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Uso de coberturas a base de fécula de mandioca e quitosana na manutenção da qualidade de camarão embalado a vácuo

Coating based on cassava starch and chitosan in maintenance of vacuum packaged shrimp quality

Uso de recubrimiento a base de fécula de yuca y quitosana para mantener la calidad del camarón envasado al vacío

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Resumo

O camarão é um produto com boas características nutricionais e forte apelo mercadológico, porém, altamente suscetível à contaminação microbiológica. Por este motivo, o uso de métodos adequados de conservação é imprescindível para garantir a qualidade deste alimento ao longo de sua cadeia de comercialização. Os métodos convencionais de conservação do camarão fazem uso de embalagens plásticas não biodegradáveis, associadas à refrigeração e ao vácuo. Como alternativa a estas embalagens plásticas, podem ser utilizadas coberturas à base de biopolímeros como polissacarídeos e proteínas. Neste trabalho foi avaliada a qualidade do camarão recoberto com películas de fécula de mandioca e quitosana. Os camarões frescos foram coletados, descascados e mergulhados em misturas filmogênicas de fécula de mandioca, quitosana e mistas de fécula de mandioca com quitosana (1:1), sendo realizado também um controle negativo. As amostras foram armazenadas à vácuo sob refrigeração por seis dias, sendo que nos dias 3 e 6 foram realizadas análises em três repetições de contagem de bactérias mesófilas, pH e umidade. Os grupos com coberturas apresentaram contagens bacterianas inferiores ao controle, especialmente os grupos contendo quitosana. O pH e a umidade sofreram alterações durante os dias apenas nos grupos com cobertura de fécula de mandioca e controle, sendo a variação do pH associada ao aumento na contagem mesofílica nesses grupos. A influência da aplicação do revestimento frente à conservação do camarão, além de criar uma barreira em volta do mesmo, apresenta propriedades antimicrobianas quando considerada a quitosana, podendo ser um método promissor na conservação de um alimento minimamente processado.

Palavras-chave: Pescado; Conservação; Biopolímeros.

Abstract

Shrimp is a product with good nutritional characteristics and strong market appeal, however, highly susceptible to microbiological contamination. For this reason, the use of appropriate preservation methods is essential to guarantee the quality of this food throughout its marketing chain. Conventional methods of shrimp preservation make use of non-biodegradable plastic packaging associated with refrigeration and vacuum. As an alternative to these plastic packages, coatings based on biopolymers such as polysaccharides and proteins can be used. In this work, the quality of the shrimp covered with films from cassava starch and chitosan was evaluated. Fresh shrimp were collected, peeled, and dipped in filmogenic solutions of cassava starch, chitosan, and mixed cassava starch with chitosan (1:1), a negative control was performed. The samples were stored in vacuum packages for six days, and on days 3 and 6, three repetitions of mesophilic bacteria count, pH, and humidity analysis were performed. The groups with coatings presented lower bacterial counts than the control group, especially the groups containing chitosan. The pH and humidity changed during the days of experiment only in the group covered with cassava starch and control group, being pH variation associated with the increase of mesophilic bacteria count in these groups. The influence of the application of the coating on the conservation of the shrimp, in addition to creating a barrier around it, shows antimicrobial properties when considering chitosan, and may be a promising method for the conservation of minimally processed food.

Keywords: Seafood; Conservation; Biopolymers.

Resumen

El camarón es un producto con buenas características nutricionales y fuerte atractivo en el mercado, sin embargo, altamente susceptible a la contaminación microbiológica. Por esta razón, el uso de métodos de conservación adecuados es esencial para garantizar la calidad de este alimento en toda su cadena de comercialización. Los métodos convencionales para conservar los camarones hacen uso de envases plásticos no biodegradables, asociados con la refrigeración y el vacío. Como alternativa a estos paquetes de plástico, se pueden utilizar recubrimientos a base de biopolímeros como polisacáridos y proteínas. En este trabajo, se evaluó la calidad de los camarones cubiertos con películas de almidón de yuca y quitosana. Se recogieron camarones frescos, se pelaron y se sumergieron en mezclas filmogénicas de almidón de yuca, quitosana y almidón de yuca mezclado con quitosana (1: 1), y también se realizó un control negativo. Las muestras se almacenaron al vacío bajo refrigeración durante seis días, y en los días 3 y 6, se realizaron análisis con tres repeticiones para el tratamiento del recuento de bacterias mesofílicas, pH y humedad. Los grupos con recubrimientos presentaron recuentos bacterianos por debajo del control, especialmente los grupos que contienen quitosana. El pH y la humedad cambiaron durante los días solo en los grupos cubiertos con almidón y control de yuca, y la variación del pH se asoció con un aumento en el recuento mesofílico en estos grupos. La influencia de la aplicación del recubrimiento en la conservación del camarón, además de crear una barrera a su alrededor, tiene propiedades antimicrobianas cuando se considera el quitosana y puede ser un método prometedor para la conservación de un alimento mínimamente procesado.

Palabras clave: Camarón, Conservación, Biopolímeros.

1. Introduction

Food quality is a topic of worldwide relevance and involves several sensory, safety, and conservation aspects (Yang, Wei, & Pei, 2019). An example of alternative technology is the use of edible coatings in food, whose contribution to the preservation of the integrity of the food has been verified by several authors, in foods of plant origin (Coelho et al., 2017; Nunes et al., 2017; Rodrigues et al., 2019) and animal origin (Angioletti et al., 2018; Nunes et al., 2017; Pereira et al., 2018).

Some animal source foods, such as shrimp, are highly susceptible to deterioration, as they present characteristics like chemical composition favorable to the metabolism of microorganisms, mucus production, and richness of nutrients. (Furuya et al., 2008). Thus, despite the numerous benefits attributed to shrimp, such as richness of proteins of great biological value, those types of food are highly prone to microbial and chemical changes, being of great importance the research and application of conservation methods to prolong its useful life (Queiroga et al., 2014).

The temperature and time are extrinsic factors that affect this type of seafood, then soon after its arrest the shrimp must be cooled (Furuya et al., 2008). Cooling is very important because it prevents the action of microorganisms and enzymes on the shrimp. Adequate conservation methods can minimize losses in the processing, storage, and marketing of the shrimp, also add value to the product (Carlos & Neto, 2002).

Edible coatings and films are thin layer of material used to coat or pack food and extend their shelf life. For film composition, chemical components have advantages and limitations, polysaccharides, proteins, and lipids are the most used ones. Polysaccharides have a great advantage for being an economical material, in their molecular composition there is a large number of hydroxyls and polar groups (Dehghani et al., 2018).

The raw materials can have different origins for formation of the coatings, for example the proteins can be from animal sources or plant-based. The initial stage of the formation process is the denaturation of proteins caused by heat, pH, or use of solvents followed by a peptide association caused by molecular interactions (Azeredo, 2012).

Polymer blend is a mixture of a least two polymers with several advantages, including the power to combine several component properties in order to obtain good thermal, mechanical, and chemical conditions with low economic value. To obtain a polymer blend, it is necessary to understand the chemical and physical characteristics and their applications (Fernandes et al., 2012).

Cassava starch is an example of polymer that has several advantages for the formulation of these coverings, such as the low cost and the ability to form resistant, transparent, and efficient barriers against gas passage (Silva et al., 2019). Another prominent polymer is chitosan, a product derived from chitin that has good gel point, in addition to high biocompatibility and biodegradability (Gonçalves et al., 2019).

Chitosan is the second most abundant polymer in nature, it is non-toxic and has the ability to be easily converted into gel (Chevalier et al., 2016), is considered a promising polymer in the composition of food coatings mainly due to its antimicrobial potential (Mejía, Martínez & Lara, 2018).

Vacuum packaging is a very simple method with a low investment cost. It consists of removing air from the package, until the amount of oxygen available at the end of the process is less than 1%, in which there must still be a minimum permeability of gases such as water vapor. Due to the absence of large amounts of oxygen, the growth of aerobic microorganisms and oxidation reactions are inhibited. It also has the advantages of retaining compounds responsible for the aroma and preventing the occurrence of injuries caused by cold in food (Iglesias, Cabezas, & Luis, 2006).

A sustainable and innovative packaging has the purpose of minimizing food waste and to preserve the microbiological and organoleptic quality of the food, in addition to contributing to reduce the use of petroleum-derived plastics.

Thus, considering the nutritional value of the shrimp and aiming to produce biodegradable coating in order to reduce the use of plastics and preserve the sensory and organoleptic characteristics of the crustacean, the present study aimed to evaluate the effect of the application of edible cover based on chitosan and cassava starch in vacuum packaged shrimp stored under refrigeration conditions in qualitative parameters.

2. Material and methods

2.1. Study object

Samples of shrimp of the genus Litopenaeus vennamei were purchased in the region of Mossoró in Rio Grande do Norte under cooling conditions, transported immediately to the Food Technology Laboratory at UFERSA and packed in a thermal insulation box. The shrimps were minimally processed by removing the head and shell followed by washing in sterile distilled water.

The study consisted of a microbiological and physical-chemical evaluation of minimally processed shrimp covered with chitosan, cassava starch, polymer blend, and an uncoated group (control). All samples were placed in vacuum and refrigerated packaging at 7 ° C ± 1. The coverings applied on the shrimp were composed of polysaccharides (chitosan and / or cassava starch) and a plasticizer (glycerol).

2.2. Study design

After processing, the shrimp samples were separated into four groups: I C (No Cover), II CC (edible Chitosan Coating) III SC (edible Cassava Starch Coating) and IV CSC (Polymeric blend edible coating). After processing and vacuum packaging, the samples were stored in refrigeration for six days and subjected to evaluation of microbiological parameters (total count of aerobic mesophilic bacteria) and physicochemical parameters (potential hydrogen and moisture content).

2.3. Control (C)

The control group consisted of shrimp samples that underwent minimal processing operations, but received no coating. This group served as a basis for comparing and analyzing the microbiological and physical chemical data obtained with the other coated samples.

2.4. Chitosan Coating production (CC)

Chitosan coating was produced according to Xiao et al. (2010), with adaptations. 20g / L of chitosan powder, acetic acid 1% (v/v) in aqueous solution and 6 g/L of glycerol were mixed to form a solution. The solution was kept under continuous stirring for 24 h at room temperature.

2.5. Cassava Starch Coating production (SC)

The production of the cassava starch coating was performed as proposed by Nunes et al. (2017). 30g/L of cassava starch and 6 g/L of glycerol were added to sterile distilled water. The mixture was heated at 70 ° C for 15 minutes under stirring.

2.6. Chitosan and Cassava Starch Coating production (CSC)

For the production of this coating, a polymer blend was made using 20g/L of chitosan and 30g/L of cassava starch. The plasticizer was added at a concentration of 6g/L of the total solution. The solution was kept under stirring for 24 h at room temperature.

The CSC coating was produced by mixing the aforementioned coatings in a 1: 1 ratio.

2.7 Methodology for analysis

The aerobic mesophilic bacteria count was performed according to Freire et al (2016). Serial dilutions were produced by weighing 1 g of the sample in 9 mL of 0.1% peptone salt solution (D-1), the dilutions used were: 10 ^ -2 and 10 ^ -3, based on the principle that the food could be contaminated and just one dilution would not be enough to count microorganisms, the other dilutions were obtained from the first. The dilutions were spread on a standard hardened agar surface for microorganisms counting, the plates were inverted and incubated in a bacteriological culture oven at 37 ± 1 ° C. The plates were analyzed after 48 hours of incubation. The values of colony forming units (CFU) obtained in the counts were expressed in log CFU / g, the counts were performed in duplicates, where at the end of the counting, it was calculated an average value for each group.

The physical chemical parameters pH and moisture content were performed, with adaptations, according to Lima et al. (2019). The potential of hydrogen (pH) was measured by macerating 5 g of the sample in 10 mL of distilled water and measuring it in a properly calibrated digital potentiometer. The moisture content was measured by consecutive weighing of sample aliquots before and after 24 hours of drying in a stove at 105°C, the results were expressed as water loss percentage.

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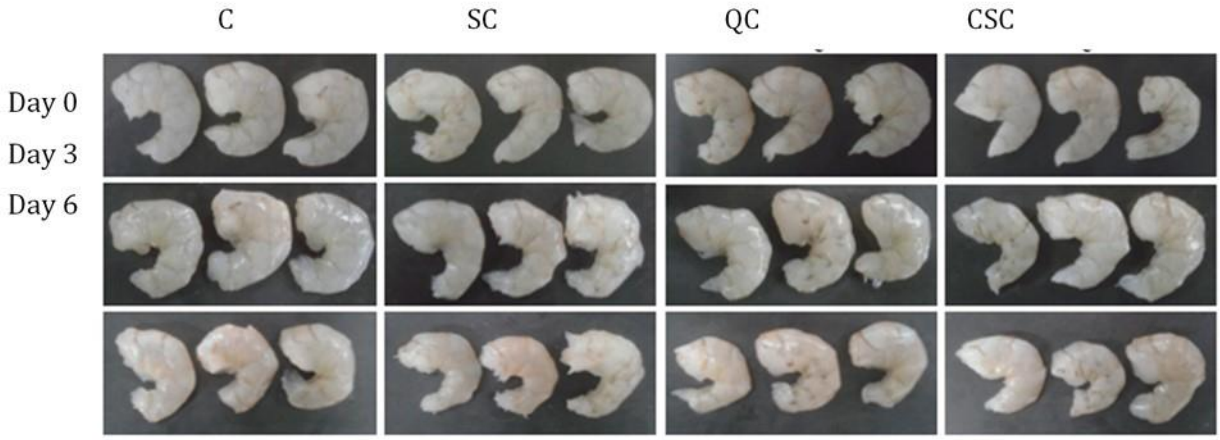
2.8. Data analysis

All analyzes were performed with three repetitions per treatment, the data obtained were statistically evaluated by one-way analysis of variance (ANOVA) and the means of all groups were compared by Tukey test at the 5% level of significance.

3. Results and Discussion

Figure 1 shows the general appearance of shrimp coated with cassava starch, chitosan, and both polymers.

Figure 1 - General appearance of minimally processed shrimp coated with cassava starch, chitosan, and cassava starch with chitosan, stored in vacuum packaging under refrigeration for six days.



Source: The author (2019).

3.1 Aerobic mesophilic count

The data obtained in the aerobic mesophilic count is shown in Table 1. Analyzing the efficiency of the coating on day 6, microorganism counts were made on the plates. According to the obtained data, it was observed the efficiency of the coats regarding the development of these bacteria, where all edible coatings presented a lower value of microorganisms UFC / g when compared to the control group. The coating with the lowest count was the one formulated with chitosan. This is a biopolymer with antimicrobial potential (Alencar et al., 2018) and prevents the growth of this type of contaminant, which can cause deterioration in the organoleptic and sensory properties of the food. By reproducing an encapsulating effect between the coat and the food, an efficient barrier is created preventing direct contact between the environment and the food (Dias et al., 2018).

SC group presented a larger number of mesophilic bacteria compared to the CSC group, making it evident, according to Table 1, that the association of cassava starch and chitosan is more efficient to prevent the development of aerobic mesophilic bacteria.

Table 1 shows the microbiological data of the shrimps treated over 6 days.

Table 1 - Results obtained from the analysis of aerobic mesophiles, pH, and humidity of shrimp coated with cassava starch, cassava starch and chitosan, and chitosan stored under refrigeration for six days.

Analysis	Day	C	SC	CC	CSC
Aerobic mesophiles (Log CFU/g)	0	5,57A	-	-	-
	6	10,28Ba	10,12Ba	9,92Aa	9,65Aa
pH	0	6,16Aa	6,29Aa	6,98Aa	7,11Aa
	6	7,31Ba	7,23Ba	7,26Aa	7,19Aa
Moisture (%)	0	73,8Aa	76,82Ab	71,95Aa	75,46Aa
	6	73,92Aa	74,64Aa	76,00Aa	71,97Aa

Equal lowercase letters on the same line indicate statistical similarity between the groups, equal uppercase letters in the same column indicate statistical similarity between the days. C (negative control); SC (cassava starch coated shrimp); CC (chitosan coated shrimp); CSC (cassava starch and chitosan coated shrimp). $P < 0.05$ was considered statistically significant at 95% confidence.
Source: The author (2019).

3.2. pH

The pH increases during the experiment. It is a parameter closely linked to microbial contamination (Fernandes et al., 2016), the increase in the number of microorganisms generates an increase in pH due to the probable accumulation of volatile bases (Freire et al., 2016). For this parameter, the coating with chitosan and cassava starch was the most efficient, preventing the development of volatile bases in the shrimp. In this regard, the association of starch with chitosan was more efficient than the use of the components alone. As opposed to the microbiological question, the starch coating obtained better results than chitosan, proven by the value of the pH being lower in the SC group than in the CC group, which shows the importance of this type of study, since a polymer that prevents the development of microorganisms may not be as efficient to avoid the influence of extrinsic factors, making an association necessary to obtain greater efficiency of the coating.

3.3. Moisture

Still in line with the importance of this type of study, we see the highest humidity value on day 6 for the CC group, even higher than the control group. It is noticed that the chitosan coating directly affects the humidity, this value increased during the experiment while the other groups had a reduction in humidity. Shrimps coated with polymeric blend obtained a reduction in moisture content, proving the benefits of the association between chitosan and cassava starch. Again, the starch obtained better results than chitosan, because it is considered an effective barrier to gas exchange, thus preventing the passage of O2 into the food, however, it has a high permeability to water vapor, being an inefficient barrier against moisture (Hassan et al., 2018).

4. Conclusion

The application of edible coatings based on chitosan and cassava starch, associated with vacuum packaging, can contribute to a better conservation of the coated shrimps based on the physical, chemical, and microbiological aspects analyzed. This group showed the best results in this experiment. However, further studies should be carried out analyzing other experimental conditions and other types of analysis of the coating's effectiveness.

References

Alencar, W. M., Picone, C. S., Silva, N. C., & Iacuzio, R. (2019). Intensificando antimicrobianos naturais: Complexos eletrostáticos de biopolímeros. *Revista Dos Trabalhos De Iniciação Científica Da UNICAMP*, (26). doi:10.20396/revpibic2620181385

Angioletti, B., Bertoli, S., Hoffmann, T., Reiter, M., & Souza, C. D. (2018). Óleos Essenciais com Efeito Antioxidante e Antimicrobiano Aplicados em Revestimento de Carne Bovina: Uma Revisão. *XXI I Congresso Brasileiro De Nutrologia*. doi:10.1055/s-0038-1674909

Azeredo, H. M. C. (2012). Edible coatings. In S. Rodrigues, & F. A. N. Fernandes(Eds), Advances in fruit processing technologies (pp. 345-361). Boca Raton: CRC Press Inc

Carlos, B. J., & Neto, A. O. (2002). *Camarões marinhos*. Viçosa, MG: Aprenda Fácil Editora.

Chevalier, R. C., Silva, G. F., Silva, D. M., Pizato, S., & Cortez-Vega, W. R. (2016). Utilização de revestimento comestível à base de quitosana para aumentar a vida útil de melão minimamente processado. *Journal of Bioenergy and Food Science*, *3*(3), 130-138.

Coelho, C. C., Fonseca, M. J., Soares, A. G., Campos, R. D., & Freitas-Silva, O. (2017). Aplicação De Revestimento Filmogênico À Base De Amido De Mandioca E De Óleo De Cravo-Da-Índia Na Conservação Pós-Colheita De Goiaba 'Pedro Sato'. *Revista Engenharia Na Agricultura - Reveng*, *25*(6), 479-490. doi:10.13083/reveng.v25i6.723

Dehghani, S., Hosseini, S. V., & Regenstein, J. M. (2018). Edible films and coatings in seafood preservation: A review. Food Chemistry, 240, 505–513. doi:10.1016/j.foodchem.2017.07.034

Dias, J. G. S., Reis, C. A., Guimarães Júnior, M., & Vaz, L. E. V. S. B. (2018). Avaliação das propriedades de barreira de filmes de quitosana/montmorilonita para revestimento de couve de folhas (brassica oleracea l. var. acephala). *Revista Brasileira de Iniciação Científica*, *5*(3), 16-27.

Fernandes, C. O., Barreiros, F. C. M., Cupertino, G. S., Andrade, W. L., Silva, H. F. C., & Carvalho, R. M. M. (2017). Análise de pH e Deterioração da Lata do Extrato de Tomate. *ANAIS SIMPAC*, *8*(1).

Fernandes, L. L., Freitas, C. A., Demarquette, N. R., & Fechine, G. J. (2012). Estudo do efeito do tipo de polipropileno na fotodegradação da blenda polipropileno/poliestireno de alto impacto. *Polímeros*, *22*(1), 61-68. doi:10.1590/s0104-14282012005000013

Freire, B. C. F., Soares, K. M. P., Costa, A. C. A. A., Souza, A. S., Silva, L. K. C., Góis, V. A., & Gomes, H. A. N. (2016). Qualidade de camarão (Litopenaeus vannamei) minimamente processado. *Acta Veterinaria Brasilica*, *10*(2), 150-155.

Furuya, W. M., Santos, L. D., Sales, P. J. P., Silva, L. C. R., Silva, T. S. C., & Matsushita, M. (2008). Fatty acids profile of malaysian praws (Macrobrachium rosenbergii) post larvae feed diets with linseed and tomato by-product meal. *Boletim do Instituto de Pesca*, *34*(4), 473-481.

Gonçalves, S. S., Antunes, L. B., Silveira, M. F., Souza, A. R., & Carvalho, D. D. (2019). Efeito Do Glicerol Nas Propriedades Mecânicas De Filmes A Base De Quitosana. *DESAFIOS - Revista Interdisciplinar Da Universidade Federal Do Tocantins*, *6*(Especial), 110-117. doi:10.20873/uft.2359365220196especialp110

Hassan, B., Chatha, S. A., Hussain, A. I., Zia, K. M., & Akhtar, N. (2018). Recent advances on polysaccharides, lipids and protein based edible films and coatings: A review. *International Journal of Biological Macromolecules, 109,* 1095-1107. doi:10.1016/j.ijbiomac.2017.11.097

Iglesias, E. G., Cabezas, L. G., & Luis, F. N. (2006). *Tecnologías de envasado en atmósfera protectora*. Madrid: CEIM.

Lima, N. B., Silva, L. B., Borges, M. V., Neves, R. R., Vera, R., & Ferreira, G. A. (2019). Caracterização Do Amido De Araruta Orgânica E Potencial Para Aplicação Tecnológica Em Alimentos. *DESAFIOS - Revista Interdisciplinar Da Universidade Federal Do Tocantins, 6*(Especial), 118-126. doi:10.20873/uft.2359365220196especialp118

Mejía, R. J., Martínez, M. T. A., & Lara, P. D. L. (2018). Quitosano: actividad antimicrobiana y mecanismos de acción. *e-CUCBA*, (9), 17-23.

Nunes, A. C., Neto, A. F., Nascimento, I. K., Oliveira, F. J., & Mesquita, R. V. (2017). Armazenamento de mamão 'formosa' revestido à base de fécula de mandioca. *Revista De Ciências Agrárias*, *40*(1), 254-263. doi:10.19084/rca16048

Pereira, R. B. M., Fonte, R. A. B., Barros, D. M., Machado, E. C. L., Oliveira, M. G., Moura, D. F., & Silva, C. G. M. (2018). Quitosana em queijo Minas frescal: ação antibacteriana sob cepa patogênica e nos atributos sensoriais/Chitosan in cheese Mines frescal: antibacterial action under pathogenic strain and in sensory attributes. *Brazilian Journal of Health Review*, *1*(2), 342-363.

Queiroga, I. M., Silva, J. A., Cavalheiro, J. M., Batista, A. S., Barreto, T. A., & Queiroga, R. D. (2014). Qualidade sensorial do camarão Litopenaeus vannamei congelado. *Semina: Ciências Agrárias, 35*(4), 1801. doi:10.5433/1679-0359.2014v35n4p1801

Rodrigues, A. O., Lucio, E. C., Melo, L. D., Canhamero, M., & Silva, F. C. (2019). Biopolímero desenvolvido a partir da farinha de arroz e sua aplicação como revestimento em frutos. *Revista Brasileira De Aplicações De Vácuo, 38*(2), 103. doi:10.17563/rbav.v38i2.1134

Silva, M. C., Lima, P. K., Silveira, M. F., Arthur, V., & Souza, A. R. (2019). Avaliação Das Propriedades Físico-Químicas E Mecânicas De Filmes De Fécula De Mandioca Incorporado Com Cafeína Irradiada. *DESAFIOS - Revista Interdisciplinar Da Universidade Federal Do Tocantins, 6*(Especial), 91-99. doi:10.20873/uft.2359365220196especialp91

Xiao, C., Zhu, L., Luo, W., Song, X., & Deng, Y. (2010). Combined action of pure oxygen pretreatment and chitosan coating incorporated with rosemary extracts on the quality of fresh-cut pears. *Food Chemistry, 121*(4), 1003-1009. doi:10.1016/j.foodchem.2010.01.038

Yang, Y., Wei, L., & Pei, J. (2019). Application of Bayesian modelling to assess food quality & safety status and identify risky food in China market. *Food Control, 100*, 111-116. doi:10.1016/j.foodcont.2019.01.010.

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