Nutritional properties of pomegranate (*Punica granatum*) agroindustrial subproducts and their application in fresh pasta

Propriedades nutricionais de subprodutos agroindustriais da romã (*Punica granatum*) e sua aplicação em massas frescas

Propiedades nutricionales de los subproductos agroindustriales de la granada (*Punica granatum*) y su aplicación en pastas frescas

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Abstract
The waste food industry generates a large amount and the costs are high, being necessary searches for alternative ways of using these bioproducts. The pasta market is expanding, in addition, it is a food with low cost and low nutritional quality. The objective of this research was to evaluate the influence of the partial replacement of semolina by pomegranate agroindustry residue flour on the physicochemical characteristics of mixed pasta. Pomegranate peel and pulp flours were produced using freeze-drying and a conventional oven as a drying method. Pasta formulations were done by evaluating the relationship of a plant part, drying method and percentage of pomegranate vegetable flour added, tests of antioxidant activity analyses, culinary analysis of the pasta cooking time, the calculation of the percentage of solids loss and yield were done. The freeze-drying process stood out for the quality both peel and pulp flour, the best results was 97,13% of moisture, 6,88% of protein, 11,07% of lipids, 2,32% of ashes, except for the carbohydrate analysis, with 93,65%, based in Tukey`s comparative mean test. The analysis of the technological properties of the masses showed that the lyophilization process reduced the loss of solids and the conventional oven process increased the yield for both parts of the plant. In the form of flour, all showed antioxidant activity, but after being added to pasta, only the one made with flour from the husk maintained this activity. Therefore, the pomegranate bioproduct proved to be a potential input for the development of pasta, aiming at nutritional and functional improvement.
Keywords: Nutritional improvement; Flour; Bioactive compounds.

Resumo
A indústria alimentícia gera uma grande quantidade de resíduos e os custos são altos, sendo necessárias buscas por formas alternativas de aproveitamento desses bioprodutos. O preparo desses resíduos na forma de farinha vegetal é uma alternativa, pois também possuem valor nutricional e compostos bioativos. O mercado de massas alimentícias

está em expansão, além disso, é um alimento de baixo custo e baixa qualidade nutricional. O objetivo desta pesquisa foi avaliar a influência da substituição parcial da semolina por farinha de resíduo da agroindústria de romã nas características físico-químicas de massas alimentícias mistas. Farinhas de casca e polpa de romã foram produzidas utilizando liofilização e estufa convencional como método de secagem. As formulações de massas alimentícias foram feitas avaliando a relação entre parte da planta, método de secagem e porcentagem de farinha vegetal de romã adicionada, testes de análises de atividade antioxidante, análise culinária do tempo de cozimento da massa, cálculo da porcentagem de perda de sólidos e rendimento. O processo de liofilização destacou-se pela qualidade tanto da farinha da casca quanto da polpa, os melhores resultados foram 97,13% de umidade, 6,88% de proteína, 11,07% de lipídios, 2,32% de cinzas, exceto para a análise de carboidratos, com 93,65%, com base no teste de média comparativa de Tukey. A análise das propriedades tecnológicas das massas mostrou que o processo de liofilização reduziu a perda de sólidos e o processo de estufa convencional aumentou o rendimento para ambas as partes da planta. Na forma de farinha, todas apresentaram atividade antioxidante, mas após serem adicionadas à massa, apenas a elaborada com farinha da casca manteve essa atividade. Portanto, o bioproduto de romã demonstrou ser um insumo potencial para o desenvolvimento de massas alimentícias, visando melhoria nutricional e funcional.
Palavras-chave: Melhoria nutricional; Farinha; Compostos bioativos.

Resumen
La industria alimentaria genera una gran cantidad de residuos y sus costos son elevados, por lo que es necesario buscar alternativas para su aprovechamiento. La preparación de estos residuos en forma de harina vegetal es una alternativa, ya que también poseen valor nutricional y compuestos bioactivos. El mercado de la pasta está en expansión; además, es un alimento de bajo costo y baja calidad nutricional. El objetivo de esta investigación fue evaluar la influencia de la sustitución parcial de sémola por harina de residuos agroindustriales de granada en las características fisicoquímicas de la pasta mixta. Se produjeron harinas de cáscara y pulpa de granada mediante liofilización y un horno convencional como método de secado. Las formulaciones de pasta se realizaron evaluando la relación entre la parte de la planta, el método de secado y el porcentaje de harina vegetal de granada añadida. Se realizaron pruebas de análisis de la actividad antioxidante, análisis culinario del tiempo de cocción de la pasta, cálculo del porcentaje de pérdida de sólidos y rendimiento. El proceso de liofilización se destacó por la calidad tanto de la harina de cáscara como de pulpa, los mejores resultados fueron 97,13% de humedad, 6,88% de proteína, 11,07% de lípidos, 2,32% de cenizas, excepto para el análisis de carbohidratos, con 93,65%, basado en la prueba de medias comparativa de Tukey. El análisis de las propiedades tecnológicas de las masas mostró que el proceso de liofilización redujo la pérdida de sólidos y el proceso de horno convencional aumentó el rendimiento para ambas partes de la planta. En forma de harina, todas mostraron actividad antioxidante, pero después de ser agregadas a la pasta, solo la hecha con harina de la cáscara mantuvo esta actividad. Por lo tanto, el bioproducto de granada demostró ser un insumo potencial para el desarrollo de pastas, con el objetivo de mejora nutricional y funcional.
Palabras clave: Mejora nutricional; Harina; Compuestos bioactivos.

1. Introduction

Food waste is one of the biggest challenges to achieving broader food security, they have a significant impact on the sustainability of the food system (Fao, 2020). The destination of fruit production is in its natural form of consumption, but there is a worldwide trend in the market for processed products such as fruit juices, pulps, jellies, and sweets (Al-Muammar and Khan, 2012).

It is estimated that 40% of industrial agricultural waste comes from fruit processing. The agricultural product processing industry continually invests in improving processing capacity and produces a large number of by-products, which in many cases are considered operating costs for the company or sources of environmental pollution (Junior et al., 2005).

During the processing of fruits and vegetables, various agroindustrial residues are produced, such as seeds, leaves, peel, stems, and roots. These residues are rich in carbohydrates, proteins, lipids, and biologically active compounds with properties by promoting very high health (Durante et al., 2017).

From the use of fruit residues, the new foods creation or evolution of existing ones is a sustainable alternative, since the full use of fruits can minimize the generation of organic residues, prolong the shelf-life of foods, and provides new sources of nutrition, in the industrial sector or residential environment (Silva and Ramos, 2009).

In the pomegranate juice industry, 1 ton of fresh fruit generates 669 kg of by-products, which are composed of two fractions: peel and seed. It is estimated that from the total weight of the pomegranate process in the industry, it produces 22 %

of seed residues and 78 % of peel residues (Pu Jing et al., 2012. e Gullon et al., 2015)\ Several studies have shown that pomegranate fruit and its extract have health benefits for many chronic diseases: type 2 diabetes, Alzheimer's, and atherosclerosis. These benefits are also attributed to the usually inedible plant part: peel, leaves, stem, and flowers (Al-Muammar and Khan, 2012).

The preparation of vegetable flour from fruit residue is an alternative and viable method, as this is used as an ingredient for the most diverse products like biscuits, cakes, bread, sweets, and pasta. Furthermore, they can be a rich source of nutrients (Zanatta et al., 2010). Also, pasta is part of the food industry, and is in full expansion in the world market, there are approximately 16.9 million tons of this product in world (Del Bem et al., 2012 and Unafpa, 2022).

Pasta is widely consumed due to its low cost, easy preparation and long self life; however, it not balanced food, it is rich in carbohydrates, but it is a poor source of fibers, proteins and physiologically active compounds. Therefore, the addition of flour with nutritional properties represents an interesting strategy to increase nutritional quality, in addition to being a way to take of by-products produced by the industry (Oliviero and Fogliano, 2016)

In this context, the study presents a proposal for the use of waste from the pomegranate industry, making flour from the peel and pulp fractions, subject to different types of drying and comparing them by physical-chemical analyses.

The objective of this research was to evaluate the influence of the partial replacement of semolina by pomegranate agroindustry residue flour on the physicochemical characteristics of mixed pasta. The DPPH and FRAP methods, for antioxidant activity analyses was done. About other properties, the culinary analysis of the pasta cooking time, the calculation of the percentage of solids loss and yield were obtained.

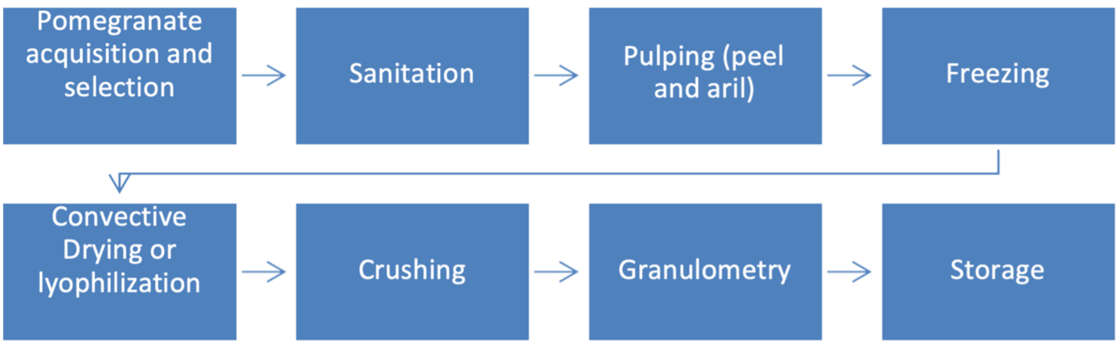
2. Methodology

An experimental, laboratory study of a quantitative nature was carried out (Pereira et al., 2018) using simple descriptive statistics with bar graphs, data classes, mean values and percentage relative values (Shitsuka et al., 2014).

The steps for obtaining pomegranate peel and pulp flour are illustrated in Figure 1. The Physical-Chemical Analyses were carried out according to techniques for determining the amounts of ash, moisture, proteins, lipids, and carbohydrates, according to the Aoac methodologies (Horwitz, 2000).

The antioxidant activity analysis used in flours and pasta was based on scavenging the stable free radical 1,1-diphenyl-2-picrylhydrazyl (DPPH) (Silveira et al., 2018) and ferric reducing power method (FRAP), according to Rufino et al. (2006).

Figure 1: Flowchart of steps to obtain flours – Federal Institute of Paraná. Umuarama – PR, 2021.



Source: Research data (2025).

The methodology for preparing the pasta had as standard ingredients: semolina flour, water (25 mL), egg (43 g), and salt (1 g); in proportion described in Table 1, which preparation was carried out manually until gluten network formed, then incorporated flour pomegranate in specific percentages. After modeling the masses into sheets up to 1 mm thick, the product was cut on a cutter roll and stored at freezing until physical-chemical analysis. For the culinary properties analysis, the dough was used right after preparation. Eight varieties of pasta were formulated, which differ from each other in the percentage of pomegranate flour: 5 % and 10 %; part of the plant: peel (Pe) and pulp (Pu) and dry part of the plant method: oven convective drying (O) or lyophilization (L).

Table 1: Fresh pasta formulations.

Ingredients	**Standard pasta (SP)**	**Pasta 1**	**Pasta 2**	**Pasta 3**	**Pasta 4**	**Pasta 5**	**Pasta 6**	**Pasta 7**	**Pasta 8**
Semolina flour (g)	100	90	95	90	95	90	95	90	95
PeOF (g)[1]	---	10	5	---	---	---	---	---	---
PuOF (g)[2]	---	---	---	10	5	---	---	---	---
PeLF (g)[3]	---	---	---	---	---	10	5	---	---
PuLF (g)[4]	---	---	---	---	---	---	---	10	5

1 – peel oven-drying flour (PeOF); [2] –pulp oven-drying flour (PuOF); [3] – peel lyophilization flour (PeLF); [4] – pulp lyophilization flour (PuLF). Source: Research data (2025).

As for the methodologies applied for the culinary properties analysis, the pasta was evaluated by cooking time and loss of soluble solids, following Aoac methodologies (Horwitz, 2000) and the Tukey`s comparative mean was applied

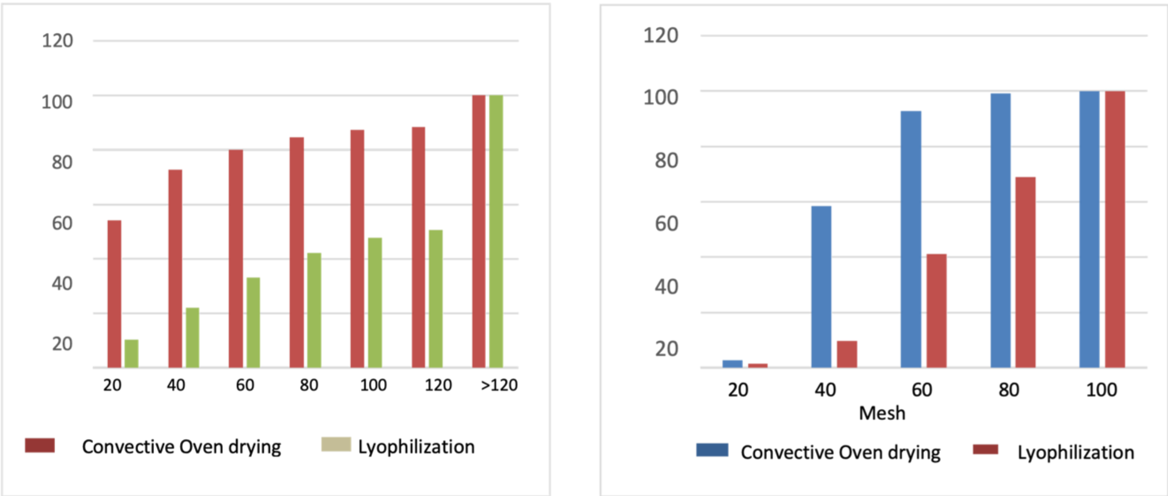
3. Results and Discussion

For the pomegranate flour the results present their characterizations regarding the different granulometric, physical-chemical analyses and antioxidant parameters. As for the pasta, the results presented are from the physic-chemical analyses, compared to the flour, antioxidant analyses and cooking characteristics. It should be noted that for the obtained pomegranate vegetable flour and for the pasta produced, in view of replacing part of the semolina flour used by the centesimal composition; tests were performed out and differentiated between types of drying and parts of plant.

3.1 Pomegranate vegetable flour analysis

Dimensioning the size of the particles and their proper classification to obtain flour for the preparation pasta is relevant. This justifies the granulometric analysis and shows results of particle distribution sizes obtained in the different adopted meshes. Figure 2 shows the granulometric distribution, based on the accumulated retention mass (%RA) in the respective mesh, both for peel flour (A) and for pulp flour (B) obtained in the different types of drying. Table 2 shows the results of the physical-chemical analyses with Tukey's comparative mean test.

Figure 2: Peel (A) and Pulp (B) granulometric analysis – Accumulated retention mass (%RA) parameter.



(A) (B)

Source: Research data (2025).

Table 2: Flour physical-chemical parameters.

Dry process	Moisture		Protein		Lipids		Ashes		Carbohydrates	
	Peel	Pulp	Peel	Pulp	Peel	Pulp	Peel	Pulp	Peel	Pulp
Convective Oven drying (%)	89.04 (±0.44)a	87.65 (±1.80)a	4.22 (±0.11)a	5.63 (±0.17)a	0.44 (±1.19)a	4.30 (±0.22)a	1.67 (±0.13)a	0.86 (±0.07)b	93.65 (±1.09)b	89.21 (±0.23)b
Lyophilization (%)	97.13 (±0.44)b	88.19 (±1.80)a	4.68 (±0.11)b	6.88 (±0.17)b	11.07 (±1.19)b	8.14 (±0.22)b	2.32 (±0.13)b	0.17 (±0.07)a	81.91 (±1.09)a	84.81 (±0.23)a

Equal lowercase letters in the same column do not differ significantly between the studied drying processes (P>0.05).
Source: Research data (2025).

To quantify pulp moisture, the dry processes used present equal efficiency, the differences of which are not significant according to the Tukey test. The values for protein, both for peel and pulp, there was a significant difference between the drying methods, lyophilization guarantees the highest percentile of this property.

Due to its high quality, pomegranate oil has many biological properties, being rich: in conjugated fatty acids, tocopherols, bioactive lipids (phytosterols, phospholipids, and triterpene), and phenolic compounds (Gumus et al., 2020). Thus, to quantify lipids, lyophilization dry better preserves the sample's lipid profile.

The ashes were qualified according to the amount of inorganic residue of foods (Onias et al., 2020) where the main vitamins found in the pomegranate peel are: calcium, potassium, nitrogen, iron, and zinc, while in the pulp fruit are found: iron and zinc. In this study, the drying methods varied significantly among themselves and the peel flour with lyophilization dry method was statically different.

Both flours had high amounts of carbohydrates, the values found in this study ranged from 79.56 to 83.39 % for peel flour and 74.79 to 78.3 % for pulp flour. These values are similar to those other authors found: 81.98 % for peel and pulp flour; 78.67% for peel flour and 68.38 % for seed pomegranate flour, Farias (2018), Ismail (2014) and Nogueira (2020), respectively.

The analysis of antioxidant activity in pomegranate flour was based on the FRAP and DPPH techniques. The values of µM ferrous sulfate/g of flour (FRAP methodology) and Trolox equivalent (µmol/g of pulp – DPPH methodology) resulted from the application of the techniques in the combinations of flours subjected to convective oven and lyophilization dry, combined with the parts of the plant studied; whose analysis of variance verified by the ANOVA table, results in significant interaction (95 %) between variables; associated with Tukey's comparative mean test, as shown in Table 3.

Table 3: Deployment table of factorial design to compare averages flours.

	DPPH (µmol/g of pulp)		**FRAP (µM ferrous sulfate/g of flour)**	
Types of drying	pulp	peel	pulp	peel
Convective Oven drying	836.88 aA	1359.71 aB	9380.86 aB	8466.14 aA
Lyophilization	570.53 aA	1472.02 aB	9475.07 bB	9245.52 bA

Means followed by the same lowercase letter in the column and uppercase in the line do not differ by Tukey's test at 5 % probability. Source: Research data (2025).

The lyophilization process and convective oven drying show no significant difference by Tukey's test, so the conservation of bioactive compounds are independent of the drying method, but the peel part stood out for conservation of bioactive compounds compared the pulp in the DPPH method. For the FRAP technique, there was a significant difference in the drying method and part of the plant, with the lyophilization process for the peel showing better conservation. Peel flour has higher antioxidant activity compared to the pulp in both tests.

3.2 Analysis of fresh mixed food pasta

The physical-chemical analysis of pasta confirmed most of the results obtained for the flour produced. The highest humidity was achieved with the use of flour from the peel, combined with the lyophilization dry technique, this being the only preparation outside the limits recommended by RDC Resolution nº 93/00 of Anvisa (2000) which are up to 35 % for wet mass.

For ashes, peel flour accompanied by lyophilization as a drying method showed the highest content. The studied lipids have the highest indexes evidenced for the flours produced with pomegranate pulp and with convective oven dry, since Anvisa (2000) defines the values of lipids for pasta with levels below 0.8 to 11 % on wet bases, the values found in the prepared doughs were within the recommended range, with values from 1.34 % to 2.48 %.

The carbohydrate index was higher in the use of pulp flour. Silva et al. (2019) studied the behavior of the dough whit the addition of alfalfa sprout residue and observed that carbohydrate values decrease as the proportion of vegetable flour added increases, the same was observed in this research.

The amount of protein was not influenced by the part of the plant in the pasta produced, by the type of drying applied, or by the concentration proposed.

The properties of the pasta produced were based on the culinary analysis of the pasta cooking time, and the calculation of the percentage of solids loss and yield (Table 4).

Table 4: Properties of the pasta produced.

Types Flour – Plant part	Type dry	%	Pasta cooking time (min)	Loss Solids (%)	Performance (%)
Peel	Lyophilization	5	7.50	0.03	264.06
Pulp	Lyophilization	5	10.08	0.01	270.15
Peel	Convective Oven drying	5	7.98	0.03	262.31
Pulp	Convective Oven drying	5	10.13	0.03	270.59
Peel	Lyophilization	10	7.67	0.00	290.53
Pulp	Lyophilization	10	10.17	1.02	297.07
Peel	Convective Oven drying	10	7.62	0.93	318.56
Pulp	Convective Oven drying	10	10.20	1.00	298.58

Source: Research data (2025).

According to Fogagnoli (2014), cooking time has a significant effect on water absorption and loss of soluble solids in pasta, this effect was observed in this study.

For fresh pasta quality criteria, the Hummel criterion (1996) was used, where losses of solids of up to 6 % are classified as characteristics of very good quality wheat pasta, up to 8 % of average quality pasta, and equal values or greater than 10 % are characteristics of low-quality pasta. Yield, which is related to the water absorption capacity, in this work, Hummel (1996) cites as adequate a yield of 200 % to 300 %, in this study all the results are within the adequacy ranges according to the author.

To define the antioxidant activity DPPH and FRAP tests were also performed. Table 5 demonstrates the antioxidant potential in the pasta, it can be seen that the pasta made with pulp flour did not show antioxidant activity and the addition of pomegranate peel flour in the pasta can increase the antioxidant activity.

Table 5: Antioxidant analysis result.

Types Flour– Plant part	Type dry	%	DPPH	FRAP
Peel	Lyophilization	5	4.66	13046.11
Pulp	Lyophilization	5	----	12487.70
Peel	Convective Oven drying	5	3.18	12885.90
Pulp	Convective Oven drying	5	----	12304.75
Peel	Lyophilization	10	10.80	13151.43
Pulp	Lyophilization	10	----	12242.44
Peel	Convective Oven drying	10	13.36	12885.90
Pulp	Convective Oven drying	10	----	11895.27

Source: Research data (2025).

The production of pasta with the addition of agroindustrial waste contributes to the development of products with greater added value and nutritional value, in response to a demand for foods with greater health benefits and protection (Silva, 2016). Thus, the best results of maintenance of bioactive are present for peel flour in the major concentration, so it becomes possible to add in preparation of fresh pasta with improvements of antioxidant properties.

4. Conclusion

In view of the results presented, it is seen that the use of pomegranate residue and after its drying in the form of flour are viable for the development of new products, as a way of reducing the disposal of waste produced by the food industry and possibly improving the nutritional potential and antioxidant activities.

For the analysis of the flour, the lyophilization process stood out, maintaining the best standards in the physical and chemical analyses, regardless of the part of the plant used.

Both elaborated flours showed antioxidant activity, highlighting the peel flours, but after adding to the dough only those elaborated with peel flour maintained antioxidant activity, demonstrating that both can be considered functional food. The lyophilization process was beneficial for the analysis of solids loss during cooking for both parts of the plant, while the drying process in the oven was positive for the yield analysis for both parts of the plant.

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Nomenclature

ANOVA – analysis of variance PeLF – peel lyophilization flour

PeOF – peel oven drying

DPPH – 1,1-diphenyl-2-picrylhydrazyl FRAP – ferric reducing power method

PuLF – pulp lyophilization flour

PuOF – pulp oven-drying flour

%RA – accumulated retention mass

References

Al-Muammar, M. N. & Khan, F. (2012). Obesity: the preventive role of the pomegranate (*Punica granatum*). *Nutrition*. 28, 595-604. https://doi.org/10.1016/j.nut.2011.11.013

ANVISA - National health surveillance agency. resolution RDC nº. 14 de 31/10/2000. *Norms and Standards for Food, Pasta*. <http://bvsms.saude.gov.br/bvs/saudelegis/anvisa/2000/rdc0014_21_02_2000.html.

Del Bem, M. S, Polesi, L. F., Sarmento, S. B. S., Anjos, C. B. P. (2012). Physical-chemical and sensory properties of pasta made with hydrothermally treated leguminous flours. *Food and Nutrition*, Araraquara, BR, 23, 101-110.

Durante, M., Montefusco, A., Marrese, P. P., Soccio, M., Pastore, D., Piro, G. M., Lenucci, M. S. (2017). Seeds of pomegranate, tomato, and grapes: An underestimated source of natural bioactive molecules and antioxidants from agri-food by-products. *Journal of Food Composition and Analysis*, 63, 65- 72. https://doi.org/10.1016/j.jfca.2017.07.026Get rights and content

FAO - Organization of Nations United (2020). *Food loss and waste in Latin America and the Caribbean*.

Farias, M. M. (2018) *Study of the addition of pomegranate peel pulp and flour (Punica granatum L.) in the quality of bread* (Master's dissertation) - Federal University of Fortaleza, Brazil.

Fogagnoli, G., Seravalli E.A.G., 2024, Application of passion fruit peel flour in fresh pasta. *Brazilian Journal of Food Technology*. 17, 204-212, Brazil. https://doi.org/10.1590/0103-8478cr20180508

Gullon, B., Pintado, M. E., Fernández-López, J., Pérez-Álvarez, J. A., Viuda-Martos, M. (2015). In vitro gastrointestinal digestion of pomegranate peel (*Punica granatum*) flour obtained from co-products: changes in the antioxidant potential and bioactive compounds stability. *Journal of Functional Foods*, 19, 617-628. https://doi.org/10.1016/j.jff.2015.09.056

Gumus, Z. P., Argon Z. V. & Celenk V. U. (2020*). Cold pressed oils: green technology, bioactive compounds, functionality, and applications*. Academic Press. 597-609.

Horwitz, W. (2000). *Official methods of analysis of the Association Analytical Chemist*. 17 ed. AOAC- Association of Official Analytical Chemists. Arlington: AOAC Inc., 1 and 2.

Hummel, C. (1966). *Macaroni Products: manufacture, processing and packing*. 2.ed., Food Trade Press, 287, London.

Ismael, T., Akthar, S., Riaz, M., Ismail, A. (2014). Effect of pomegranate peel supplementation on nutritional, organoleptic and stability properties of cookies. *Food Composition and Analysis*. 65, 661-666. https://doi.org/10.3109/09637486.2014.908170

Junior J. E. L., Neiva, J. N. M., Rodriguez, N. M., Pimentel, J. C. M., Lôbo, R. N. B. (2005). Intake and digestibility of by-products from fruit processing in sheep. *Brazilian Journal of Zootechnics*. 34. https://doi.org/10.1590/S1516-35982005000200036

Nogueira L. P. S., Cavalcanti, M. T., Sousa, P. A., Fonseca, J. V. S., Andrade, M. L. (2020). Processing and characterization of organic pomegranate residues for agro- industrial use. *Brazilian Journal of Environmental Management*, 14, 60-63. https://www.gvaa.com.br/revista/index.php/RBGA/article/view/7637.

Pu J., Tian, Y., Haiming S., Yi S., Margaret, S., Boyan, G., Linwei, L., Liangli, Y. (2012) Antioxidant properties and phytochemical composition of China-grown pomegranate seeds, *Food Chemistry*,132, 1457-1464. https://doi.org/10.1016/j.foodchem.2011.12.002

Oliviero, T. & Fogliano, V. (2016) Food design strategies to increase vegetable intake: The case of vegetable enriched pasta. *Trends in Food Science & Technology,* 5., 58-64.

Onias, E. A., Araujo, R. H. C. R., Sousa, T. C. F., Oliveira, A. M. F., Queiroga, T. B. (2020). Mineral composition of pomegranate peel, seed and aril during fruit development. *Brazilian Journal of Development*, 6, 102392-102403. https://doi.org/10.34117/bjdv6n12-657

Rufino, M. S. M, Alves, E. R., Brito, E. S., Morais S. M., Sampaio, C. G., Pérez-Jiménez, J., Saura-Calixto, F. D. (2006), Scientific methodology: determination of total antioxidant activity in fruits by the iron reduction method (FRAP), *Online Technical Communication*, ISSN 1679-6535, Embrapa, Brazil.

Silva, M. B. & Ramos ,A. M. (2009). Chemical composition, texture and sensory acceptance of mass sweets made with banana pulp and a whole banana. *Ceres Magazine*, 56, 551- 554. Available in: https://ojs.ceres.ufv.br/ceres/article/view/3465.

Silva, R.J. (2016). *Incorporated food pasta of freeze-dried tomato disposal: development and characterization* (Master's dissertation) – Federal University of Bahia. Brazil.

Silva, M .L. T., Brinques, G. B., Gurak, P. D. (2019). Use of sprouts by-product flour for the preparation of fresh pasta. *Brazilian Journal of Food Technology*, 22. https://doi.org/10.1590/1981-6723.06318

Silveira ,A. C., Kassuia, Y. S., Domahovski, R. C., Lazzarotto, M. (2018). Adapted DPPH method: a tool to quickly and reproducibly analyze antioxidant activity of yerba mate fruit pulp, *Technical Communication* 421, Embrapa, ISSN 19080-3982, Brazil.

UNAFPA, 2022, *Estimated world pasta production (tons).* pasta-unafpa.org/newt/unafpa/default.aspx?IDCONTENT=102.

Zanatta, C. L., Schlabitz, C., Ethur, E. M. (2010). Physical-chemical and microbiological evaluation of flours obtained from non-compliant commercial vegetables. *Food and Nutrition*, 21, 459-468.