry and pigs, which consumed more grains in their diets. In addition, their biological characteristics (speed of the production cycle, prolificacy, power processing and excellent quality of meat) makes its play important role in improving the diet of the population (Lebas et al. 1986).

About 70% of the production cost in this activity is represented by the food. Alfalfa hay is traditionally included in diets of rabbits as a source of fiber, and contributes to significant amount of protein because it has averaged 17% CP; however it can raise up to 40% the cost of the diets (Herrera, 2003; Scapinello et al., 2003).

The use of agro-products in animal feed has always been a reality and the possibility of inclusion depends, among several factors, the availability of this material, the levels used in animal production, competition with other alternative products, the safety of use, costs and, of course, nutritional value (Mejia, 1999).

Soybean hulls are a sub product of industrialization of the grain, which has great prominence on the national scene because of high production of soybean, and represents an average of 8% of grain weight (Klopfenstein, Owen, 1987). The product is notable by high supply, competitive prices and quality composition that fits the feed, as has the proportion of highly fermentable fractions (cellulose and hemicellulose), and the low presence of lignin, a major component that affects the digestion of fiber (Serrana, 2006).

In the case of monogastric**,** bulky ingredients rich in pectin, such as soybean hulls can be degraded in the large intestine in greater percentages than bulky conventional (eg alfalfa hay). However, at levels where the substitution of alfalfa hay by soybean hulls did not affect animal performance, economic advantage may be better because of the cost of this ingredient to be lower, not reaching 50% of the cost of alfalfa hay. In this context, this study aimed to evaluate the effects of substitution of alfalfa hay by soybean hulls in diets for New Zealand White rabbits on performance and carcass parameters.

Materials and Methods

The experiment was conducted in the Rabbit Laboratory of Department of animal Science, at the Federal University of Santa Maria – RS. The period of experiment was from November 16th to December 28th, 2009, totaling 42 days. Were used 36 rabbits, 18 male and 18 female crossbred (New Zealand White x California), weaned at 35 days old.

The animals were housed individually in cages of precast concrete, with 0.7 x 0.5 x 0.4 m, floor and front of galvanized wire, equipped with feeders and drinkers type ceramic pots. The experimental design was completely randomized with three replications and 12 treatments, each animal was considered an experimental unit. The means were submitted to analysis of variance and after to Tukey's test, with 5% significance level, and with the aid of the statistical package SAS (2003).

The animals were submitted to the following treatments: TA = diets without the inclusion of soybean hulls; TACS = replacement of 50% of alfalfa by soybean hulls, TCS = replacement of 100% alfalfa by soybean hulls (Table 1). Isonutritive diets were formulated to meet the needs of the corresponding category, according to the AEC (1987). The diets were non pelleted and prepared at Feed Factory, Department of Animal Science UFSM.

The weighing of animals and feed was realized at 35 and 77 days, always in the first hours of the morning. At the end of the experiment was carried out the slaughter of animals for carcass characteristics, skin removal and evisceration. The carcass was weighed with the kidneys and liver, a digital scale. The parameters evaluated were body weight (BW), mean daily gain (MDG), daily feed intake (DFI), feed conversion (FC), hot carcass weight (HCW), hot carcass yield (HCY), weight skin (PP), weight of the gastrointestinal tract (TGI), Stomach Full (EC), empty weight of the caecum (PCV) and liver weight (FW).

Table 1- Formulation of experimental diets (%).

Ingredients	Treatments		
	TA	TACS	TCS
Corn	17.25	17.6	17.6
Rice hulls	6.00	5.02	4.72
Wheat bran	25.0	25.0	25.0
Alfafa hay	30.0	15.0	0.00
Soybean meal	17.5	20.9	24.3
Soybean oil	2.50	2.80	3.70
Soybean hulls grain	0.00	11.0	22.0
Salt	0.5	0.5	0.5
Dicalcium phosphate	0.81	1.00	1.00

Limestone	0.24	0.98	0.98
Vit. and Min Premix	0.2	0.2	0.2
Total	100	100	100

Nutricional levels

Ingredients		Values	
Crude protein (%)	18.00	18.00	18.00
Fat (%)	3.00	3.00	3.00
FDA (%)	15.0	15.0	15.0
Calcium (%)	0.84	0.84	0.84
Useful phosphorus (%)	0.45	0.45	0.45
Total phosphorus (%)	0.7	0.7	0.7
Digestible energy (Kcal/kg)	2600	2600	2600
Total lisine (%)	0.70	0.70	0.70
Sodium (%)	0.23	0.23	0.23

Results and Discussion

Performance data (Table 2) showed that animals feed with TCS consumed less ration than those feed with TA, having better food conversion. Probably due better digestive and metabolical use of diet with soybean hull. This sub product has low lignin content than alfafa hay, add to greater concentration of pectic substances with high fermentability cecum-colon. What probably proportionate high nutrients availability. Similar results were obtained by Retore (2009) who testing alfafa (FA), citric pulp (PC) and soybean hulls (CS) observed improvement in food conversion of animals feed with CS. And didn't observed significant effect in weight gain among animals feed with FA or CS.

The live weight of animal at 77 days old didn't differ among tested ingredients, agreeing with Arruda et al. (2003), who testing different fiber source (alfafa hay and soybean hulls) didn't observed difference for final weight.

Table 2 – Mean initial liveweight, final liveweight, average feed intake, average daily gain, feed conversion ratio of rabbits from 35 until 77 days old.

Variables	TA	TACS	TCS
Initial liveweight (g)	617.0 ±60.4	611.5 ±85.6	630.5 ±89.4
Final liveweight (g)	1995.0 ±10.1	1963.0 ±128.4	1990.0 ±55.7
Average feed intake (g/day)	99.4a ±8.8	91.3ab ±9.1	86.5b ±8.7
Average daily gain (g/ day)	32.8 ±5.6	31.5 ±4.0	32.3 ±2.8
Feed conversion ratio	3.19a±4.4	2.99ab±2.9	2.76b ±2.1

Means with different letters in the same raw differ significantly according to Tukey ($P<0.05$)

The carcass weight, carcass income and weight of liver (Table 3) did not present difference about tested levels. The skin weight was significantly higher for animals that consumed diets with FA. Probably because of the higher levels of hypodermic fat promoted by diet intake containing just alfafa hay as bulk ingredient.

There was no difference to weight gastrointestinal trait and stomach full, even like to empty caecum among treatments. Although exists the hypothesis that foods with high fermentability level could cause hypertrophy cecocolica, the individual variability among animals may obstructed the observation oh this result. Arruda et al. (2003) found higher caecum weight and cecal content for animals of CS treatment, due the chemical nature of cells wall of these fiber foods.

Table 3 – Parameters for carcass and gastrointestinal tract of rabbits slaughtered at 77 days old

Parameters	TA	TACS	TCS
	Carcass		
Carcass wheight (g)	1060.0 ±31.2	1070.0 ±88.3	1055.0 ±17.8
Carcass efficiency (%)	53.1±1.3	53.7±2.1	53.7±0.9
Wheight of liver (g)	62.5 ±6.4	51.2 ±4.7	56.2 ±9.4
Wheight of skin (g)	238.2a ±13.1	223.7ab ±12.5	211.2b ±7.5
	Gastrointestinal parameters		
TGI full	138.7 ±13.1	150.0 ±14.1	142.5 ±16.6
Stomach full	91.2 ±13.1	93.7 ±4.8	105.0 ±13.5
Empty Caecum	35.0 ±7.0	45.0 ±7.0	43.7 ±10.3

Means with different letters in the same raw differ significantly according to Tukey (P<0.05)

Conclusion

The inclusion of soybean hull in the feed of growing rabbits showed to be promissory, did not affecting negatively the performance and slaughter yield of animals.

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PEARL MILLET (PENNISETUM GLAUCUM) EVALUATION IN GROWING RABBITS

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Abstract

Two experiments were conducted to determine the nutritional value and assess the performance of growing rabbits fed diets containing different levels of pearl millet (Pennisetum glaucum) ADR 7010, without pearl millet ensiled inoculant (MESI) and pearl millet ensiled inoculant with enzyme- bacterial Katec Bacto ® Silo Master Tropical (MECI). In the digestibility trial were used 40 New Zealand White rabbits, male and female, with an average of 45 days old, distributed in a completely randomized design with four treatments, one reference diet and three test diets containing 70% of its volume by the reference diet and 30% for pearl millet ADR 7010, MESI and MECI and ten repetitions. The amount of digestible energy (kcal / kg) and digestible protein (%) of pearl millet ADR 7010, MESI and MECI were 11.77 and 3361, 3547 and 3427 and 12.79 and 12.41 based on total dry weight. In the experiment, we used 320 New Zealand White rabbits, including 160 males and 160 females, 32 days old, distributed in a completely randomized design with 16 treatments, ten repetitions and two animals each. Diets were formulated to contain increasing levels of corn replacement of a reference diet (20, 40, 60, 80 and 100%) by 7010 ADR millet grain milled, MESI and MECI. There were no differences in feed intake, daily weight gain, feed conversion, carcass characteristics and cost of ration per kilogram of rabbit produced, as corn was replaced by the pearl millet ADR 7010 in diets for rabbits based on digestible energy. The conclusion is that pearl millet ADR 7010, MESI and MECI have good nutritive value and can replace 100% of corn in diets of growing rabbits.

Keywords: digestibility, carcass, energy value, feeding

AVALIAÇÃO DE MILHETO (PENNISETUM GLAUCUM) PARA COELHOS EM CRESCIMENTO

Resumo

Dois experimentos foram conduzidos com o objetivo de determinar o valor nutritivo e avaliar o desempenho de coelhos em crescimento alimentados com rações contendo diferentes níveis de milheto grão (*Pennisetum glaucum*) ADR 7010, milheto ensilado sem inoculante (MEsI) e milheto ensilado com inoculante enzimo-bacteriano Katec® Bacto Silo Máster Tropical (MEcI). No ensaio de digestibilidade foram utilizados 40 coelhos da raça Nova Zelândia Branco, machos e fêmeas, com média de 45 dias de idade inicial, distribuídos em um delineamento inteiramente casualizado, com quatro tratamentos, uma dieta referência e três dietas teste composta por 70% do seu volume pela dieta referência e 30% pelo milheto ADR 7010, MEsI e MEcI e 10 repetições. O valor de energia digestível (kcal/kg) e proteína digestível (%) do milheto ADR 7010, MEsI e MEcI foram de 3361 e 11,77, 3547 e 12,79 e 3427 e 12,41 com base na matéria seca total. No experimento de desempenho, foram utilizados 320 coelhos da raça Nova Zelândia Branco, sendo 160 machos e 160 fêmeas, com 32 dias de idade inicial, distribuídos em delineamento inteiramente casualizado, com 16 tratamentos, dez repetições e dois animais por unidade experimental. As rações foram formuladas contendo níveis crescentes de substituição do milho de uma dieta referência (20,

40, 60, 80 e 100%) pelo milheto grão ADR 7010 moído, MEsI e MEcI. Não foram observadas diferenças no consumo diário de ração, no ganho diário de peso, na conversão alimentar, nas características de carcaça e no custo em ração por quilograma de coelho produzido, à medida que o milho foi substituído pelo milheto ADR 7010 nas rações para coelhos, com base na energia digestível. Pode-se concluir que o milheto ADR 7010, MEsI e MEcI apresentaram bom valor nutritivo e podem substituir 100% do milho nas rações de coelhos em crescimento.

Palavras–chave: alimentação, carcaça, digestibilidade, valor energético

Introduction

The lack of information on the nutritive value limits the use of alternative feeds such as millet grain, which, until a few years ago wasn't used in feeds because its cost wasn't inviting and the offer was little and discontinuous. The growing in pearl millet culture in Brazil, especially in Centro-Oeste, has made available the grain in Brazilian market, it can be used in animal feeding, since it has a good nutritive value, especially for monogastric animals. The pearl millet (*Pennisetum glaucum*) is the 6th most cultivated cereal in the world (154 millions of tons) and is largely used in Africa, Asia and North America in human and animal feeding (FAO, 2005). In 2007, was released the first millet hybrid in Brazil, ADR 7010, which presents important characteristics in gran market, such as high productivity levels. The use of ADR 7010 in broiler feeding was observed by Murakami et al. (2009), and the results were satisfactory. However, there is no information on the use of this millet variety in rabbit feeding. Therefore, this work aims to determine the nutritive value of millet grain ADR 7010, MEsI and MEcI, through digestibility trial, and to evaluate the performance in growing of rabbits fed with increasing levels of millet grain ADR 7010, MEsI and MEcI, substituting corn.

Materials and Methods

Two experiments were carried out in the rabbit sector of Fazenda Experimental de Iguatemi da Universidade Estadual de Maringá. In the digestibility assay, we used 40-45 days old animals divided in four treatments - a reference group diet and three test diets, in which pearl millet cultivar ADR 7010, MESI e MECI took the place of 30%, based on dry material, of a reference diet. Pearl millet ensiled was made in experimental 200 litres silos, and water was added to it, in order to increase humidity levels to approximately 30%. Pearl millet ensiled was used after 40 days from the silos closure. The experimental foods were dry pelleted and, throughout the whole experiment, the animals were freely fed, once a day, and had free access to water. The experimental period lasted eleven days, from which seven were destined to the animals adaptation to the place and four to feces collection. In order to calculate the digestibility coefficients and digestible nutrients coefficients in the pearl millet ADR 7010, MESI e MECI, we used the methodology described in Matterson et. al. (1965). The digestibility coefficients and digestible nutrients coefficients based on total dry matter, obtained for the pearl millet ADR 7010, MESI e MECI, were compared based on the value of f ($p>0,05$). In the performance assay, we evaluated feeds containing increasing levels of substitution of corn (20, 40, 60, 80 e 100%) by pearl millet ADR 7010, MESI e MECI, based on the corn digestible energy. We used 320 New Zealand White rabbits, of 32 to 70 days old, divided in a completely randomized design, with 16 treatment, ten replications and two animals by experimental unit. The evaluated performance characteristics were live weight, daily weight gain (DWG), daily feed intake (DFI), food conversion, weight and carcass output. the levels of liberty related to the treatments excluding reference diet were converted into polynomials. Dunnet test was used to compare the results obtained with reference diet to those obtained with each of the feeds with different levels of pearl millet grain ADR 7010, MESI e MECI inclusion.

Results and Discussion

No differences were observed (P>0,05) on the coefficients of digestibility of dry matter, raw protein, raw energy and ADF amongst the different presentation forms of the pearl millet ADR 7010. These results indicate the use of inoculant had no influence whatsoever on the availability of the evaluated nutrients or the energy. Likewise, no differences were observed (P>0,05) on the digestible nutrients, except that the digestible value of NDF was higher (P<0,05) for the millet silage with inoculant. The increase in the fiber digestibility is a result of different factors that change the intake and the susceptibility of the fiber digestion. Furlan et al (2003), evaluating the nutritive value of several millet varieties in rabbit feeding, found apparent digestibility of raw energy (CDEB) and raw protein (CDCP) coefficient of 83,16% and 45,86% for the common millet and 87,49% and 83,51% for the cultivar millet IAPAR. The same authors found very close values of digestible energy (ED) for the common and IAPAR millet – 3410 and 3505 kcal/kg of MS.

Table 1 - Coefficients of apparent digestibility of dry matter (CDMS), raw protein (CPD), neutral detergent fiber (CDNDF), acid detergent fiber (CDFDA) and raw energy (GEDC) and digestible dry matter (DDM), protein digestible (PD), digestible neutral detergent fiber (FDND), digestible acid detergent fiber (DADF) and digestible energy (DE) of pearl millet grain ADR 7010, MECI and MESI based on total dry matter.

Nutrient (%)	Pearl Millet	MEsI	MEcI
CDDM	88,71	93,07	91,13
CDCP	85,39	90,63	85,26
CDNDF[1]	24,35[a]	14,51[a]	32,56[b]
CDADF[2]	18,56	19,84	17,66
CDEB kcal/kg	75,02	78,98	76,72
DMD %	81,25	90,17	88,74
CPD %	11,77	12,79	12,41
NDFD %	4,28[A]	3,31[A]	7,30[B]
ADFD %	0,63	0,51	0,46
ED kcal/kg	3361	3547	3427

[AB] Averages followed by different lowercase letters in the row, differ by the F test (P <0.05). [ab] Averages followed by different capital letters in the row, differ by the F test (P <0.05)

Regarding the results of performance and weight and carcass output (Table 2), we notice there was no difference for the evaluated parameters with the gradual inclusion of pearl millet grain ADR 7010, MEsI e MecI in substitution of corn digestible energy. Likewise, comparing the results obtained with the reference diet with each of the inclusion levels of pearl millet grain ADR 7010, MEsI and MEcI in substitution of digestible energy of corn there were no differences (P> 0,05) for any of the performance traits, weight and carcass yield and feed cost/kg weight gain in the period 32-70 days old, indicating that the addition of millet, regardless of level, effectively replaces the corn.

Table 2. Live Weight at 70 days (PV70), daily weight gain (ADG), feed intake (FI), feed conversion (FC), body weight (PCAR), carcass yield (RCAR) and cost of feed/kg live weight gain (R$) of growing rabbits fed diets containing different levels of millet grain ADR 7010, MESI and MECI

Characteristics	Control Feed	% corn substitution by pearl millet grain					Media	CV[1] (%)
		20	40	60	80	100		
PV70 (g)	2159	2201	2159	2141	2167	2064	2143	9,42

GPD (g)	38	39	38	38	38	36	38	14,13
CRD (g)	115	121	120	117	118	109	116	10,78
CA	3,08	3,15	3,24	3,18	3,18	3,2	3,19	10,17
PCAR (g)	1146	1163	1148	1156	1169	1086	1143	12,24
RCAR (%)	53,19	52,86	53,16	53,96	54,1	53,8	53,57	4,21
Custo/kg (R$)	1,91	1,94	1,94	1,91	1,87	1,86	1,89	10,07
Silage Millet Without Inoculant								
PV70 (g)	2159	2191	2298	2128	2048	2092	2136	9,06
GPD (g)	38	39	42	37	35	36	38	13,46
CRD (g)	115	114	119	114	111	110	113	12,74
CA	3,08	3,07	3,08	3,14	3,3	3,12	3,12	14,56
PCAR (g)	1146	1154	1159	1184	1090	1114	1137	7,96
RCAR (%)	53,19	52,71	51,24	53,86	53,53	53,29	53,02	5,59
Custo/kg (R$)	1,91	1,83	1,64	1,82	1,87	1,75	1,75	14,86
Silage Millet with Inoculant								
PV70 (g)	2159	2153	2236	2118	2130	2138	2147	5,91
GPD (g)	38	38	40	37	37	38	38	8,79
CRD (g)	115	111	119	106	107	116	114	9,7
CA	3,08	3,01	3,04	3,04	3,02	3,01	3,1	9,19
PCAR (g)	1146	1149	1176	1111	1104	1118	1139	9,49
RCAR (%)	53,19	53,46	52,95	53,1	53,01	53,7	53,26	3,24
Custo/kg (R$)	1,91	1,83	1,84	1,70	1,66	1,76	1,76	10,07

1.Variation Coefficient

The pH levels found for millet grain ADR 7010, MECI and MESI, which were 5.9, 4.8 and 4.5 units, can be considered satisfactory because they are close to those cited by Jobim et al. (1997).

Conclusion

Under the conditions in which the experiment was carried out, we concluded that pearl millet ADR 7010, and the Pearl Millet Ensiled with or without inoculation has good nutritive value and can replace the corn in the formulations in diets for growing rabbits, and their use will depending on supply and market price. The addition of inoculant on silage fermentation of millet had no influence on the performance of rabbits.

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BIOLOGICAL UTILIZATION OF VISCERA SLAUGHTER WASTE FROM RABBITS AS COMPOST

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ABSTRACT

The aim of the trial was to study composting as a bioconversion technique for the treatment and processing of rabbit viscera, considered as a slaughter waste. Nine compost cribs (0.60 m x 1 m x 0.40 m high) were made and contained one of the following mixtures (3 cribs /treatment): Control - 60% wood chips-40% rabbit faeces; Viscera - 60% wood chips-40% viscera, and VF - 60% wood chips-20%faeces-20% rabbit viscera. The cribs were located on the grounds of a penitentiary located in Entre Ríos, Argentina, that included a rabbit production unit, a rabbit slaughter house, a vegetable garden, and a carpentry unit. Prior to turning the compost, temperature and pH readings were determined weekly and samples were sent to the laboratory for soils of the Faculty of Agronomy (Univ. Buenos Aires) to determine humidity, electrical conductivity, and nutrient content. Treatment data were tested using statistical analyses procedures for time repeated measures. The pH of the 3 treatments complied with standard values set for organic fertilizers (pH 4-9) with no differences ($P>0.05$) among treatments. Viscera and Control treatments showed a moisture content level close to the recommended value (<20%). All treatments produced compost with values below the threshold for ash (<60% set by the EPA). The contents of K and P were acceptable for all treatments, being higher in Control and Viscera groups compared to the VF treatment. The organic carbon content was lower than the recommended level (> 15% set by the EPA) after 15 days of composting, although treatments Viscera and Control had higher values than VF, being close to recommended levels. In conclusion, the composting process offers a technically relevant solution to the negative environmental impact caused by the improper handling of the viscera of rabbits. The physical and chemical data results from the three treatments suggest the recommendation of using composting mixtures from the sawdust-faeces and sawdust-viscera.

Key words: Composting, Rabbit viscera, Faeces, Penitentiary unit.

INTRODUCTION

The generation of organic wastes as pollutants is a global environmental problem. The proper use of these wastes will benefit not only agricultural production but also help to improve environmental protection, which would prevent the wastes (e.g., blood and viscera) from being disposed into the environment without previous chemical treatment (Uicab Brito and Sandoval-Castro, 2003). The ‘composting’ method would be an alternative use of meat by-product wastes.

The low number of rabbits slaughtered in Argentina (200,000 rabbits /year in 8 slaughter houses with national authorization to export; MINAGRI data 2011) determined that the wastes that are not used directly were discarded in the trash, burned, buried or disposed into rivers or streams.

Composting is the result of a natural process in which certain beneficial organisms reduce and transform organic wastes into a useful product. The viscera of rabbits have a large amount of microbial flora that may be beneficial to the soil if it is used as fertilizer. There are no studies to date on the use of domestic rabbit viscera to obtain compost for use as soil fertilizers. The objective of this work was to study the composting method as a bioconversion technique for the treatment and processing of the viscera from rabbit slaughter.

MATERIALS AND METHODS

The study was carried out on the grounds of the Criminal Unit N◦ 1 (Entre Ríos, Argentina) using the wastes (faeces) from the production unit of rabbits, the slaughter room, and a carpentry unit. Nine compost cribs (0.60 m x 1 m x 0.40 m high) were made from the following mixtures (3 compost cribs / treatment): Control - 60% wood chips-40% rabbit faeces; Viscera - 60% wood chips and 40% viscera, and VF: 60% wood chips, 20% faeces, and 20% rabbit viscera. The faeces or viscera were deposited at the bottom of each crib, and then was piled with wood chips, repeating the process until a desired height was achieved, but always taking care that all cribs were covered with the vegetable residue.

The compost cribs were located on the ground, being kept under natural conditions but was covered by a plastic sheet in the case of rain. Water irrigation levels were applied at a rate that corresponded to maintaining a humidity level of 85%. Dumps were performed weekly.

Prior to turning compost, temperature (multi-voltmeter with thermocouple), humidity (manual), and pH (reactive strips, MERK) were measured weekly at three points in each compost crib (2 measurements in the corners and 1 in the center). Samples were sent to the laboratory for soils of the Faculty of Agronomy (University of Buenos Aires) to determine electrical conductivity and pH (potentiometer) in all samples. Organic carbon (Walkley Black methodology), phosphorus (Kurtz and Bray1 methodology), potassium (Ac NH4-1N-pH 7 methodology) and ash (AOAC, 1984) samples were taken in the second and last week.

Treatment data were tested using Proc Mixed of SAS (2004) for time repeated measures. Estimates of the fixed week and treatment effects were obtained and the covariance structure was computed using REML estimates.

RESULTS AND DISCUSSION

From the physical point of view, after 4 weeks, the compost obtained for each of the treatments presented odor ‘similar to the ground’, dark brown color and good consistency, presenting it as a product with good physical properties, which is in agreement with that described by Dickerson (2000). Table 1 shows the temperature determinations and results of chemical analyzes of compost samples.

In general, the temperatures from day 7 were below the range that favors the growth of microorganisms (55-75 ◦C) with the center measured higher than the temperatures measured at the corners of the cribs. The temperatures varied depending on the week of study, but decreased with composting time, hence resulting week x treatment interaction (P <0.0001) with the Control treatment cribs having the lowest temperatures. The lowest values at week 3 were due to adverse weather conditions in the days before measurements were taken.

The pH results obtained in all treatments complied with the standard values set for organic fertilizers (pH 4-9) with no differences (P>0.05) among treatments. The pH values measured in the field (reactive strips) were higher and more variable compared to laboratory determinations. Viscera and Control treatments showed a moisture content closer to the recommended value of <20%) established by the Environmental Protection Agency (EPA, 1995), although the highest value of moisture found in the mixed treatment viscera-faeces (VF) could have been due to a flooding problem in one of their cribs after the third week.

Table 1: Temperature, pH and compost chemical determinations by per week and treatment

Item	Week				Treatments			Probability			SE
	1	2	3	4	Control	Viscera	VF	week	Treat.	WkxTr	
Temperature Corner 1 (◦C)	35.2	30.6	27.4	31.6	29.4	32.0	32.2	<.0001	.0118	.0050	0.76
Temperature Center (◦C)	36.6	35.1	27.9	32.3	30.9	33.5	34.6	<.0001	.0438	.0089	0.99
Temperature Corner 2 (◦C)	35.3	31.8	27.9	32.3	30.6	32.0	32.9	<.0001	.1485	.0023	0.72
pH (field)	8.33a	8.00a	7.56ab	6.56b	7.67	7.83	7.33	<.0001	.2577	.6619	0.43
pH (laboratory)	7.59	7.90	7.82	7.71	7.72	7.70	7.83	.0391	.2937	.0002	0.17
Electrical conduct.(ds/m)	6.86	6.84	5.80	6.53	5.73	7.59	6.25	.9148	.5851	.2518	2.20
Humidity (%)	nd[1]	20.5	nd	27.2	22.2a	22.1a	27.3b	.0023	.0367	.5851	1.67
O. Carbon (%)	nd	16.4	nd	6.43	12.7	11.6	9.95	<.0001	.1012	.0084	1.61
Ash (%)	nd	8.96	nd	13.3	11.4	14.0	7.93	.0381	.0073	.0323	0.99
P (ppm)	nd	252.6	nd	277.6	315.3	257.4	222.8	.4363	.1110	.5186	21.2
K (ppm)	nd	509.5	nd	593.5	591.5	576.5	486.6	.0451	.1292	.6053	25.3

[1]nd: not determined

With respect to ash content, all treatments produced compost with values below the threshold (<60%, EPA, 1995) but without significant differences between Control and Viscera treatments. The contents of K and P were acceptable for all treatments and higher in Control and Viscera compared to VF treatments. The organic carbon content was lower than recommended (> 15% EPA, 1995) from 15 days of composting, although treatments, Viscera and Control, had values that were higher than the VF treatment, being similar to recommended levels.

CONCLUSIONS

The composting process offers a technically relevant solution to the negative environmental impact caused by the improper handling and disposal of the viscera of rabbits generated in slaughter houses. In the case of the Criminal Unit, composting allows the combined treatment of 2 sub-products (of animal origin: faeces and viscera and from plants and sawdust from the carpentry unit) to produce 'compost' that can be used in the organic garden of the prison unit. The physical and chemical data results from the three treatments suggest the recommendation of using composting mixtures from the sawdust-faeces and sawdust-viscera.

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NUTRITIONAL EVALUATION OF VEGETAL CRUDE GLYCERIN FOR GROWING RABBITS

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Abstract

This study was carried out to determine the digestible energy of glycerin through a digestibility assay and evaluate different inclusion levels of vegetal crude glycerin in rabbit feeding in replacement of corn. In the digestibility assay, 60 New Zealand White rabbits were used, 45 days old, assigned in a completely randomized design to five treatments with one reference diet and four test diets, where the glycerin was included at 4, 8, 12 and 16%, replacing the reference diet volume and 12 replications. The digestible energy and digestible dry matter values of the glycerin were, respectively, 5,330 kcal/kg of dry matter and 90.57%. In the performance assay, 100 New Zealand White rabbits were utilized, 32 days old, distributed in a completely randomized design into five treatments, with diets containing increasing levels of glycerin (0, 3, 6, 9 and 12%) in replacement of corn, and 10 replications with two animals per experimental unit. The data were submitted to polynomial regression, while the differences with the data obtained with the reference diet were compared by Dunnett's Test ($P<0.05$). A decreasing linear effect was observed for LW at 50 days, LW at 70 days, DWG from 32 to 50 days and from 32 to 70 days of age, DFI from 32 to 50 days and from 32 to 70 days of age, and CW as the level of glycerin inclusion increased. By Dunnett's test, only LW at 50 days and DFI from 32 to 70 days of age of the animals fed with the diet containing 12% of glycerin were lower than those obtained by the animals that received the reference diet. It is concluded that it is possible to include 12% vegetal crude glycerin in growing rabbit feeding in replacement of corn energy.
Keywords: digestible energy, inclusion level, substitution.

Introduction

Corn is one of the main sources of energy in monogastric diets, as it contains high quantities of starch. However, high levels of this nutrient in rabbit diets can cause digestive problems, resulting in high mortality rates during the growing phase (ARRUDA et al., 2003). According to CARABAÑO et al. (1997), the maturation of enzymatic processes is important, especially regarding the amount of starch that reaches the caecum, which may be the major problem in diets with high starch levels, because the availability of an easily fermentable energy source supports the proliferation of glucose-dependent flora, destabilizing the cecal microflora and leading to digestive disorders. Therefore, it is necessary to maximally reduce the starch level in the diet of the animals from weaning to 50 days of age. Therewith, ingredients that can contribute to this reduction, without changing the energy value of the diet, deserve great attention. Presently, in addition to oils and fats that can be utilized in rabbit diets – although in limited amounts – glycerin appears as an alternative. Glycerin, a by-product of the biodiesel industry, also known as glycerol, it is an organic compound with alcohol function that shows a great energetic value. This paper aimed to determine the glycerin digestible energy through a digestibility assay and evaluate different levels of vegetal crude glycerin inclusion in rabbit diets replacing corn.

Material and Methods

The trial was accomplished in the rabbit sector located at the Iguatemi Experimental Farm of the State University of Maringá, Paraná State, Brazil, from April to June 2009. For the digestibility assay, 60 New Zealand White rabbits were utilized, males and females, 45 days old, allocated in individual metabolism cages. The design was completely randomized with five treatments (one reference diet plus four test diets), and 12 replications. The reference diet was formulated based on corn, wheat bran, soybean meal, alfalfa hay (*Medicago sativa*), stargrass hay (*Cynodon nhenfluensis*), soybean oil and supplemented with vitamins and minerals. For test diets, vegetal crude glycerin was included at levels of 4, 8, 12 and 16%, replacing the natural matter of the reference diet. All diets were dry pelleted. The assay was conducted according to the European Reference Method for *in vivo* digestibility trials (PEREZ et al., 1995).

The apparent digestibility coefficients of glycerin dry matter and gross energy were calculated using the regression method (VILLAMIDE, 1996).

In the performance trial, 100 New Zealand White rabbits were used, 32 days old, distributed into five treatments (0, 3, 6, 9 and 12%) of glycerin inclusion replacing corn digestible energy and ten replications, with two animals per experimental unit. The diets (Table 1) were isonutritive with levels of crude protein, methionine+cystine, lysine, calcium, phosphorus, neutral detergent fiber, acid detergent fiber and digestible energy, respectively, of 16%, 0.60%, 0.76%, 0.80%, 0.50%, 42%, 21% and 2,650 kcal/kg of dry matter. The levels of starch, however, decreased with the inclusion of glycerin with values of 26, 23, 20, 17 and 14%, respectively, for all five diets.

The animals were housed in galvanized wire cages, with automatic water dispenser and semi automatic feeders, with free access to feed and water. The rabbits were weighed at 32, 50 and 70 days of age, along with the feeds and leftovers, in order to calculate feed intake, weight gain and feed conversion. At slaughter, weight and carcass yield were evaluated. Hot carcass with head and without edible viscera was considered in order to determine carcass weight.

Table 1 – Percentage and chemical composition of the experimental diets

Ingredients	Reference	Inclusion Levels of Vegetal Crude Glycerin (%)			
	Diet	3	6	9	12
Stargrass	22.60	22.81	23.02	23.23	23.44
Alfalfa hay	15.00	15.50	16.00	16.50	17.00
Corn	22.10	17.58	13.05	8.52	4.00
Wheat bran	23.00	23.25	23.50	23.75	24.00
Soybean meal	13.00	13.62	14.25	14.87	15.50
Limestone	0.80	0.75	0.70	0.65	0.60
Dicalcium phosphate	0.40	0.43	0.45	0.48	0.50

Salt	0.40	0.37	0.35	0.32	0.30
Premix[1]	0.50	0.50	0.50	0.50	0.50
Methionine	0.09	0.09	0.09	0.10	0.10
Lysine	0.05	0.04	0.03	0.02	0.00
Cycostat®[2]	0.06	0.06	0.06	0.06	0.06
Soybean oil	2.00	1.50	1.00	0.50	0.00
Inert	0.00	0.50	1.00	1.50	2.00
Glycerin	0.00	3.00	6.00	9.00	12.00
Total	100	100	100	100	100

[1]Nuvital, composition per kg of product: vit. A – 600,000 UI; vit. D – 100,000 UI; vit. E – 8,000 mg; vit. K3 - 200 mg; vit. B1 - 400 mg; vit. B2 - 600 mg; vit. B6 - 200 mg; vit. B12 – 2,000 mcg; pantothenic acid – 2,000 mg; choline – 70,000 mg; Fe – 8,000 mg; Cu – 1,200 mg; Co - 200 mg; Mn – 8,600 mg; Zn – 12,000 mg; I - 64 mg; Se - 16 mg; Methionine – 120,000 mg; antioxidant – 20,000 mg; [2]Robenidine-based active principle (6.6%).

Performance data and animal carcass characteristics were submitted to polynomial regression analysis, while the differences with the data obtained with the reference diet were compared by Dunnett's test ($P<0.05$).

Results and Discussion

The digestibility coefficients of glycerin gross energy and dry matter were, respectively, 95.41% and 92.93%. Applying these percentages to the chemical composition, the values of digestible energy and dry matter of glycerin for rabbits were, respectively, 5,330 kcal/kg and 90.57%.

Analyzing performance, a linear reduction ($P<0.05$) was observed for variables LW at50 days, LW at 70 days, DWG from 32 to 50 days and from 32 to 70 days, and CW, as the inclusion levels of glycerin increased. Using Dunnett's test, only LW at 50 days and DFI from 32 to 70 days of age of the animals that received the diet with addition of 12% of glycerin in partial substitution of corn digestible energy, and also CW for the animals fed with the diets containing 9 and 12% of glycerin were lower ($P<0.05$) in relation to those that consumed the reference diet. CERRATE et al. (2006) evaluated the inclusion of 5 and 10% of crude glycerin in broiler chickens and observed that the level of 10% impaired feed intake, final live weight and, consequently, feed conversion of the animals. However, LAMMERS et al. (2007), including 5 e 10% of crude glycerin in the diet of nursery pigs, observed no effect on animal performance.

Table 2 – Estimated means and coefficient of variation (CV) of live weight (LW) from 50 to 70 days (d), daily weight gain (DWG), daily feed intake (DFI), feed conversion (FC), carcass weight (CW) and carcass yield (CY) of rabbits fed, from 32 to 70 days of age, with diets containing different levels of vegetal crude glycerin inclusion replacing corn, as basis of digestible energy.

Características	Reference Diet	Inclusion Levels of Vegetal Crude Glycerin (%)				Mean	CV
		3	6	9	12		
LW 50d (g)[1]	1,497	1,445	1,505	1,404	1,391*	1,448	6.30
LW 70d (g)[1]	2,079	2,044	2,088	1,974	1,978	2,033	6.37
DWG 32-50d (g)[1]	39.42	36.52	39.88	34.27	33.52	36.72	13.81
DWG 32-70d (g)[1]	34.00	33.06	34.24	31.24	31.33	32.77	10.40
DFI 32-50d (g)	112.14	114.46	112.84	107.23	101.81	109.70	10.15

DFI 32-70d (g)[1]	123.13	126.25	122.71	119.13	111.33*	120.51	7.03
FC 32-50d (g)	2.84	3.13	2.83	3.13	3.04	2.99	15.03
FC 32-70d	3.62	3.82	3.58	3.81	3.55	3.68	10.07
CW (g)[1]	1,200	1,137	1,150	1,056*	1,098*	1,128	5.06
CY (%)	55.94	55.97	55.32	53.86	54.89	55.20	3.57

[1] Linear effect; LW 50d: y= 1,498.96-8.4395X, R^2=0.59; LW 70d: y= 2,087.07-9.0577X, R^2=0.63; DWG 32-50d: y= 39.5367-0.4689X, R^2=0.59; DWG 32-70d: y= 34.2046-0.2384X, R^2=0.63; DFI 32-70d: y= 126.6540-1.0240X, R^2=0.72; CW: y= 1,185,22-9.4992X, R^2=0.68.

Means followed by "*", in the row, differ from those obtained with the reference diet by Dunnett's test ($P<0.05$).

Conclusions

Vegetal crude glycerin provided 5,330 kcal/kg of digestible energy for rabbits, demonstrating is it a great source of energy value. Based on results of live weight at slaughter, its inclusion in growing rabbit diets can occur up to the maximum level studied, 12%.

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