Acta Scientiarum

http://www.uem.br/acta
ISSN printed: 1806-2563
ISSN on-line: 1807-8664
Doi: 10.4025/actascitechnol.v35i4.20251

Chemical characterization of pressed and refined licuri (*Syagrus coronata*) oils

Luciana Carolina Bauer[1], Jeanny Mércia do Amaral Damásio[1], Marcondes Viana da Silva[1], Débora de Andrade Santana[2], Simone Andrade Gualberto[2] and Julliana Izabelle Simionato[1,3*]

*[1]Programa de Pós-graduação em Engenharia de Alimentos, Universidade Estadual do Sudoeste da Bahia, Praça Primavera, 40, 45700-000, Itapetinga, Bahia, Brazil. [2]Departamento de Estudos Básicos e Instrumentais, Universidade Estadual do Sudoeste da Bahia, Itapetinga, Bahia, Brazil. [3]Universidade Federal Tecnológica do Paraná, Londrina, Paraná, Brazil. *Author for correspondence. E-mail: jsimionato@utfpr.edu.br*

ABSTRACT. Knowing the composition of foods is fundamental to assess their potentialities and the availability of nutrients to consuming populations. The objective of this work was to increase knowledge about the licuri fruit (*Syagrus coronata)* by quantifying the fatty acids and verifying the antioxidant potential in the kernel´s fruit and in the pressed oil´s fruit. The lipid profile data shows a predominance of saturated fats, high levels of medium-chain fatty acids such as lauric and myristic fatty acids, a composition very similar to the coconut oil. Antioxidant activity was observed using methods of DPPH radical sequestration, ferric reduction and total level of phenolic compounds. The oil characterization in the Licuri fruit brings the prospect of using the same in cosmetic and pharmaceutical industry, as well as a healthy alternative for consumption by the population living in the semi-arid region in Brazil.

Keywords: medium-chain fatty acids, antioxidant, DPPH, FRAP, phenols.

Caracterização química dos óleos prensado e refinado do licuri (*Syagrus coronata*)

RESUMO. O conhecimento da composição dos alimentos é fundamental para se avaliarem a disponibilidade de nutrientes para as populações consumidoras e as potencialidades dos mesmos. Neste trabalho objetivou-se aprofundar os conhecimentos sobre o Licuri (*Syagrus coronata)*, através da quantificação dos ácidos graxos da amêndoa e do azeite do fruto, e do estudo do seu potencial antioxidante. Os dados do perfil lipídico mostram predominância de lipídios saturados, alto teor de ácidos graxos de cadeia média, onde destacam-se os ácidos graxos láurico e mirístico, composição bastante parecida com a do óleo de coco. A atividade antioxidante foi constatada através dos métodos de seqüestro do radical DPPH, redução de íon de ferro e teor total de compostos fenólicos. A caracterização do óleo do Licuri traz a perspectiva de usá-lo na indústria cosmética e farmacêutica, bem como uma alternativa saudável para consumo pela população que vive na região semi-árida do Brasil.

Palavras-chave: ácidos graxos de cadeia média, antioxidante, DPPH, FRAP, fenólicos.

Introduction

Due to its continental size, Brazil has an abundance of foods, especially from vegetal source that are either yet to be nutritionally characterized or need better characterization. Knowing the nutritional composition of foods is fundamental to assess the availability of nutrients, so they can be adequately consumed by the population. Furthermore, it is also important for verification of the nutritional adequacy of diets, for the development of studies about the relationships between diets and diseases, for agricultural planning and its use by the food, chemical and pharmaceutical industry.

Licuri or ouricuri (*Syagrus coronata*) is a poorly studied palm tree commonly found in the Brazilian Cerrado, and thus it is part of the group of foods that need better characterization. The species has clear preference for the dry, arid regions of Brazil's Caatingas. Its distribution includes the north of Minas Gerais, the whole eastern and central portion of Bahia and the south of Pernambuco, including the states of Sergipe and Alagoas. However it blossoms and yields fruit throughout the year, it is in the months of March, June and July that it bears more fruit, which characterizes its harvest period (BONDAR, 1938).

Licuri has been studied mainly as a source of animal nutrition, especially ruminants, and more specifically, caprines. Numerous studies demonstrate that supplementing animal nutrition with licuri oil has positive aspects such as improved sensorial acceptance of goat's milk and its fatty content, and an improvement in the milk's stability (QUEIROGA et al., 2010).

The licuri fruit is commonly found as part of the diets of many small communities in the Brazilian Northeast, where its extract that is a kind of milk and its kernel are consumed also as sweets, liqueurs and ice creams.

Its kernel is also used for oil extraction because of the high oil content (54%) (PINTO et al., 2012). Licuri oil is similar to the coconut palm (*Cocus nucifera*, Lin) oil (BONDAR, 1938), with 83.2% short- and medium-chain fatty acid content (QUEIROGA et al., 2010). It is used in diets as a source of vegetable oil, and in the production of high quality soaps, given that licuri oil is considered the best Brazilian oil for this type of production.

Due to its similarity with coconut oil, currently linked to a number of health benefits such as weight loss, and in an attempt to expand consumption and research, the objective in carrying out this study was to improve knowledge about this native Brazilian specie by quantifying the fatty acids and lipids present in kernel oil and licuri pressed oil, as well as studying its antioxidant potential.

Material and methods

Sampling

Samples of licuri fruit kernel were obtained from markets at Chapada Diamantina, Bahia. Samples of cold-pressed licuri fruit oil were obtained from a producer's cooperative in the Piemonte da Diamantina region, Bahia.

Fatty acid assay

The assays were carried out at the Chromatographic Assay Center (CEACROM) of Universidade Estadual do Sudoeste da Bahia.

The methodology proposed by Bligh and Dyer (1959) was used to get the oil from the kernels of the licuri fruit finely processed. These extractions were carried in triplicate.

Both lipids obtained from kernel extraction (n = 3) and pressed oil samples (n = 3) were transesterified according to the methodology proposed by Bannon et al. (1982), with modifications according to Simionato et al. (2010). The chromatographic assay was carried out using a Thermo-Finnigan Trace-GC-Ultra gas chromatographer equipped with a flame ionization detector (FID) and a BPX-70 fused-silica capillary column (120 m, 0.25 mm i.d.). The operation parameters established after verification of the best resolution conditions were: injector and detector temperatures, 250 and 280°C, respectively. The column temperature was programmed at 140°C for 10 minutes, proceeding through a first ramp of 15°C min.$^{-1}$ until it reached 200°C for 1 minute. The second ramp was 10°C min.$^{-1}$ until reaching 230°C for 1 minute.

The third ramp was 0.4°C min.$^{-1}$ until it reached 233°C for 3 minutes. The fourth ramp was 0.5°C min.$^{-1}$ until it reached 238°C for 2 minutes. Total assay time amounted to 41.50 minutes. Gas (White Martins) flows were 30 mL min.$^{-1}$ for hydrogen, 30 mL min.$^{-1}$ for nitrogen, and 250 mL min.$^{-1}$ for synthetic air.

Injections (1.2 μL) were carried out in duplicate and the fatty acids methyl ester peak areas were determined with software ChromQuest 4.1.

Fatty acid (FA) identification was carried out after verification of the peak equivalent chain length and comparison of sample retention times with a standard sample containing a mixture of fatty acid methyl esters (189-19 Sigma, EUA), as described by Simionato et al. (2010).

Quantification of FA in mg g^{-1} of total lipids was carried out in relation to the internal standard, methyl tricosanoate (23:0), Sigma, EUA. The calculation of FA concentrations contained in the samples were carried out according to Joseph and Ackman (1992), using the following equation 1:

$$C(\text{mg g}^{-1}) = \frac{A_X \cdot M_{23:0} \cdot F_{RT}}{A_{23:0} \cdot M_A \cdot F_{CT}} \quad (1)$$

where:

A_X = fatty acid methyl esters area;

$A_{23:0}$ = internal standard area;

$M_{23:0}$ = mass of internal standard added to the sample (in milligrams);

M_A = sample mass (in grams);

F_{RT} = theoretical response factor of fatty acid methyl esters;

F_{CT} = conversion factor to express results in mg of fatty acids per g of total lipids (LT).

Verification of agreement between theoretical response and experimental factors was carried out as described by Simionato et al. (2010) and Costa et al. (2011).

The detection limit was visually estimated (RIBANI et al., 2004) from successive dilutions of 10 times each of a methyl tridecanoate standard 2.0 mg mL^{-1} until peak disappearance. The last dilution where the characteristic peak could be identified was determined as the detection limit. The quantification limit was stipulated as being 10 times larger than the detection limit.

Antioxidant potential

Obtaining the methanol extracts

The extracts were obtained according to Seneviratne et al. (2009), using 20 ml of Methanol/Water (80:20, v v^{-1}) and 1.0 g of the sample.

Antioxidant activity by sequestration of DPPH radical

The antioxidant activities of licuri refined and pressed oils were measured through the reaction with radical DPPH (2,2-difenil-1-picrilhidrazil), according to Brand-Williams et al. (1995), with a few modifications. Different methanol extract aliquots from the samples – 200, 350 and 500 μL – were mixed with 2.0 mL of DPPH methanol solution (4.70%). The mixture was left in the dark for 30 minutes. Absorbance was measured at 517 mm, where methanol was used as blank. The inhibition percentage of radical DPPH was determined according to equation 2.

$$\%\ \text{Inhibition}\ \ DPPH^{\bullet} = \frac{(Abs_{DPPH^{\bullet}} - Abs_{amostra})}{Abs_{DPPH^{\bullet}}} x\,100 \qquad (2)$$

where:

$Abs_{DPPH\bullet}$ = DPPH• absorbance

$Abs_{amostra}$ = sample absorbance

The results of % inhibition DPPH• were plotted into a graph as a function of the extract concentration and IC_{50}, a value that estimates the necessary antioxidant concentration to inhibit 50% of the DPPH radical, was found with linear regression.

Antioxidant activity using the ferric reduction antioxidant power method (FRAP)

Ferric reduction capacity in the licuri kernel-extracted oil and in the pressed oil obtained from the cooperative was measured according to the methodology proposed by Rufino et al. (2006). After obtaining the methanol extracts, three dilutions were prepared, 0.125, 0.25 and 0.5 mg mL^{-1}, for the refined oil and pressed oil extracts.

Linear analytical curves were obtained using ferrous sulphate solutions in concentrations between 2000 and 20 μM. The result was expressed by the quantity of ferrous sulphate in μM produced per gram of licuri refined oil and/or pressed oil.

Total phenolic compounds

The levels of total phenolic compounds in the samples were determined from the preparation of three dilutions – 0.125, 0.25 and 0.5 mg mL^{-1} – of licuri refined oil and pressed oil extracts, according to the procedure proposed by Wettasinghe and Shahidi (1999), using the Folin-Ciocalteau reagent (FCR).

Linear analytical curves were obtained using a gallic acid stock solution in a 1 mg mL^{-1} concentration, which was diluted so as to obtain concentrations between 0.5 and 0.01 mg of gallic acid equivalent mL^{-1}.

Total phenolic compounds present in the extracts obtained were expressed in μM of ferrous sulphate per gram of licuri refined oil and/or pressed oil.

Results and discussion

Fatty acid analysis

Fatty acids detection and quantification limits were estimated based on methyl tridecanoate, resulting in values 0.015 and 0.15 mg g^{-1} of fatty acids, respectively. The analytical curve went linear from 0.005 mg g^{-1}, R^2 = 0.9995, with the following equation: $Y = 1.10^7 X + 11948$ where Y is the chromatographic response and X is the concentration of fatty acid methyl ester.

The results obtained for the quantification of fatty acids in licuri refined and pressed oils are presented in Table 1.

Table 1. Fatty acid quantification (mg g^{-1}) of licuri refined kernel oil and pressed oil.

	Fatty acid content	
Fatty acid	Oil (mg 100 g^{-1*})	Pressed Oil (mg g^{-1**})
6:0	0.7735 ± 0.0115	3.5805 ± 0.1780
8:0	26.1570 ± 0.4162	98.2238 ± 4.9299
10:0	17.7881 ± 0.4039	64.3126 ± 3.2213
11:0	0.0837 ± 0.0027	0.4165 ± 0.0163
12:0	117.0886 ± 2.7445	451.6702 ± 20.8223
14:0	37.4558 ± 0.7919	147.6250 ± 6.4694
16:0	18.5197 ± 0.4322	70.7473 ± 3.8606
16:1n9	0.0512 ± 0.0004	0.2240 ± 0.0106
17:0	0.0285 ± 0.0013	0.1778 ± 0.1063
17:1n7	0.0155 ± 0.0003	nd
18:0	6.9164 ± 0.2941	31.4634 ± 2.2374
18:1n9c	34.6028 ± 1.3091	123.3873 ± 5.7273
18:2n6	9.8679 ± 0.1943	28.4871 ± 1.6639
18:3n6	0.2337 ± 0.0014	0.9713 ± 0.1181
18:3n3	nd	0.2745 ± 0.2742
20:0	0.0437 ± 0.0005	0.1340 ± 0.0582
20:1	0.0992 ± 0.0065	nd
Total Saturates	224.855	868.3511
Total Unsaturated	44.8703	153.3442

nd = not detected. *mg of fatty acid per 100 g of licuri kernel. **mg of fatty acid per g of pressed oil. Numbers represent average±standard deviation of analysis carried out in triplicate.

The levels of saturated fatty acids in the refined oil and pressed oil samples were approximately five times higher than unsaturated fatty acids. The most predominant saturated fatty acid on both samples was lauric acid, at 43.4 and 44.2% of total fatty acids present in the refined oil and the pressed oil, respectively. This was followed by myristic acid

(13.89 and 14.45%) and oleic acid (12.83 and 12.08%) for both samples. Similar results were found by La Salles et al. (2010), in a study about fatty acid composition in refined licuri oil for biodiesel production.

Coconut oil samples used by Chandrashekar et al. (2010) while studying hypocholesterolemic effects, presented a predominance of the same fatty acids with values of 48.5, 21.2 and 5.2%, results that prove the similarities in the composition of both oils.

This lipid composition demonstrates that licuri oil is rich in Medium-Chain Fatty Acids (MCFA), some 60.02 and 60.50% of the composition for refined oil and pressed oil, respectively. These fatty acids have from 6 to 12 carbons and have unique properties with important nutritional and medical applications.

Among the nutritional applications is its use as supplement for athletes who exercise for long periods, as reported by Gomes and Aoki (2003). Differently from long-chain fatty acids, medium-chain fatty acids are oxidized rapidly during rest periods and exercise, which makes them a quick source of energy to the organism, preventing it from consuming stocks of muscular glycogen, therefore delaying fatigue. MCFA demonstrate also to be beneficial in the treatment of pathologies caused by deficient lipid absorption, burns and generalized infections (GOMES; AOKI, 2003).

Population studies by Fife (2005) show the possible health benefits of MCFA in the treatment or prevention of diseases such as cancer and diabetes. Such studies state that contrary to what was thought, coconut oil does not influence cholesterol concentrations in blood, helps to decrease body fat accumulation and avoids blood clot formation, therefore it is not linked to cardiac disease.

A study by Silva et al. (2011) assessing the effects of extra virgin coconut oil supplement on the lipid and cardiovascular profile of hypercholesterolemic individuals concluded that consumption of 30 mL a day of oil can significantly reduce body weight, body mass index, triglycerides, very low density lipoprotein (VLDL) and shows a tendency to reduce total cholesterol, low density lipoprotein (LDL) and to slightly increase high density lipoprotein (HDL). Due to the similar compositions of coconut and licuri oils, we suggest that similar results can be achieved with consumption of licuri oil.

Furthermore, licuri refined and pressed oils presented respectively 6.87 and 6.92% of palmitic acid in their composition, lower than the levels found in coconut oil 7.83% (NEVIN; RAJAMOHAN, 2006), corn 12.00% and soy 12.66% (JORGE et al., 2005), cotton 23.91% and palm 48.86% (CORSINI et al., 2008). These can be considered positive results, since palmitic acid is one of the saturated fatty acids that have the most hypercholesterolemic or atherogenic effect (DRISKELL, 2006).

Antioxidant activity potential

The various analytical assays used to determine antioxidant capacity are mainly based on two reaction mechanisms, Hydrogen Atom Transfer (HAT), and Single Electron Transfer (SET). Both mechanisms have the objective of determining the protective effect of the sample against free radicals, however they are different as to the initiating radical, the kinetics of the reaction and the side reactions (CASTELO-BRANCO; TORRES, 2011). Thus, when investigating the total antioxidant capacity of a substance it is important to use at least one assay from each mechanism. In the DPPH radical assay both mechanisms are involved, and in the ferrous reduction assay (FRAP) only the transference of one hydrogen atom is involved.

The results from the investigation into the antioxidant potential of licuri refined and pressed oils, both for the DPPH radical assay and the ferrous ion reduction (FRAP) are presented on Table 2.

Table 2. Antioxidant capacity of licuri refined and pressed oils as determined by DPPH• assay and ferrous reduction capacity (FRAP).

Licuri samples	DPPH*	FRAP**
Refined Oil	0.2783	157.25 ± 5.30
Pressed Oil	0.3336	144.75 ± 12.37

*IC50, mg mL^{-1}; **µM of ferrous sulphate g^{-1}.

IC_{50} is defined as the concentration of substrate that can inhibit 50% of the activity of free radical DPPH (BRAND-WILLIS et al., 1995). This concentration can be considered high, if compared with antioxidants par excellence, such as ascorbic acid (IC_{50} = 2.15 µg mL^{-1}) and BHT (IC_{50} = 5.37 µg mL^{-1}) (CANSIAN et al., 2010).

A comparative study between the antioxidant activities of cold and hot extracted coconut oil carried out by Seneviratne et. al (2009), demonstrated that extraction at high temperatures can incorporate a higher quantity of antioxidants. Furthermore, there are no other studies in literature about the antioxidant potential of oils extracted from fruit kernels, however, articles related with plant extracts or essential oils prove the low antioxidant activity of licuri refined oil (ANDRADE et al., 2012; CANSIAN et al., 2010).

Phenolic compounds are substances that have structures with aromatic rings and conjugated

double bonds from which they exert their antioxidant activity, and they are the most abundant antioxidants in diets. Phenolic compound concentrations were 189.93 ± 23.72 and 553.33 ± 89.62 mg equivalent of gallic acid per gram of licuri pressed oil and refined oil, respectively. In a study carried out by Gutfinger (1981), the phenolic content of olive oil varied according to the method of extraction. Oils extracted with solvents had higher quantities of phenols than virgin oils extracted by press. These results are similar to those found in the present study, and justify the increased antioxidant activity for licuri kernel oil in all assays (NEVIN; RAJAMOHAN, 2006; SENEVIRATNE et al., 2009).

There is growing interest in research for new sources of antioxidants, especially those that can prevent the pernicious effects of free radicals on the human body and on food fats and other compounds. Among them, natural sources of antioxidants are being emphasized, especially foods that are rich in these compounds and that can be consumed by the population as part of a balanced diet.

Conclusion

The results obtained demonstrate that just as with coconut oil, licuri is a good source of medium-chain fatty acids and also has a significant quantity of phenolic compounds and oxidant potential, which can open perspectives in order to improve consumption of this native fruit of the Brazilian Caatinga, since these substances can bring important health benefits.

Acknowledgements

The authors wish to thank Coordenação de Aperfeiçoamente de Pessoal de Nível Superior (CAPES) and Fundação de Amparo a Pesquisa da Bahia (FAPESB) for their financial support, and Universidade Estadual do Sudoeste da Bahia (UESB) for the infrastructure necessary to carry out this study.

References

ANDRADE, M. A.; CARDOSO, M. G.; BATISTA, L. R.; MALLET, A. C. T.; MACHADO, S. M. F. Óleos essenciais de *Cymbopogon nardus*, *Cinnamomum zeylanicum* e *Zingiber officinale*: composição, atividades antioxidante e antibacteriana. **Revista Ciência Agronômica**, v. 43, n. 2, p. 399-408, 2012.

BANNON, C. D.; CRASKE, J. D.; HAI, N. T.; HARPER, N. L.; O'ROURKE, K. L. Analysis of fatty acid methyl esters with high accuracy and reliability. II. methylation of fats and oils with boron trifluoride methanol. **Journal of Chromatography**, v. 247, n. 1, p. 63-69, 1982.

BLIGH, E. G.; DYER, W. J. A. A rapid method for total lipid extraction and purification. **Canadian Journal of Biochemistry Physiology**, v. 37, n. 8, p. 911-917, 1959.

BONDAR, G. O. Licurizeiro e suas potencialidades na economia brasileira. **Instituto Central de Fomento Econômico da Bahia**, v. 2, n. 18, p. 1-18, 1938.

BRAND-WILLIAMS, W.; CUVELIER, M. E.; BERSET, C. Use of a free radical method to evaluate antioxidant activity. **Food Science and Technology**, v. 28, n. 1, p. 25-30, 1995.

CANSIAN, R. L.; MOSSI, A. J.; OLIVEIRA, D.; TONIAZZO, G.; TREICHEL, H.; PAROUL, N.; ASTOLFI, V.; SERAFINI, L. A. Atividade antimicrobiana e antioxidante do óleo essencial de ho-sho (*Cinnamomum camphora Ness e Eberm Var. Linaloolifera fujita*). **Ciência e Tecnologia de Alimentos**, v. 30, n. 2, p. 378-384, 2010.

CASTELO-BRANCO, V. N.; TORRES, A. G. Capacidade antioxidante total de óleos vegetais comestíveis: determinantes químicos e sua relação com a qualidade dos óleos. **Revista de Nutrição**, v. 24, n. 1, p. 173-187, 2011.

CHANDRASHEKAR, P.; LOKESH, B. R.; GOPALA KRISHNA, A. G. Hypolipidemic effect of blends of coconut oil with soybean oil or sunflower oil in experimental rats. **Food Chemistry**, v. 123, n. 3, p. 728-733, 2010.

CORSINI, M. S.; JORGE, N.; MIGUEL, A. M. R. O.; VICENTE, E. Perfil de ácidos graxos e avaliação da alteração em óleos de fritura. **Química Nova**, v. 31, n. 5, p. 956-961, 2008.

COSTA, E. N.; LACERDA, E. C. Q.; SANTOS, S. M.; SANTOS, C. M.; FRANCO, M.; SILVA, R. R.; SIMIONATO, J. I. Action of successive heat treatments in bovine milk fatty acids. **Journal of the Brazilian Chemistry Society**, v. 22, n. 11, p. 2115-2120, 2011.

DRISKELL, J. A. **Sports nutrition**: fats and proteins. Boca Raton: CRC, 2006.

FIFE, B. F. Coconut oil and health. **Proceedings of the International Coconut Forum held in Cairns**, v. 125, n. 125, p. 49-56, 2005.

GOMES, R. V.; AOKI, M. S. A suplementação de triglicerídeos de cadeia média promove efeito ergogênico sobre o desempenho no exercício de endurance? **Revista Brasileira de Medicina do Esporte**, v. 9, n. 3, p. 154-161, 2003.

GUTFINGER, T. Polyphenols in olive oil. **Journal of American Oil Chemists Society**, v. 58, n. 11, p. 966-968, 1981.

JORGE, N.; SOARES, B. B. P.; LUNARDI, V. M.; MALACRIDA, C. R. Alterações físico-químicas dos óleos de girassol, milho e soja em frituras. **Química Nova**, v. 28, n. 6, p. 947-951, 2005.

JOSEPH, J. D.; ACKMAN, R. G. Capillary column gas-chromatographic method for analysis of encapsulated fish oils and fish oil ethyl-esters-Collaborative study. **Journal of AOAC International**, v. 75, p. 488-506, 1992.

LA SALLES, K. T. S.; MENEGHETTI, S. M. P.; LA SALLES, W. F.; MENEGHETTI, M. R.; SANTOS, I. C.

F.; SILVA, J. P. V.; CARVALHO, S. H. V.; SOLETTI, J. I. Charaterization of *Syagrus coronata (Mart.) Becc*. Oil and properties of methyl esters for use as biodiesel. **Industrial Crops and Products**, v. 32, n. 3, p. 518-521, 2010.

NEVIN, K. G.; RAJAMOHAN, T. Virgin coconut oil supplemented diet increases the antioxidant status in rats. **Food Chemistry**, v. 99, n. 2, p. 260-266, 2006.

PINTO, L. F.; SILVA, D. I. S.; SILVA, F. R.; SANTOS, V. B.; SOLETTI, J. I.; CARVALHO, S. H. V. Assessment of the feasibility of different oil sources to biodiesel production. **Acta Scientiarum. Technology**, v. 34, n. 2, p. 227-231, 2012.

QUEIROGA, R. C. R. E.; MAIA, M. O.; MEDEIROS, A. N.; COSTA, R. G.; PEREIRA, R. A. G.; BOMFIM, M. A. D. Produção e composição química do leite de cabras mestiças Moxotó sob suplementação com óleo de licuri ou de mamona. **Revista Brasileira de Zootecnia**, v. 39, n. 1, p. 204-209, 2010.

RIBANI, M.; BOTTOLI, C. B. G.; COLLINS, C. H.; JARDIM, I. C. S. F.; MELO, L. F. C. Validação em métodos cromatográficos e elétroforéticos. **Química Nova**, v. 27, n. 5, p. 771-780, 2004.

RUFINO, M. S. M.; ALVES, R. E.; BRITO, E. S.; MORAIS, S. M.; SAMPAIO, C. G.; PÉREZ-JIMENEZ, J.; SAURA-CALIXTO, F. D. Metodologia científica: determinação da atividade antioxidante total em frutas pelo método de redução do ferro (FRAP) **Comunicado Técnico**, v. 125, p. 1-4, 2006.

SENEVIRATNE, K. N.; HAPUARACHCHI, C. D.; EKANAYAKE, S. Comparison of the phenolic-dependent antioxidant properties of coconut oilextracted under cold and hot conditions. **Food Chemistry**, v. 114, n. 4, p. 1444-1449, 2009.

SILVA, R.; FORTES, R.; SOARES, H. Efeitos da suplementação dietética com óleo de coco no perfil lipídico e cardiovascular de indivíduos dislipidêmicos. **Brasília Médica**, v. 48, n. 1, p. 42-49, 2011.

SIMIONATO, J. I.; GARCIA, J. C.; SANTOS, G. T.; OLIVEIRA, C. C.; VISENTAINER, J. V.; SOUZA, N. E. Validation of the determination of fatty acids in Milk by gas chromatography. **Journal of the Brazilian Chemical Society**, v. 21, n. 3, p. 520-524, 2010.

WETTASINGHE, M.; SHAHIDI, F. Evening primrose meal: a source of natural antioxidants and scavenger of hydrogen peroxide and oxygen-derived free radicals. **Journal of Agricultural and Food Chemistry**, v. 47, n. 5, p. 1801-1812, 1999.

Received on March 26, 2013.
Accepted on March 26, 2013.