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Red and Purple Flesh Potatoes a Healthy and Attractive Alternative Associated with New Market Trends

María-Teresa Pino and Cristina Vergara

Abstract

The potato is the fourth most important crop in the world in terms of human food, after maize, wheat and rice (FAOSTAT, 2019). The cultivated potato is a vital food-security crop considering its worldwide growth, from latitudes 65° Lat N to 53° Lat S, high yield, and great nutritive value. The potato is a good source of dietary energy and micronutrients, and its protein content is high in comparison with other roots and tubers. The cultivated potato is also a concentrated source of vitamin C and some minerals such as potassium and magnesium. Tuber flesh color generally ranges from white to dark yellow in cultivated potato; however, the high potato diversity shows tuber flesh color varies from white to dark purple. Red and purple-flesh potatoes are an interesting alternative for consumers due to phenolic compounds and antioxidant capacity. The goal of this publication is to show the advances in red and purple flesh potato, in terms of anthocyanin profile, color extraction and stability in simulated *in vitro* digestion.

Keywords: Antioxidant activity, Anthocyanins, *in vitro* digestion, Red and purple flesh potato, *Solanum tuberosum*

1. Introduction

The cultivated potato (*Solanum tuberosum* L.) is the fourth most important crop in the world, after maize, wheat, and rice. The cultivated potato is a vital food-security crop considering its worldwide growth and nutritional value. This crop is cultivated from latitudes 65° Lat N to 53° Lat S. However, the major potato-producing regions are in the relatively temperate zones, but it is also cultivated in Andean tropical highlands and in tropical and sub-tropical environments as a winter crop [1]. In the last decade, the developing world's potato production exceeded that of the developed world, showing a significant increase and demand in Asia, Africa, and Latin America, however in these areas it is often cultivated in marginal areas with limited access to farm inputs [2]. Potato is a very efficient food crop and produces more dry matter and proteins per unit area in comparison to cereals. In addition, potato is an efficient water user, however drought susceptible crop, because under rainfed conditions, it yields more food per unit of water than other major crops. For every m³ of water applied to the crop, potato

produces 5600 kcal of dietary energy, compared to 3860 in maize, 2300 in wheat and 2000 in rice [3]. Because of its high nutritional value and yield, cultivated potatoes constitute the bulk of the economically and agronomically important crop production. It accounts for large quantities of dietary daily energy intake compared to other crops and contributes to hunger reduction and improved nutrition. In addition, potato is also a good source of protein content, micronutrients, a concentrated source of vitamin C and potassium in comparison with other roots and tubers [4]. However, depending on potato flesh color, the nutritional value may be higher or different, because the color is associated to unique metabolite profile on phenolics, flavonoids, and carotenoids. These compounds are directly associated with antioxidant activity, and highly desirable in diet because of their beneficial effects on human health [5]. The present chapter will be focused on red and purple flesh potatoes as a healthy and attractive alternative associated with new market trends.

2. Color fleshed potatoes high in anthocyanins and antioxidant activity is promising food

2.1 Potato diversity in Chile

Chile is one of the countries with the largest potato diversity in the world and is also recognized as a center of origin (or center of diversity). Potato migration from the Andes to coastal Chile caused its adaptation to long-day conditions, this process contributed to the development of commercial cultivars worldwide [6]. Chile is the origin of the *Solanum tuberosum* group *Chilotanum* corresponding to lowland tetraploid landraces. Several Chilean potato genetic diversity and population structure studies have shown the close genetic distance between Chiloe Island landraces and the modern potato group. This germplasm appears to represent an interesting gene pool that could be exploited in potato breeding programs or also used for niche markets, by the specific needs and preferences. A collection of *S. tuberosum* consisting of 30 accessions of native landraces originating from the island of Chiloe, nine commercial cultivars commonly used in Chile and one accession of *S. fernandezianum* from Robinson Crusoe Island, located at 257 m altitude (33°39'9.03" S, 78°50'45.9" W) was evaluated; the results showed that commercial cultivars do not present the same genetic variability as native potatoes, and the allelic richness of commercial cultivars is lower than that of native *S. tuberosum ssp. tuberosum*. Most of the native potato were clustered in accordance with their geographical location, while commercial cultivars, were clustered in accordance with their breeding programs in Chile and Europe [7, 8]. The most complete morphological description of the Chilean germplasm was published in 2008 in the Catalog of Native Potatoes from Chile. Two institutions of the Chilean government, INIA, and SAG (Agricultural and Livestock Service of Chile), among 589 native accessions analyzed, 320 different allelic phenotypes were found indicating that there are at least 320 different genotypes in the collections. Of these, 158 belonging to the INIA collection were not found in the SAG collection. These 158 new genotypes should increase the number of known Chilean potatoes. As expected, different genotypes were known under the same popular name [9]. The genetic diversity and heterozygosity contain invaluable genetic, physiological, and biochemical attributes, that can guarantee new healthy food and safe global food productivity. The INIA (Agriculture Research Institute of Chile) is working to preserve that biodiversity, identifying the attributes of each landrace for further crop improvement, in terms of nutrition, flesh color, disease resistance, and other attributes.

2.2 Cultivated potato and red-purple fleshed potatoes

Cultivated potato is a high valued crop because of its nutritional properties and biochemical composition, rich in starch, reducing sugars, non-reducing sugars, proteins, and carotenoids. Other important nutrients in potatoes include minerals and vitamins such as potassium, magnesium, vitamin C as well as vitamin B6, among others [10, 11]. Potatoes are a reliable source of ascorbic acid – ranged from 5.8 to 21 mg of vitamin C per 100 g tuber on a fresh weight (FW) basis–, however several studies have reported changes in the content of vitamin C in potato tubers depending on variety [12, 13]. Potato flesh color ranged from white to dark yellow cultivars are the most common, a recent review showed that the total carotenoids content of tubers is influenced by location, season, genotype, and their interactions, with values between 5 and 10 mg kg⁻¹ FW of total carotenoids, for white-fleshed potatoes, to over 100 mg kg⁻¹ FW of total carotenoids for dark-yellow potatoes [14]. Total carotenoids expression was observed in the mid of the tuber maturation process rather than in ready-to-harvest tubers. The predominant carotenoid forms found in cultivated potato were lutein, violaxanthin, zeaxanthin, and neoxanthin [15].

Today, with a major market shift for antioxidant-rich foods, the traders are also seeing an increase in the demand for red and purple fleshed potatoes, because these contain an important group of secondary plant metabolites associated with positive health benefits: phenolics, flavonoids, and anthocyanins [16]. Red and purple fleshed potatoes provide a natural source of anthocyanins and antioxidant activity [17]. Anthocyanins are recognized as natural flavonoid colorants ranged from orange-red (pelargonidin), reddish to blue-violet (malvidin), for use in food industry and pharmaceutical ingredients, because of their potential health benefits. The six predominant anthocyanidins found in higher plants (including root and tubers) are cyanidin, delphinidin, pelargonidin, peonidin, petunidin, and malvidin [18]. The phenolics compounds, flavonoids, and anthocyanins are potent antioxidants which contribute to the physiological defense against oxidative and free-radical-reactions. Food containing anthocyanins have been associated with a reduction in inflammation markers and a lower risk of chronic diseases, including obesity, diabetes, cardiovascular disease, and cancer [19, 20]. In addition, a recent study showed that anthocyanins ameliorate neurodegeneration at a molecular and clinical level and dietary anthocyanin's supplement prevents neurodegenerative diseases [21]. Colored fleshed potatoes contain relatively low amount of total phenolic acids, but its flavonoids and flavones extracts showed high scavenging activities toward oxygen compared to other fruits and vegetables [16].

In relation to the predominant anthocyanidins, a study in four potato cultivars ("Hermanns Blaue", "Highland Burgundy Red", "Shetland Black", and "Vitelotte") identified Petunidin derivatives in all of them except in "Highland Burgundy Red". Malvidin was the predominant on the "Vitelotte" cultivars. "Shetland Black" was the only one containing minor peonidin [22]. The evaluation of anthocyanin phenolic compounds of potato peels from ten colored potato cultivars (red and purple) the most prominent were pelargonidin, peonidin, and malvidin aglycones. All samples revealed antioxidant and antitumor activities, and no toxic effect [23]. Another recent study on colored potato (three red-fleshed, three-purple fleshed, and one marble-fleshed) showed that red and purple-fleshed potatoes are rich sources of anthocyanins. Pelargonidin and petunidin were the main anthocyanidin forms, and all aqueous extracts presented *in vitro* antioxidant, antibacterial and antifungal activities, and no toxic effects [24].

Because most native color fleshed potatoes have low yield, wide phenotypic variations and uneven flesh color, the INIA Chile's Potato breeding program has

developed new putative color flesh potato cultivars as raw material to food coloring and ingredient extraction, with high anthocyanins flesh concentration and high yield. **Table 1** shows significant differences in color intensity (E1%), total anthocyanins (CAT), total polyphenol content (TPC), and antioxidant activity (FRAP), for selected red flesh potato (INIA RS58-3), purple flesh potato (INIA RQ12-521), blue-violet flesh potato (INIA RÑ98-9). Principal component analysis and matrix of correlation coefficients showed a good fit between color intensity (E1%) and total anthocyanins (CAT) with values from 0.63 between E1% and CAT-based in tuber dry weight between 0.90 for E1% and CAT-based in tuber fresh weight. Both red (INIA RS58-3) and blue-violet (INIA RÑ98-9) fleshed potatoes showed higher color intensity and higher total anthocyanins (CAT), also these two potato lines showed higher values in total polyphenol content (TPC), and antioxidant activity (FRAP). Conversely, the light purple flesh potato (INIA RQ12-521) showed lowest color intensity and consequently lower CAT, TPC, and antioxidant activity. Thus, selected red flesh potato (INIA RS58-3) and blue-violet flesh potato (INIA RÑ98-9) are promising raw material for natural color extraction and food coloring ingredients.

In term of Anthocyanin profile (**Table 2**), in these color fleshed potatoes, the predominant anthocyanins identified were Pelargonidin-3-glucoside, Peonidin-3-glucoside, Peonidin-3-arabinoside, Delphinidin 3-glucoside, Delphinidin 3-galactoside, Delphinidin 3-rutinoside, Delphinidin-3,5-diglucoside, Delphinidin 3-galactoside, Delphinidin 3-glucoside, Delphinidin 3-rutinoside, Malvidin-3-glucoside, and Malvidin-3,5-diglucoside. The major picks in red flesh potato (INIA RS58-3) were in Peonidin and Delphinidin derivatives, while in blue-violet flesh potato (INIA RÑ98-9) the picks were in Delphinidin and Malvidin.

2.3 Stability and Bioaccessibility: potato anthocyanins

The concentration and stability of these anthocyanins are affected by several parameters such as agronomic factors and postharvest storage. However, the stability of acylated anthocyanins is still not well addressed, and few studies in anthocyanins contents (CAT) in colored-flesh potato tubers during processing and digestion have been published [25, 26]. The stability of anthocyanins is affected by pH, temperature, and light. During the digestion process, anthocyanins stability is affected because undergo variation in pH and in digestive enzymatic activity. Therefore, the anthocyanins stabilization is needed to maintain their health effects in the human body and increase its positive effects. The anthocyanins stability could be improved by using micro-encapsulation technology such as spray-drying [26–28]. Micro-encapsulation is a technique wherein a bioactive compound is encapsulated by a biopolymer, to protect the compound from oxygen, water, or other conditions, thereby improving its stability and release in the desired stage [26, 28]. In order to know bio stabilization of anthocyanins extract from purple flesh cultivated potato, a study was addressed on the encapsulation anthocyanins' efficiency and bioaccessibility. The anthocyanin extract from INIA purple flesh potato (PPE) was micro-encapsulated by spray-drying [29] (**Figure 1**). Maltodextrin (MD) was used as the encapsulating agent, due to its high solubility in water, low viscosity, bland flavor, and colorlessness. Briefly, the mixture (extract PPE-maltodextrin) was fed into spray dryer at 130°C. The encapsulation efficiency (EE) was 86%, due the high anthocyanins-MD interactions caused by hydrogen bonding and/or electrostatic interactions. The total anthocyanins were 1.34 ± 0.02 mg cy-3-gluc⁻¹ and antioxidant activity (FRAP) was 10.1 ± 0.6 mg trolox equivalentg⁻¹. The moisture ($5.6 \pm 0.4\%$), water activity ($a_w = 0.225 \pm 0.001$), and particle size (6.51 ± 0.1 μm)

Color flesh Potato selected lines	Skin Color	Flesh Color	Tuber Shape	S.S. BRIX	Color (E1%)	CAT (mg C3G kg FW ⁻¹)	TPC (mg EAG kg FW ⁻¹)	FRAP (μmol TroloxKg DW ⁻¹)
INIA RS58-3	RF	RF	Rd	7.75b	0.149b	927.77b	1866.28b	12804.3b
INIARQ12-521	PF	PL	O	6.70a	0.073a	221.80a	758.10a	3687.26a
INIARÑ98-9.	VB	VB	Rd	8.70c	0.170c	931.63b	1706.53b	12595.2b
CV				4.28	9.18	6.12	6.77	19.84
<i>p-value line</i>				<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
<i>p-value season</i>				<0.0001	0.8241	0.5231	<0.0001	0.0001
<i>p-value season x line</i>				<0.0001	0.0767	0.4097	<0.0001	0.0017

Where, Red = RF, PF = Strong purple, PS = light purple, VB = blue-violet; Tuber shape Rd = Round, O = Oval. **Color intensity** (E1%) is the optical density of a 1% juice solution at the wavelength of maximum absorbance intensity (INIA RÑ98-9: Abs = 522 nm, INIA RQ12-521: Abs = 521 y RS58-3: Abs = 506 nm) by spectrophotometer (Jasco V-700). **Total anthocyanin content** (TAC) by pH differential method expressed as mg of cyanidin-3-glucoside equivalents per fresh weight (FW). **Total polyphenol content** (TPC) by the Folin–Ciocalteu method expressed as mg Gallic acid equivalent (GAE) per fresh weight (FW). **Antioxidant activity (FRAP)** measured by the FRAP method as described as Trolox equivalent by spectrophotometer (Jasco V-700). Different letters in the same column indicate statistical difference ($p \leq 0.05$) among potato lines. Three replicates were analyzed (with 3 instrumental measures per sample). Data were analyzed by one-way ANOVA followed by the Tukey test ($p < 0.05$) by InfoStat version 2020. <http://www.infostat.com.ar>.

Table 1.
Color intensity (E1%), total anthocyanins (CAT), total polyphenol content (TPC) and antioxidant activity (FRAP) in tubers, for selected red flesh potato (INIA RS58-3), purple flesh potato (INIA RQ12-521), blue-violet flesh potato (INIA RÑ98-9) cultivated in Osorno (40°34'26.22"S, 73°8'0.53"W.), Chile during two seasons (2019-2020 and 2020-2021).

Color flesh Potato selected lines	Skin Color	Flesh Color	Tuber Shape	Anthocyanin profile (predominants)
INIA RS58-3	RF	RF	Rd	Pelargonidin-3-glucoside, Peonidin-3-glucoside, Delphinidin 3-galactoside
INIARQ12-521	PF	PL	O	Peonidin-3-arabinósido, Delphinidin 3-glucoside, Delphinidin 3-galactoside, Delphinidin 3-rutinoside, Malvidin-3-glucósido,
INIARÑ98-9.	VB	VB	Rd	Peonidin-3-arabinósido, Delfinidina-3,5-diglucósido, Delphinidin 3-galactoside, Delphinidin 3-glucoside, Delphinidin 3-rutinoside, Malvidin-3,5-diglucósido,

Where, Red = RF, PF = Strong purple, PS = Light purple, VB = blue-violet; Tuber shape Rd = Round, O = Oval. Anthocyanin profile by HPLC analysis was carried out in Jasco Intelligent Quaternary Gradient PumpPU-2089 Plus, UV/VIS detector e interface LC-NetII/ADC, C18 Kromasil 100-5 de 150 mm at 30C°. Detection: UV @ 520 nm.

Table 2.
Anthocyanin profile of tubers, for selected red flesh potato (INIA RS58-3), purple fleshed potato (INIA RQ12-521), blue-violet flesh potato (INIA RÑ98-9) cultivated in Osorno (40°34'26.22"S, 73°8'0.53"W.) Chile, during two seasons (2019-2020 and 2020-2021).

were within the range described for anthocyanin encapsulated obtained by spray-drying [27, 30, 31].

PPE-MD encapsulation improved its anthocyanins stability due to anthocyanin extract and encapsulating agent interaction that may occur by hydrogen bonding and/or electrostatic interactions. Reduced damage of active anthocyanins was observed under adverse storage conditions. The time-course of the storage stability assay during 140 days at 60°C showed that encapsulated extract (PPE-MD) showed significantly higher anthocyanins retention than non-encapsulated PPE (**Figure 2**), thereby extending shelf life, color, and antioxidant capacity [29]. These results agree with earlier reports on use of spray drying technique on black-carrot, black berry, maqui and plum [27, 32–34].

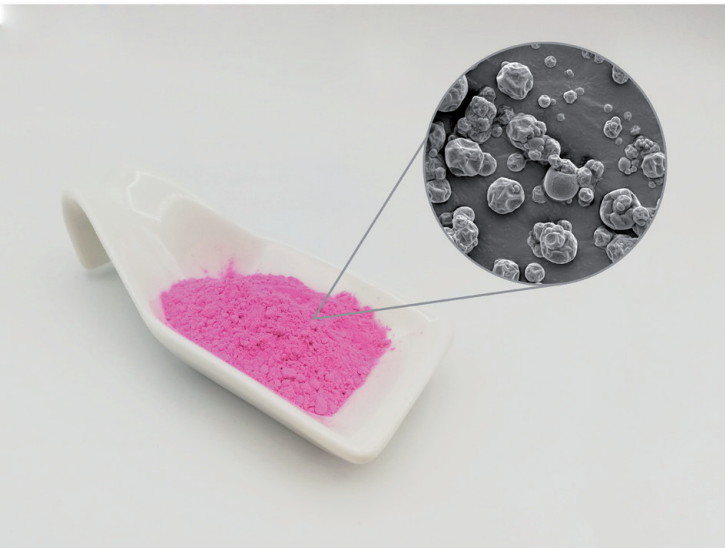
Other important aspect is the *in vitro* bio accessibility (BA) of anthocyanins. Bio accessibility is defined as the amount of bioactive compound (anthocyanins) that was released from the food matrix after digestion [35]. The BA of encapsulated anthocyanins extracts of purple flesh potato (PPE-MD) was significantly higher than non-encapsulated extract (**Figure 3**). Micro-encapsulation protects PPE-MD during *in vitro* digestion, against environmental conditions, especially pH. The BA of the PPE and PPE-MD was higher than previous similar studies in maqui extract [27] and blueberry extract [28]. The encapsulation technology is a useful strategy to protect anthocyanins from purple flesh cultivated potato, during storage and *in vitro* gastrointestinal digestion model, as well. The anthocyanins micro-encapsulation contributes to the development of new purple potato products in powder formulation, potentially useful as colorants for the food industry or health ingredients (antioxidant and anti-inflammatory properties).

2.4 Red and purple flesh potato-based food and natural ingredients responding to new global food market trends

The global consumer trend preferences and the health and wellness market in the next coming years, show a promising future for non-traditional color fleshed potato, as red, purple, and blue fleshed potato, because their antioxidant activity



(a)



(b)

Figure 1.
(a) Microencapsulated powders (anthocyanin extract from INIA purple flesh potato (PPE + maltodextrin) and (b) scanning electron microscopic (SEM) for anthocyanins microencapsulated powders.

and health benefit are capturing the consumers’ attention. Most studies about market trends have projected that “the global health and wellness food market” would grow at a CAGR of over 6% (6–8%) during the next years. This forecast is explained in part, because the world, upon COVID-19 pandemic impact, will face the growing incidences of chronic diseases, stress, obesity, aging and other adverse health conditions, see more detail in [36–38] reports. In potato, some reports about its market under the COVID-19 pandemic situation shows that potatoes become popular due to their long shelf-life. In relation to global market, most potatoes are consumed as fresh vegetable, however, is shifting from fresh potatoes to processed potato-based foods. Based on application, the processed potato market is segmented into ready-to-cook, snacks, potato flour-gluten free, and other potato-based food additives for soups, gravies, bakery, and desserts driven by urbanization and changes in eating habits among many other factors. Thus, these global food market trends, raises further questions for food industry and R&D institutions, would be capable to develop new color fleshed potato-based foods and potato-based ingredients keeping its nutritional value and color.

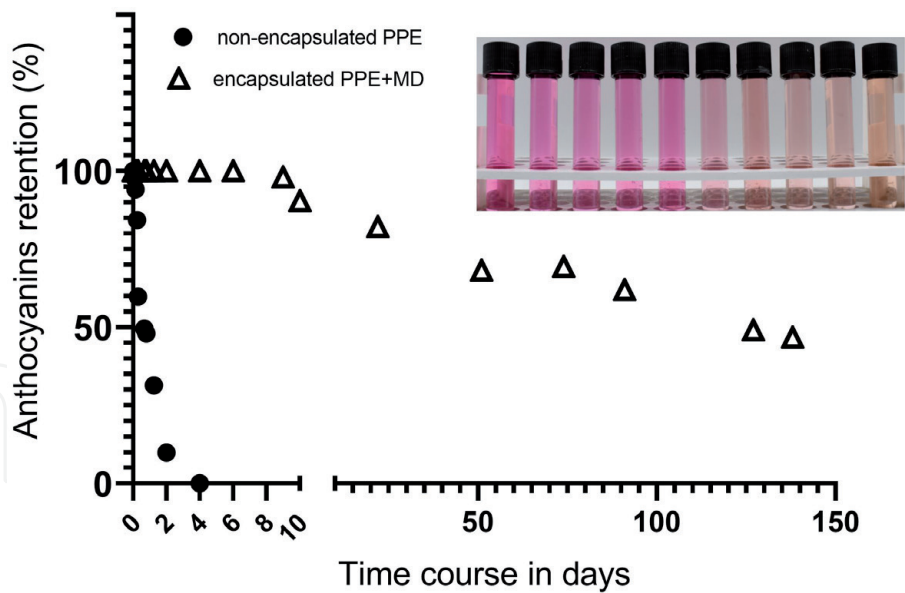


Figure 2.
Time-course storage stability assay for anthocyanins retention at 60°C for 140 days storage from non-encapsulated extract (PPE, ●) and encapsulated extract (PPE-MD, Δ), and the visual degradation of anthocyanins for liquid (analysis solution) on non-encapsulated PPE (source: Adapted Vergara et al. [29]).

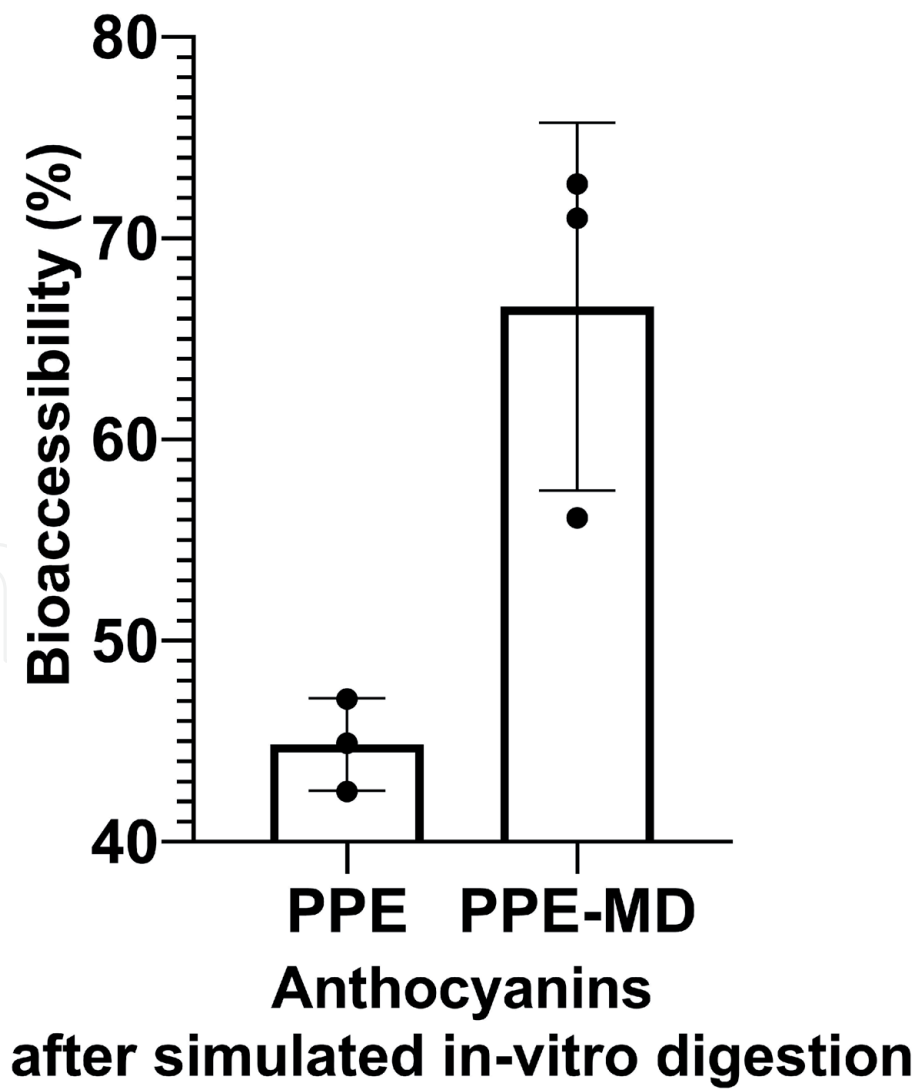


Figure 3.
Bio accessibility (%) of non-encapsulated (PPE) and encapsulated (PPE-MD) anthocyanins extract after simulated in-vitro digestion.

A recent research studied how the anthocyanin degradation and anthocyanin profile were influenced in red-fleshed potatoes (cv Herbie 26) after different methods of processing (dried cubes, French fries, chips, semi-finished products, and finished products); most evaluated processes showed losses on anthocyanin content. Chip products showed higher retention anthocyanins. Pelargonidin-3-feruloylrutinoside-5-glucoside, and pelargonidin-3-caffeoylrutinoside-5-glucoside, were most thermally stable [25]. To reduce the loss of effectiveness of plant-based compounds as anthocyanins, and polyphenols from color fleshed potatoes, micro-encapsulation arise as an alternative. This technique allows the development of novel plant-based ingredients able to keep their functionality after processing.



(a)



(b)

Figure 4.
(a) Potato-based ingredient, flakes elaborated from red flesh potato (INIA RS58-3), purple fleshed potato (INIA RQ12-521), blue-violet flesh potato (INIA RÑ98-9). (b) Flakes elaborated from light purple fleshed potato (INIA RQ12-521).

However, commercial product development depends on financial and operational viability. In the previous section of this chapter, anthocyanins' stability and bioaccessibility from color fleshed potatoes were discussed with emphasis in micro-encapsulation for INIA purple flesh potato and *in vitro* digestion. Thus, micro-encapsulated spray dried powder from purple-fleshed potato could be applied in drinks, in snacks, and in milk products because its stability and bioaccessibility [29]. The application of aqueous extracts from color fleshed potato was also tested and validated as natural colorants in a soft drink during 30-days shelf-life when compared with the commercial colorant E163 [24].

Potato flake is an ingredient with multiple applications in processed food and long shelf life. A recent study compared the convective tray drying method with a refraction-based drying method for producing potato flakes (cv. Kufri Pukhraj, a light yellow to gold flesh potato). The results showed that those flakes obtained by refraction-based drying had better nutritive value, color and acceptability. It recommended its application for the fortification of flour, baby foods, and extruded products [39]. Previously, a study in anthocyanin-rich red potato flakes showed that might improve the antioxidant system by enhancing hepatic SOD (superoxide dismutase) mRNA in mice [40]. The replacement of part of the wheat flour with purple fleshed potato powder (from freeze-dried) and albedo showed an enhancement antioxidant activity of fortified breads, and longer shelf life [41]. In addition to the previous reported health benefits, the purple fleshed potato powder (from freeze-dried) has the potential to aid in the amelioration of ulcerative colitis symptoms, a major form of inflammatory bowel disease [42].

Potato-based ingredients (flakes, spray dried powder, and freeze-dried powder) were elaborated from red flesh potato (INIA RS58-3), purple fleshed potato (INIA RQ12-521), and blue-violet flesh potato (INIA RÑ98-9) because their application in food industry (**Figure 4**). The spray dried powder shows better physical properties when compared to the freeze-dried powder. Conversely, freeze-dried powder

Potato-based ingredients	Color (E1%) Color intensity	CAT (mg C3G g ⁻¹) ingredient	FRAP (μmol Trolox g ⁻¹) ingredient
Flakes Red flesh INIA RS58-3	0.42 ± 0.03 ^{ab}	1.9 ± 0.2 ^b	45.1 ± 1.2 ^b
Flakes Purple flesh potato INIA RQ12-521	0.27 ± 0.02 ^c	1.2 ± 0.3 ^c	47.0 ± 1.7 ^b
Freeze-dried powder Red flesh INIA RS58-3	0.47 ± 0.01 ^a	2.7 ± 0.1 ^a	56.9 ± 4.9 ^a
Freeze-dried powder Purple flesh potato INIA RQ12-521	0.39 ± 0.01 ^b	2.2 ± 0.2 ^{ab}	46.4 ± 0.6 ^b

Color intensity (E1%) is the optical density of a 1% juice solution at the wavelength of maximum absorbance intensity (INIA RÑ98-9: Abs = 522 nm, INIA RQ12-521: Abs = 521 y RS58-3: Abs = 506 nm) by spectrophotometer (Jasco V-700). **Total anthocyanin content (TAC)** by pH differential method expressed as mg of cyanidin-3-glucoside equivalents per fresh weight (FW). **Antioxidant activity (FRAP)** measured by the FRAP method as described as Trolox equivalent by spectrophotometer (Jasco V-700). Different letters in the same column indicate statistical difference ($p \leq 0.05$) among ingredient and potato lines. Three replicates were analyzed (with 3 instrumental measures per sample). Data were analyzed by one-way ANOVA followed by the Tukey test ($p < 0.05$) by InfoStat version 2020. <http://www.infostat.com.ar>.

Table 3. Color intensity (E1%), total anthocyanins (CAT) and antioxidant activity (FRAP) of potato-based ingredients (flakes and freeze-dried powder) elaborated from red flesh potato (INIA RS58-3), and purple flesh (RQ12-521).

preserves better the nutritional value such as naturally occurring. And, in spray dried powder the high temperature of heat may cause the loss of nutritional value. Red flesh potato (INIA RS58-3) and purple flesh potato (INIA RQ12-521) were selected for further evaluation because they fresh tubers show greater differences in color intensity. Potato-based ingredients as flakes and freeze-dried powder were compared (**Table 3**) for color intensity (E1%), total anthocyanins (CAT), and antioxidant activity (FRAP). As expected, freeze-dried powder preserved better the color intensity (E1%), total anthocyanins (CAT) and antioxidant activity (FRAP), however the flakes values were also attractive. These potato-based flakes and freeze-dried powder are food coloring because both ingredients provide color and bioactive compounds, with different applications.

3. Conclusion

All these antecedents, suggest that red and purple fleshed potatoes are not only a promising crop for starvation problem, also their consume promote health and may prevent chronic diseases. Anthocyanin-rich extracts from red and purple fleshed potatoes have high potential as natural colorants with multiple applications in food industry. Also, these potatoes contain an important group of secondary plant metabolites associated with antioxidant activity and positive health benefits, as phenolics, flavonoids, and anthocyanins. INIA's new putative color flesh potato cultivars (red flesh potato (INIA RS58-3), purple flesh potato (INIA RQ12-521), blue-violet flesh potato (INIA RÑ98-9)) are promising raw materials for natural color extraction and food coloring ingredients.

Acknowledgements

This chapter is a review the latest research on color fleshed potato and recent results of the authors on red to purple fleshed potato foodcoloring ingredients as well. We would like to acknowledge all authors cited in the references.

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Conflict of interest

The authors declare no conflict of interest.

Appendices and nomenclature

INIA	Instituto de Investigaciones Agropecuarias de Chile (Institute of Agricultural Research of Chile).
CAGR	Compound annual growth rate.

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