Acta Scientiarum

http://www.uem.br/acta
ISSN printed: 1679-9275
ISSN on-line: 1807-8621
Doi: 10.4025/actascitechnol.v34i3.10602

Collagen extraction from chicken feet for jelly production

Poliana Fernandes de Almeida[1,2], Marleide Guimarães Oliveira de Araújo[2] and José Carlos Curvelo Santana[1*]

*[1]Programa de Pós-graduação em Engenharia de Produção, Universidade Nove de Julho, Av. Francisco Matarazzo, 612, 05001-100, Água Branca, São Paulo, São Paulo, Brazil. [2]Instituto Federal de Educação, Ciência e Tecnologia de Mato Grosso, Cuiabá, Mato Grosso, Brazil. *Author for correspondence. E-mail: jccurvelo@uninove.br*

ABSTRACT. This work aimed to produce jellies with the collagen extracted from chicken feet. Jelly samples were prepared with flavors of pineapple (GAB) and white chocolate (GCB). Using a hedonic scale, 30 untrained tasters evaluated sensory acceptance and willingness to consume the jellies. Results showed that GCB and GAB samples, respectively, scored 7.8 and 7.4 in the hedonic scale for all sensory attributes; indicating that both products had good acceptance. In relation to the willingness to consume the GCB and GAB samples, 85 and 74% of consumers, respectively, declared that they would consume once a week.

Keywords: chicken feet, sensory attributes, jelly.

Obtenção de colágeno a partir de tarsos de frangos para produção de geleias

RESUMO. Este trabalho objetivou a produção de geleias a partir do colágeno extraído dos tarsos de frango. Prepararam-se amostras com sabor de abacaxi (GAB) e chocolate branco (GCB). Trinta provadores não-treinados avaliaram, em escala hedônica, a aceitação sensorial e a disponibilidade em se consumir as geleias. Os resultados mostraram que as amostras GCB e GAB obtiveram uma média, respectivamente, de 7,8 e 7,4 em escala hedônica, para todos os atributos; indicando que ambos os produtos foram bem aceitos. Quanto ao consumo das amostras GCB e GAB, 85 e 74% dos provadores, respectivamente, indicou que consumiriam uma vez por semana.

Palavras-chave: pés de frango, qualidades sensoriais, geleia.

Introduction

The development of new food products has been studied, through the discovery of new sources of food or the reuse of by-products or wastes. For this, nutritional and sensory aspects should be taken into account, so they could supply some vitamin or minerals without rejection the product by the consumers. In this context, there are the so-called functional foods (BARCELOS et al., 2002; BARIMALAA; OKOROJI, 2009; LENTZ, 2008; RODRIGUES et al., 2011).

In this way, new products have been developed in our country, such as the yeasts of cashew, iamb and mangaba (ALMEIDA et al., 2005); guava-based drinks (SANTOS et al., 2007), drinks of acerola enriched with nutrients of cassava leaves (ALMEIDA et al., 2003); cassava spirit (CURVELO-SANTANA et al., 2010; FERREIRA et al., 2005; SUMAN et al., 2011); liquor from tangerine peel (VIANA et al., 2011); wines of mandacaru fruits (ALMEIDA et al., 2006), of acerola (ALMEIDA et al., 2008, 2010; SANTANA et al., 2010; SANTOS et al., 2005), of hog plum (NARAIN et al., 2004; SEVERO JÚNIOR et al., 2007) and of cashew (COSTA et al., 2006); essential oil from orange rind (EVANGELISTA et al., 2010); snacks of pupunha and cassava (CARVALHO et al., 2009); chocolate-based drink produced with water-soluble soybean extract and cheese whey (MOREIRA et al., 2010); cereal bars with jackfruits (SANTOS et al., 2011) and malt and beer of corn (BIAZUS et al., 2006a, 2006b, 2007, 2009; SEVERO JÚNIOR et al., 2005).

The waste generated in industries of meat products are frequently very large and represent a serious problem due to the high content of organic matter, and these wastes can serve as sources of microorganisms' proliferation. Thus, according to Pardi et al. (2001) and Pelizer et al. (2007), the environmental problems are worsened by inadequate treatment of industrial solid waste. In this way, it is necessary to minimize these wastes, even before they reach the grease and rendering plants.

The increasing concern for the environment has been mobilizing several segments of the market.

Numerous government agencies and industries are preparing to implement an environmental policy that reduces the negative impacts on nature (GIRAÇOL et al., 2011; PELIZER et al., 2007). Accordingly given the current situation where the competitiveness reigns, a special attention is being given to minimize or reuse solid wastes generated during industrial processes (LAUFENBERG et al., 2003; PASSARINI et al., 2012).

According to Barbieri (2004), a new attitude is required from the entrepreneurs and managers to obtain the solution or minimization of environmental problems. These actors must consider the environment in their decisions, adopting administrative and technological conceptions that contribute to increase the carrying capacity of the planet.

Therefore the competition has influenced the industries to develop new sources of competitive advantages, requiring a continuous innovative process. This has led the companies to generate and use technologies and tools to create opportunities for new products, services and industrial processes (QUADROS et al., 2010). Pressured by the new challenges, the aviculture aims to fit itself to the new world of intense competition and environmental protection laws. The waste generated become part of the production process, emphasizing the importance of choosing the best destination of these, aiming an activity with higher sustainability.

In this context, the practices to minimize wastes are economically advantageous, since they offer possibilities to save products and processes to treat them, considering the environmental control. Several by-products considered as waste are used to manufacture meals, such as skin, feet, bones, blood, among others. This is confirmed by Padilha et al. (2006) and the fate of industrial waste generated in the slaughtering and processing of chickens without commercial purposes, such as viscera, head, feet, skin, fat, bone, and disqualified carcasses may be the factory of by-products, or depending on the manner of the process of pet food industrialization (the raw material is a by-product from a secondary process obtained when manufacturing a core product), they can be processed raw or cooked.

Despite of commercial purposes of the waste generated in the slaughter of chickens, the studies in this area have not advanced much in order to identify other forms and/or technologies of treatment and disposal, which are of concern to the Brazilian poultry industry. Some companies have gradually developed technologies to solve these bottlenecks in the environmental scope related to the production (PADILHA et al., 2006).

According to Laufenberg et al. (2003), the waste may contain many substances with high values. If employing an appropriate technology, this material can be converted into commercial products or raw materials to secondary processes. In this way, several food wastes disposed previously as useless currently are transformed into by-products with wide commercial acceptance. An alternative to take advantage of the waste is the development of new products, providing a better destiny with higher commercial value to them.

With the increasing world population, it is necessary to search for alternative foods to meet demand. However these alternative sources should have not only nutritive food produced at large scale with low cost, but also should present good sensory characteristics (COSTA et al., 2008). The raw material considered as waste in some regions can be the base of traditional by-products with high added value in other regions. For instance, in some Asian countries, chicken feet are a delicacy, but in Brazil, the consumers do not have much interest in these products. The sale of a ton of chicken feet is below 1.0 R$ ton^{-1}. These characteristics of national market are crucial to define its low sale price.

Alves and Prudêncio-Ferreira (2002) obtained collagen from skin and feet of chicken. The yield of dehydrated collagenous materials was around 16% in relation the weight of skin and tendon in nature. Dehydrated materials were obtained with high content of collagen. The lyophilisation process was more efficient for removing water from the material and resulted in a product with higher content of lipids. They exposes that, on average, 5.5 kg of skin can be taken from a normal pig carcass, and it is obtained a solution with only about 5% of gelatin in the extraction process.

Food and pharmaceutical industries throughout the world are observing a growing demand for collagen and gelatin. The most popular and used is the gelatin of mammals (pigs and cattle) that are subjected to greater restrictions and skepticism among consumers, by socio-cultural and health concerns (KARIM; BHAT, 2009).

This demand for new gelling agents to replace the gelatin of mammals has guided several studies on different raw materials, such as for example the gelatin of marine origin (fish skin, bone, and fins) (HAUG et al., 2004), and other surveys focusing the extraction and classification of gelatin from fish as verified in Badii and Howell (2006), Haug et al. (2004), Arnesen and Gildberg (2007), Gómez-Estaca et al. (2009), Soung-Hun et al. (2006), however it is an underused source.

In this context, the present study aimed at producing jellies with the collagen extracted from low cost raw material, in order to verify the

acceptability of the product and adjust the processing method, and evaluates it according to its sensory attributes.

Material and methods

Development of jellies

In general, jellies are develop from fruits, but there are also the calf's foot jellies from animal origin, in this sense we opted to designate the product as jellies, since they have in their formulation raw materials of animal origin, such as the feet of chicken and milk, and we also sought a final consistency similar to calf's foot jelly.

The raw material used in the processing of jellies was feet of freshly slaughtered chicken from the Federal Institute of Education, Science and Technology of Mato Grosso – *Campus* São Vicente. The jelly production, using chicken feet, is a relatively easy and fast process, but requires lots of care during the manipulation because it is a product whose raw material is excellent for the development of microorganisms. Therefore, the adoption of Good Manufacturing Practices since the processing until the storage of the final product is indispensable for the safety of the final product. Firstly, the chicken feet were washed; the nails were removed, again washed with cold water to remove any residue of dirt. Afterwards they were subjected to the cooking process at 120ºC for 20 min. in order to extract the collagen, following the procedure steps listed in the Figure 1 (ALVES; PRUDÊNCIO-FERREIRA, 2002; ARNESEN; GILDBERG, 2007).

The content of moisture, ash, fat and proteins were determined according to the methods from AOAC (1996), Silva et al. (2011) and Stroher et al (2012). The conversion factor used for proteins was 5.36, and the collagen content was determined through the hydroxyproline analysis, in which a factor of 8.0 is used in the conversion to collagen (ASCAR, 1985).

To produce experimental jellies according to the Figure 1, we ground the chicken feet to a higher yield of collagen along with milk, which besides enriching nutritionally the final product, as it is protein-rich, also contribute to disguise the odor of chicken.

After cooking, the liquid part was separated, filtered, and the sample was put in a glass container then subjected to cooling. After that, the fat accumulated on the surface, due to the low density, facilitating the removal and disposal. Because it is an experimental pilot project we used a mixture of 500 mL of collagen and water, heating with 200 g of sugar and additives as shown in Figure 2.

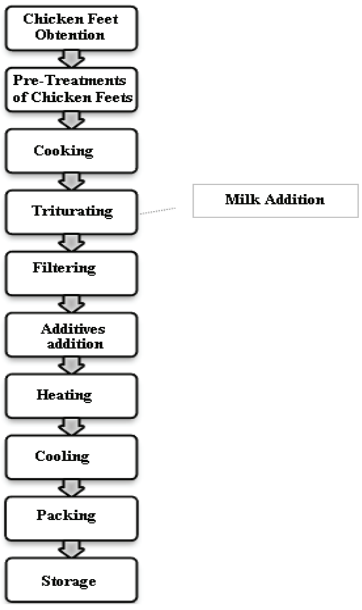

Figure 1. Flowchart of collagen extraction from chicken feet and jelly production.

Figure 2. Separation of the fat (a) and cooking of chicken feet (b).

Two samples of jellies were prepared, called GAB and GCB. The first was prepared with pineapple flavor, and the second with white chocolate flavor. In the GAB sample, we added yellow tartrazine dye, artificial pineapple flavor, citric acid and ascorbic acid. In the GCB sample, we added 10 g of Siber® (white chocolate), a mixture that includes dyes, starch, acidulant, acidity regulator and anti-wetting agent. Also, powdered pectin was added to both samples, which is a soluble fiber with a high nutritional contribution and it also increases the final consistency of the jelly, contributing to the gelling and nutritional action of the collagen extracted from the chicken feet.

Sensory analysis

Sensory analysis was performed with 30 untrained tasters, students of the IFMT *Campus* São Vicente. The team included individuals of both sexes, aged between 15 and 25 years. The procedure occurred in the Laboratory of Sensorial Analysis of the Foods. Samples were served in individual cabins, in disposable coded plastic cups. The tasters had a water cup at their disposal, which was used to rinse

the mouth between the samples. The following attributes were evaluated: appearance, flavor, aroma, texture and even the willingness to consume the product. We used the affective test with 9-point structured hedonic scale, ranging from 1 (really disliked) to 9 (really liked) for the attributes color, aroma, flavor and texture (ALMEIDA et al., 2010; ANDRAE-NIGHTINGALE et al., 2009; BARIMALAA; OKOROJI, 2009; FAKHOURI et al., 2007; KARACA et al., 2009; MOREIRA et al., 2010; SANTOS et al., 2007, 2011).

The 9-point structured hedonic scale is the most employed to evaluate the acceptance of food, with the main advantage of understanding ease and use by untrained tasters, making them the preferred options in trials with consumers (TEIXEIRA et al., 1987). Of the relative values of acceptability, we can infer the preference, i.e., the most accepted samples are the most preferred and vice versa (ANDRAE-NIGHTINGALE et al., 2009; FERREIRA et al., 2005).

The test of consumption frequency was also carried out with scale of 1 - would not consume, 2 - would consume once a month, 3 - would consume twice a month, 4 – would consume once a week, to 5 – would consume twice a week. The results obtained with the questionnaires were tabulated considering the frequency of the responses (TEIXEIRA et al., 1987). Both the affective test with 9-point structured hedonic scale and the frequency test were accomplished in the same moment, and the questionnaire was distributed to the tasters in a single sheet.

Results and discussion

The samples of jellies distributed to the tasters in the sensory evaluation are shown in Figure 3, where one can see the difference in color, the jelly samples flavored white chocolate were darker that those with pineapple flavor.

Figure 3. Samples of experimental jellies with flavor of pineapple, GAB (A) and white chocolate, GCB (B).

Table 1 presents the yield in the material extracted from the chicken feet. The material able to be used in the production of jelly is around 36% of the total weight of chicken feet used. Thus, from 1 ton of chicken feet, we can obtain up to 355.4 kg of jellies, which is a quite significant yield, mainly considering that the price is very low in the Brazilian market.

Table 1. Chemical composition of chicken feet in nature.

Constituents	Mean values (g 100 g^{-1})
Moisture (g)	64.46
	Dry basis
Proteins (g)	62.90
Lipids (g)	34.04
Minerals (g)	0.66

Source: Alves and Prudêncio-Ferreira (2002).

The Table 2 lists the mean values of sensory analyses of jellies of chicken feet, and although the main focus of this study is to verify the acceptance of jellies produced with collagen extracted from chicken feet, we also compared the samples using the Student's t-test. The Figure 4 presents the sensory values in hedonic scale for the better understanding of the results.

The sensory attributes of the jellies received high scores in the evaluations. The lower score was close to 7 points in hedonic scale (corresponding to: I liked), while the majority received scores close to 8 points (I really liked), indicating that both jellies were well accepted by the consumers. Similar values were also obtained by Valduga et al. (2009) using probiotics, gelatin (collagen), and wheat fiber in the composition of light cheese. Karaca et al. (2009) found similar values when evaluating sensorially ice creams with different fat contents.

For the attributes flavor, aroma and texture, the t-test showed no significant differences between the samples, but, for the appearance of the samples, there were considerable differences.

Table 2. Evaluation of sensory attributes of jellies of chicken feet.

	Mean sensory values			
Samples	Aroma	Appearance	Flavor	Texture
GAB	7.6^{a}	7.8^{b}	7.9^{d}	7.9^{e}
GCB	7.5^{a}	6.8^{c}	7.7^{d}	8.0^{e}
$t_{95\% = 1.67}$	0.28	2.6	0.78	0.01

OBS: same letters indicate no significant difference between the samples.

In relation to the appearance, the GCB sample (gelatin with white chocolate flavor) had an average slightly lower than GAB sample (gelatin with pineapple flavor), probably due to the darker color of the first sample, as shown in Figure 3. According to Almeida et al. (2008) and Santana et al. (2010), the color is one of the main sensory attributes that can influence decisions, including those related to foods. In this way, the appearance, safety, acceptance

and sensory attributes of foods are all affected by the color. Although these effects are associations inherent to psychological characteristics, they interfere on the choice of the products.

It is highlighted that in this research, the main intention was to verify the acceptance of a gelatin produced with collagen extracted from chicken feet, and not to perform a comparison between them. In this way, we can observe that both jellies were well accepted by the consumers.

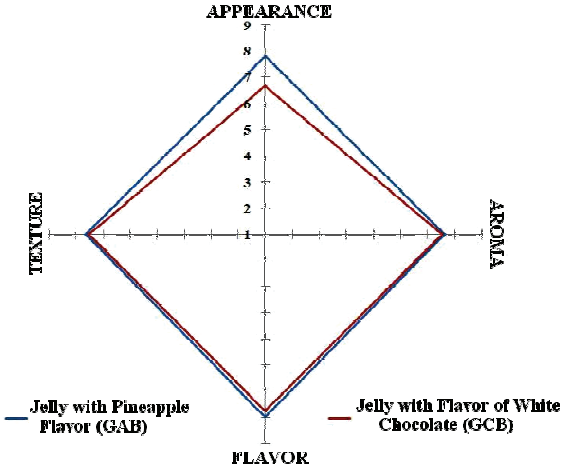

Figure 4. Distribution, at hedonic scale, of the values obtained for the sensory attributes of the jellies.

The Figure 5 presents the results for the responses of consumers about the willingness to consume the jellies of chicken feet. The frequency of consumption was considered high, because only 3% of the tasters said that they would not consume the pineapple jelly (GAB). At least 22.2% would consume once a week the same jelly (GAB), and 37.03%, the white chocolate jelly (GCB); 51% would consume twice a week the GAB formulation, while 48.14%, the GCB formulation. In general, around 74 and 85% of the consumers would consume once or more times a week the gelatins with flavors of pineapple and white chocolate, respectively, confirming the acceptance of these products.

In this way, the results pointed out that the consumers of the samples GAB and GCB 'liked' or 'really liked' the product, and 50% of them would consume the jellies more than once a week.

Some consideration can be made from the jellies produced with collagen extracted from chicken feet. The raw material used has low cost, since 1 ton only costs R$ 1.00, and still receives a nobler destiny.

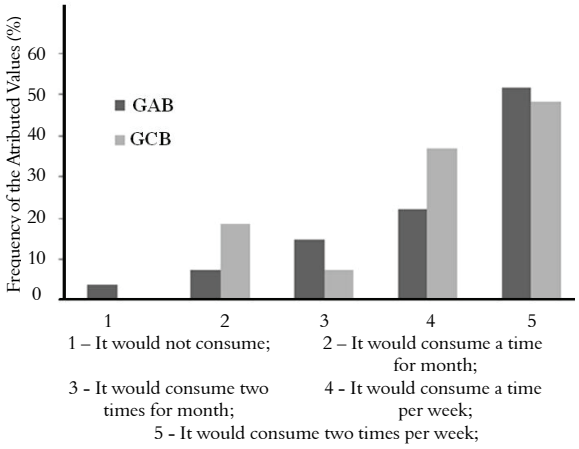

Figure 5. Frequency of the values assigned to consume the jellies.

Conclusion

The present study presented a proposal of reuse of a waste from the aviculture in obtaining a high quality food. The results indicated that the consumers of the samples GAB and GCB 'liked' or 'really liked' the product, and from 74-85% would consume at least once a week. Thus, we concluded that the production of jelly using chicken feet would add value to this poultry industry waste, because the same have good acceptance from the consumer.

Given the complexity of the proposed experiment, further studies should be accomplished in order to identify a better formulation using factorial planning and sensory analysis with a greater number of tasters comparing them to a trademark consolidated in the market.

Acknowledgements

The authors express their gratitude to Uninove, for its financial support to develop this research.

References

ALMEIDA, K. O. L.; SANTANA, J. C. C.; SOUZA, R. R. Sensorial analysis of functional food, which enriched by *Manihot* spp. Leaft. **Brazilian Journal of Agro-Industrial Products**, v. 5, n. 2, p. 127-131, 2003.

ALMEIDA, J. B. O.; SEVERO JÚNIOR, J. B.; CORREIA, E. C. O.; MELO, V. V.; SANTANA, J. C. C.; SOUZA, R. R. Use of yeast from tropical fruits wines in human Feeding. **Brazilian Journal of Food Technology**, v. 5, 5° SIPAL, p. 65-69, 2005.

ALMEIDA, S. S.; NARAIN, N.; SOUZA, R. R.; SANTANA, J. C. C. Optimization of processing conditions for wine production from acerola (*Malpighia glabra* L.). **Acta Horticulturae**, v. 864, p. 471-478, 2010.

ALMEIDA, S. S.; SOUZA, R. R.; SANTANA, J. C. C.; TAMBOURGI, E. B. Sensorial analysis of wines from *Malpighia glabra* L. pulp. **Brazilian Journal of Operation and Management**, v. 5, n. 1, p. 1-12, 2008.

ALMEIDA, M. M.; TAVARES, D. P. S. A.; ROCHA, A. S.; OLIVEIRA, L. S. C.; SILVA, F. L. H.; MOTA, J. C. Kinetics of mandacaru fruit wine production. **Brazilian Journal of Agro-Industrial Products**, v. 8, n. 1, p. 35-42, 2006.

ALVES, S. G. T.; PRUDÊNCIO-FERREIRA, S. H. Propriedades funcionais de material colagenoso de pés de frango. **Archivos Latinos Americanos de Nutricion**, v. 52, n. 3, p. 289-293, 2002.

ANDRAE-NIGHTINGALE, L. M.; LEE, S.-Y.; ENGESETH, N. J. Textural changes in chocolate characterized by instrumental and sensory techniques. **Journal of Texture Studies**, v. 40, n. 4, p. 427-444, 2009.

AOAC-Association of Official Analytical Chemists. **Official methods of analysis**. 15th ed. Washington, D.C.: AOAC, 1996.

ARNESEN, J. A. GILDBERG, A. Extraction and characterisation of gelatin from Atlantic salmon (Salmo salar) skin. **Bioresource Technology**, v. 98, n. 1, p. 53-57, 2007.

ASCAR, J. M.. **Alimentos**: aspectos bromatológicos e legais. Analise percentual. 1. ed. São Leopoldo: Unisinos, 1985.

BADII, F.; HOWELL, N. K. Fish gelatin: structure, gelling properties and interaction with egg albumen proteins. **Food Hydrocolloids**, v. 20, n. 5, p. 630-640, 2006.

BARBIERI, J. C. **Gestão ambiental empresarial**: modelos e instrumentos. São Paulo: Saraiva, 2004.

BARCELOS, M. F. P.; VILAS BOAS, E. V. B.; LIMA, M. A. C. Nutritional aspects of combined sprouts of soybean and corn. **Ciência e Agrotecnologia**, v. 26, n. 4, p. 817-825, 2002.

BARIMALAA, I. S.; OKOROJI, C. O. Particle size distribution of commercial cowpea (*Vigna unguiculata* (L) Walp.) Flour and sensory properties of akara. **International Journal of Food Engineering**, v. 5, n. 4, p. 1-5, 2009.

BIAZUS, J. P. M.; SANTANA, J. C. C.; SOUZA, R. R.; JORDÃO, E.; TAMBOURGI, E. B. Continuous extraction of α- and β-amylases from *Zea mays* malt in a PEG 4000/$CaCl_2$ ATPS. **Journal of Chromatography B**, v. 858, n. 1-2, p. 227-233, 2007.

BIAZUS, J. P. M.; SANTANA, J. C. C.; SOUZA, R. R.; TAMBOURGI, E. B. Caracterização da atividade amilásica do malte de milho (*Zea mays* L.). **Acta Scientiarum. Technology**, v. 28, n. 1, p. 13-19, 2006a.

BIAZUS, J. P. M.; SEVERO JÚNIOR, J. B.; SANTANA, J. C. C.; SOUZA, R. R.; TAMBOURGI, E. B. Study of amylases recovery from maize malt by ion-exchange expanded bed chromatography. **Process Biochemistry**, v. 41, n. 8, p. 1786-1791, 2006b.

BIAZUS, J. P. M.; SOUZA, R. R.; MARQUEZ, J. E.; FRANCO, T. T.; SANTANA, J. C. C.; TAMBOURGI, E. B. Production and characterization of amylases from *Zea mays* malt. **Brazilian Archives of Biology and Technology**, v. 52, n. 4, p. 991-1000, 2009.

CARVALHO, A. V.; VASCONCELOS, M. A. M.; SILVA, P. A.; ASCHERI, J. L. R. Production of third generation snacks by extrusion-cooking of pupunha and cassava flour mixtures. **Brazilian Journal of Food Technology**, v. 12, n. 4, p. 277-284, 2009.

COSTA, A. G. B. F.; OLIVEIRA, C. S.; LOPES, F. L. G.; SANTANA, J. C. C.; SOUZA, R. R. Cashew Apple Wine: Preparation and Sensorial Analysis. **Revista Sodebras (on line)**, v. 10, n. 1, p. 1-4, 2006.

COSTA, D. P. S.; ROMANELLI, P. F.; TRABUCO, E. Aproveitamento de vísceras não comestíveis de aves para elaboração de farinha de carne. **Ciência e Tecnologia de Alimentos**, v. 28, n. 3, p. 746-752, 2008.

CURVELO-SANTANA, J. C.; EHRHARDT, D. D.; TAMBOURGI, E. B. Optimizing of alcohol production from manioc starch. **Ciencia e Tecnologia de Alimentos**, v. 30, n. 3, p. 613-617, 2010.

EVANGELISTA, A. F.; NARAIN, N.; SOUZAA, R. R.; SANTANA, J. C. C. Optimization of processing parameters for the extraction of essential oil from orange rind. **Acta Horticulturae**, v. 864, p. 479-484, 2010.

FAKHOURI, F. M.; FONTES, L. C.; GONÇALVES, C. M.; STEEL, C. J.; COLLARES-QUEIROZ, F. P. Filmes e coberturas comestíveis compostas à base de amidos nativos e gelatina na conservação e aceitação sensorial de uvas crimson. **Ciência e Tecnologia de Alimentos**, v. 27, n. 2, p. 369-375, 2007.

FERREIRA, G. B.; MELO, V. V.; ALMEIDA, J. B.; FERREIRA, A. E.; SOUZA, R. R. Characterizing of obtaining process of a manioc spirit. **Brazilian Journal of Food Technology**, v. 5, 5° SIPAL, p. 2-7, 2005.

GIRAÇOL, J.; PASSARINI, K. C.; DA SILVA FILHO, S. C.; CALARGE, F. A.; TAMBOURGI, E. B.; CURVELO SANTANA, J. C. Reduction in ecological cost through biofuel production from cooking oils: an ecological solution for the city of Campinas, Brazil. **Journal of Cleaner Production**, v. 19, n. 12, p. 1324-1329, 2011.

GÓMEZ-ESTACA, J.; MONTERO, P.; FERNÁNDEZ-MANTÍN, F.; GÓMEZ-GUILLÉN, M. C. Physico-chemical and film-forming properties of bovine-hide and tuna-skin gelatin: A comparative study. **Journal of Food Engineering**, v. 90, n. 4, p. 480-486, 2009.

HAUG, I. J.; DRAGET, K. I.; SMIDSROD, O. Physical and rheological properties of fish gelatin compared to mammalian gelatin. **Food Hydrocolloids**, v. 18, n. 2, p. 203-213, 2004.

KARACA, O. B.; GÜVEN, M.; YASAR, K.; KAYA, S.; KAHYAOGLU, T. The functional, rheological and sensory characteristics of ice creams with various fat replacers. **International Journal of Dairy Technology**, v. 62, n. 1, p. 93-99, 2009.

KARIM, A. A.; BHAT, R. Fish gelatin: properties, challenges, and prospects as an alternative to mammalian gelatins. **Food Hydrocolloids**, v. 23, n. 3, p. 563-576, 2009.

LAUFENBERG, G.; LAUFENBERG, G.; KUNZ, B.; NYSTROEM, M. Transformation of vegetable waste into added products: (A) the upgrading concept; (B) practical implementations. **Bioresource Technology**, v. 87, n. 2, p. 167-198, 2003.

LENTZ, K. A. Current methods for predicting human food effect - Mini-Review. **The AAPS Journal**, v. 10, n. 2, p. 282-288, 2008.

MOREIRA, R. W. M.; MADRONA, G. S.; BRANCO, I. G.; BERGAMASCO, R.; PEREIRA, N. C. Sensorial and rheologic evaluation of a chocolate-based drink produced with water-soluble soybean extract and cheese whey. **Acta Scientiarum. Technology**, v. 32, n. 4, p. 435-438, 2010.

NARAIN, N.; ALMEIDA, J. N.; GALVÃO, M. S.; MADRUGA, M. S.; BRITO, E. S. Volatile compounds in passion fruit (*Passiflora edulis* forma *Flavicarpa*) and yellow mombin (*Spondias mombin* L.) fruits obtained by dynamic headspace technique. **Ciência e Tecnologia de Alimentos**, v. 24, n. 2, p. 212-216, 2004.

PADILHA, A. C. M.; SILVA, T. N.; SAMPAIO, A. Desafios de adequação à questão ambiental no abate de frangos: o caso da Perdigão Agroindustrial – Unidade Industrial de Serafina Corrêa – RS. **Teoria e Evidência Econômica**, v. 14, ed. esp., p. 109-125, 2006.

PARDI, M. C.; DOS SANTOS, I. F.; DE SOUZA, E. R.; PARDI, E. S. **Ciência, higiene e tecnologia de carne**. Goiânia: Eduff, 2001.

PASSARINI, K. C.; GAMARRA, F. M. C.; VANALLE, R. M.; SANTANA, J. C. C. Reutilización de las Aguas Residuales en la Irrigación de Plantas y en la Recuperación de los Suelos. **Información Tecnológica**, v. 23, n. 1, p. 57-64, 2012.

PELIZER, L. H.; PONTIERI, M. H.; MORAES, I. O. Utilização de resíduos agro-industriais em processos biotecnológicos como perspectiva de redução do impacto ambiental. **Journal of Technology Management and Innovation**, v. 2, n. 1, p. 118-127, 2007.

QUADROS, D. A.; IUNG, M. C.; FERREIRA, S. M. R.; FREITAS, R. J. S. Frying quality of potato, with regard to reducing sugar and nonreducing sugar, during storage at room temperature. **Acta Scientiarum. Technology**, v. 32, n. 4, p. 439-443, 2010.

RODRIGUES, J. A. G.; QUINDERÉ, A. L. G.; QUEIROZ, I. N. L.; COURA, C. O.; ARAÚJO, G. S.; BENEVIDES, N. M. B. Purification, physical and chemical characterization, and anticoagulant activity of glycosaminoglycans isolated from the skin of Nile tilapia (*Oreochromis niloticus*). **Acta Scientiarum. Technology**, v. 33, n. 3, p. 233-241, 2011.

SANTANA, J. C. C.; DIAS, C. G.; SOUZA, R. R.; TAMBOURGI, E. B. Applying of neural network on the wine sensorial analysis from barbados cherry. **Journal of Food Process Engineering**, v. 33, supll. 1, p. 365-378, 2010.

SANTOS, S. C.; ALMEIDA, S. S.; TOLEDO, A. L.; SANTANA, J. C. C.; SOUZA, R. R. Making and sensorial analysis of *Malpighia punicifolia* L. wine. **Brazilian Journal of Food Technology**, v. 5, 5° SIPAL, p. 47-50, 2005.

SANTOS, M. S.; PETKOWICZ, C. L. O.; WOSIACKI, G.; NOGUEIRA, A.; CARNEIRO, E. B. B. Caracterização do suco de araçá vermelho (*Psidium cattleianum* Sabine) extraído mecanicamente e tratado enzimaticamente. **Acta Scientiarum. Agronomy**, v. 29, supl. esp., p. 617-621, 2007.

SANTOS, C. T.; BONOMO, R. F.; FONTAN, R. A C. I.; BONOMO, P.; VELOSO, C. M.; FONTAN, G. C. R. Characterization and sensorial evaluation of cereal bars with jackfruit. **Acta Scientiarum. Technology**, v. 33, n. 1, p. 81-85, 2011.

SEVERO JÚNIOR, J. B.; CORREIA, E. C. O.; FERREIRA, A. E.; ALMEIDA, S. S.; SANTANA, J. C. C.; SOUZA, R. R. Study of yeast effect on maize (Zea mays) beer quality. **Brazilian Journal of Food Technology**, v. 5, 5° SIPAL, p. 30-33, 2005.

SEVERO JÚNIOR, J. B.; ALMEIDA, S. S.; NARAIN, N.; SOUZA, R. R.; SANTANA, J. C. C.; TAMBOURGI, E. B. Wine clarification from *Spondias mombin* L. pulp by hollow fiber membrane system. **Process Biochemistry**, v. 42, n. 11, p. 1516-1520, 2007.

SILVA, C.; SAVARIZ, F. C.; FOLLMANN, H. M.; NUÑEZ, L.; CHAPLA; V. M. SILVA, C. F. Physical-chemical analysis of colonial italian type salami commercialized in Toledo, Paraná state. **Acta Scientiarum. Technology**, v. 33, n. 3, p. 331-336, 2011.

SOUNG-HUN, C.; JAHNCKE, M. L.; KOO-BOK, C.; JONG-BANG, E. The effect of processing conditions on the properties of gelatin from skate (*Raja Kenojei*) skins. **Food Hydrocolloids**, v. 20, n. 6, p. 810-816, 2006.

STROHER, G. L.; RODRIGUES, A. C.; GOHARA, A. K.; VISENTAINER, J. V.; MATSUSHITA, M.; SOUZA, N. E. Fatty acid quantification in different types of cookies with emphasis on *trans* Fatty Acids. **Acta Scientiarum. Technology**, v. 34, n. 1, p. 105-110, 2012.

SUMAN, P. A.; URBANO, L. H.; LEONEL, M.; MISCHAN, M. M. Effect of fermentation parameters on ethanol production from cassava liquid residue (manipueira). **Acta Scientiarum. Technology**, v. 33, n. 4, p. 379-384, 2011.

TEIXEIRA, E.; MEINERT, E. M.; BARBETTA, P. A. **Análise sensorial de alimentos**. Florianópolis: Editora UFSC, 1987. (Série Didática, p. 18-102).

VALDUGA, E.; GHISLENE, C. P.; RAUBER, F. F.; TIGGEMANN, L.; CHICHOSKI, A. J. Efeito da adição de probiótico (*Lactobacillus rhamnosus*), fibra de trigo e gelatina nas características sensoriais do queijo prato *light* durante a maturação. **Alimento e Nutrição**, v. 20, n. 2, p. 261-270, 2009.

VIANA, L. F.; MUNHOZ, C. L.; SOUZA, A. R. M.; SANTANA, L. M.; MACIEL, V.; CALIARI, M. Development and characterization of the tangerine peel liquor with different alcoholic bases. **Acta Scientiarum. Technology**, v. 33, n. 1, p. 95-100, 2011.

Received on July 6, 2010.
Accepted on May 26, 2011.