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Polyphenol and Quality Attributes from Some Potato Cultivars and it's Affected by Date of Planting and Salicylic Acid Treatments

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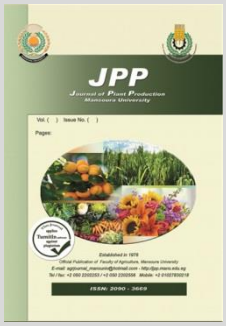

ABSTRACT

In This study we assess the effect of planting dates and salicylic acid treatments on the phytochemical content on tubers peel and flesh of potato cvs. Lady Rossetta, Burn and Cara.Three planting times; September 12th, September 26th and October 12th. Two concentrations of salicylic acid (control,100 and 200ppm) were used as foliar spray on potato cultivars. Obtained data revealed that earlier planting dates of 12th and 26 September with potato cv. Burn shows the highest increase in polyphenol and flavonoids content both in flesh (57.83 and 65.05 mg/100gFW) and peel (92.02 and 219.57mg/100gFW) gives the highest values for non-reducing sugar and total sugar content with cv. Cara, and gives the highest accumulation of anthocyanine content in peel and flesh color lightness (L*) with potato cv. Lady Rossetta. Salicylic acid at a concentration of 200ppm was effective for increasing flavonoids content, reducing, non-reducing sugar and total sugar content of tubers. While, the concentration of 100ppm was effective with polyphenol content and accumulation of anthocyanin in the peel of potato tubers. Concerning the interaction effect. Lately planted on Oct. 12th of potato cv. Cara without SA spraying or planted early at Sept. 12th with SA 200ppm increased polyphenol content, non- reducing and total sugar content % cv. Burn recorded the highest increased in flavonoids content in peel at SA 200 ppm and in flesh at 100ppm. Potato cv. Lady Rossetta at SA 200ppm registered the best values for accumulation of anthocyanin content in the peel and lightness of tuber flesh color (L*).

Keywords: Potato, salicylic acid, polyphenol, flavonoids

INTRODUCTION

Potatoes Solanum tuberosum L. is the most non-grain crop, ranked the 4th after wheat, rice, and maize, Lukianova *et al.* (2014) and represent one of the staple foods of the human diet *Frontuto et al.,* (2019). Global production of potatoes increased by 20% since 1990 and register more than 359 million ton in 2020 FAOSTAT (2020). In Egypt, potato has an economic role as a food and cash crop, total exports in 2018 to Europe and other countries reached 723.920 tons GOECI (2019).Potatoes serve as an excellent source of energy for humans owing to their high carbohydrate content and relatively low fat levels. Additionally, they are considered a moderate source of iron and are particularly rich in vitamin C, which enhances iron absorption (Dean, 1994 and Ngobese *et al.,* 2017). Potatoes also provide a substantial amount of proteins, minerals such as potassium, phosphorus, and magnesium, and vitamins including C, B1, B3, and B6 *(Mishra et al., 2020).* They are recognized for their antioxidant properties due to compounds like polyphenols, anthocyanins, flavonoids, and carotenoids, which may contribute to disease prevention. Moreover, potatoes contain significant amounts of starch, ash, sugar, and fiber, all of which offer health benefits *(*Sun *et al.,* 2021*;* Vaitkevičienė *et al.,* 2019*).* The nutritional profile of potatoes can be influenced by various factors including cultivar, processing methods, and environmental conditions (Tolessa, 2018).

Each potato cultivar possesses distinct characteristics that define its value and application. Varieties with lower dry matter content are typically suited for fresh consumption, whereas those with higher dry matter, exceeding 19.5%, are preferred for the production of chips and French fries. The quality of potato tubers is evaluated through two primary dimensions. The first, termed "external quality," encompasses attributes such as skin color, flesh color, tuber size, tuber shape, and depth of eyes, all of which can influence consumer preference. The second dimension, referred to as "internal quality," involves factors such as nutritional properties, dry matter content, specific gravity, flavor, sugar content, protein levels, starch content, and glycoalkaloid concentrations (Hussen, 2019). Consequently, the selection of potato varieties is based not solely on yield but also on both external and internal qualities.

Salicylic acid (SA) is recognized for its role in modulating the activity of antioxidant enzymes and enhancing plant resistance to abiotic stresses (Erasalan *et al.,* 2007). It acts as a growth stimulant and contributes to the increase of photosynthetic pigment levels (Fayez and Bazaid, 2014). Polyphenols, a prominent group of antioxidants *(Brown, 2005),* are crucial in various aspects of plant physiology including growth, pigmentation, cell wall formation, and the induction of resistance to both biotic and abiotic stresses (Frontuto *et al.,* 2019 and Navarre *et al.,* 2019). Additionally, polyphenols offer significant health benefits to humans, including protection against cancer, cardiovascular diseases, and allergies *(Cory et al., 2018 and Mishra et al., 2020).*In addition, peels of potato contains high

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amount of valuable chemicals than inner flesh which are natural antioxidant and has a good impact on human health (Deusser *et al.* (2012), Ezekiel *et al.* (2013), Arun *et al.* (2015), Huang *et al.* (2017) and Gebrechristos *et al.* (2019). Over million tons of potato peels are annually generated in U.S alone (Xu *et al.* (2022). This leads to environmental problems (Singh *et al.* (2020), decreasing polyphenolic antioxidant. As mentioned, potatoes are one of the most essential consumed foods in Egypt, gained attention as a source of nutrients and bioactive phytochemicals, however the total potato waste of peel represent up to 10% (Liang and McDonald(2014).Therefore, the peel evaluation must be of interest to the food industry and can be used for 'value addition' in different food products. Therefore, this study focused on determination of flavonoids and polyphenol, both in flesh and peel, anthocyanin in peel, ASH, sugar (total, reducing and non-reducing sugars), on three potato cultivars and it's affected by SA treatments and date of planting to enhancement of potato inner quality.

MTERIALS AND METHODS

Experimental site:

The experiment was undertaken on potato Solanum tuberosum L. cvs. "Burn, Cara and Lady Rosetta" at the experimental farm of Mallawy Agriculture Research Station, Agriculture, Research Centre, Giza, Egypt. During the Nile season of 2022, this trial was conducted to study the effect of foliar spraying with salicylic acid (100ppm, 200ppm and control treatment) at 3 different planting dates on the inner quality parameters of some potato cultivars.

Agriculture treatments:

The land preparation and all standard agricultural practices (soil additives, irrigation, fertilization foliar nutrient, and pest and diseases) control during the growth season were done in accordance to the recommendation of the Ministry of Agriculture and land reclamation.

Treatments:

a- Main plots (potato cultivars):

Three sowing dates were; 12th, 26th of September and 12th of October

b-sub- Plots (Sowing dates):

Three potato cultivars (Burn, Cara, and Lady Rosetta) were used in this experimental. As we can see in Table (1) the difference between them.

C- Sub-sub plots (Salicylic acid concentrations).

Two concentrations of SA were used plus control treatments as follow; 0.00 ppm (control), 100 ppm and 200ppmThe spraying times with SA were applied after 57, 70 and 84 days from planting.

Table 1. Maturity, skin and flesh color and tuber shape of potato cultivars (Burn, Cara and Lady Rossetta)

Cultivar	Maturity	Skin color	Flesh color	Tuber shape
Burn	Medium (110 days)	Cream	Medium yellow	Long oval
Cara	Late(120days)	White with red eyes	Cream	Short oval
Lady Rossetta	Medium to late(110-115 days)	Red	Light yellow	Round

Sampling:

When the potato plants reached ripeness stage (110 days from sowing). Potato tuber samples from each treatment from each replicate and from each potato cultivar were taken immediately for chemical analyses on freshly harvested tubers at the centralized lab organic Agriculture department of Mallawy, Agric. Res. Station, Agriculture Research Centre. Giza, Egypt.

Tuber chemical quality:

The following parameters were considered:

1-Polyphenols content in the flesh and peel of potato tubers (mg/100g FW).
2-Flavonoids content in the flesh and peel of potato tubers (mg/100g FW).
3-Anthocyanin in the peel of potato tubers (mg/100 FW)
4- Reducing sugars (%)
5- Non-reducing sugar (%)
6- Total sugars (%)
7-dry matter %
8- Color parameters of potato flours (L*, a*, b*, chroma and hue angle).

Extraction and Determination Methods for Phenolic in Potato tubers

Total phenolic:

Total phenolic were assessed spectrophotometrically using the modified Folin Ciocalteu colorimetric technique Singleton *et al*. (1999) and Papanov *et al*. (2019).

Total flavonoids:

Total flavonoids content of the potato extracts were assessed using a modified colorimetric method de- scribed previously Dewanto *et al*. (2002).

Determination of Anthocyanins:

Total anthocyanins content was measured colorimetrically according to the approach published by Ranganna (1977) where a known amount of the filtered extract was diluted to 100 ml with the extracting solvent. The color intensity was measured at wave length of 520 nm for water and citric acid solution extracts and 535 nm for acidified ethanol using Spectrophotometer (model 206 - ENESYS) .content referring to cyanidin-3-glucoside was estimated using the following equation:

Total anthocyanins (mg/100g FW) =

$$\frac{\text{Absorbence at 535 nm} \times \text{Volume made up of the extracts used for colour measurement} \times \text{Total volume} \times 100}{\text{ml of the extract used} \times \text{Wt of sample taken}}$$

Total soluble sugars

The phenol-sulfuric acid method described by Dubois *et al*. (1956) was used in the determination of total soluble sugars (TSS).

Reducing sugars:

Total reducing sugars (TRS) were extracted with 70% ethanol and assessed by the DNS method *(Miller (1959).*

Non -reducing sugars:

The total of non – reducing sugars was estimated as the difference between total soluble sugars and total reducing sugars.

Preparation of the flour of the treatments

The potato tubers from each treatment were washed with tap water, air dried and manually peeled in accordance to *(Jangchud et al. (2003)*. The potato peeled was thinly sliced, oven dried at 60 °C for 24 hours till constant weight.

The dried potato slices were finely ground using an electric hand mill (MOD: 5KH39QN9777, RPM. 1425 CODE S, CATNO .H 645Made: USA.) The flours were packaged in polypropylene bags sealed and stored in a refrigerator (5°C) until needed (Senanayake *et al. (2013).*

Fig. From left to right, color of potato tuber slices after drying and after ground of potato cv. Cara, Burn, Lady Rossetta compared to wheat flour.

Color determination:

The potato flour from each treatment was placed in a petri dishes (10 cm diameter; 2 cm depth) and its color was evaluated with Hunter L, a, b, parameters using a Chroma meter (Model color Tec- PCM, USA) according to (Francis (1983) As we can see in the plate 1. Additionally, color angle, and color intensity (chromaticity) were calculated according to *(Shih et al. (2009)* use the following formula:

$$\text{Hue angle} = \{\tan^{-1}(b/a)\}$$

$$\text{Chroma} = \{(a^2 + b^2)\}^{1/2}$$

Hunter L values range from 100 (white) to 0 (black), a, values range from +a (red) to -a (green), and b values range from +b (yellow) to –b (blue). Average of the reading were computed and reported. Chroma (C), total difference and hue angle (H).

- Lightness color (L), - Redness/ greenness color (a)

- Hue angle (H), - Yellowness /blueness color (b)

- Chroma (c), The L*a*b* model from CIELAB color space (Source: Hunter Lab, Reston, VA).

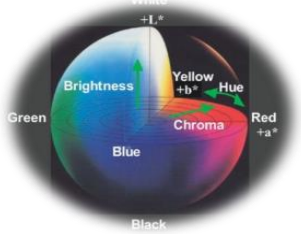

Plate.1. The L*a*b* model from CIELAB color space (Source: Hunter Lab, Reston, VA).

Statistical analysis:

The statistical analysis was carried out according to Snedecor and Cochran (1980) and Grane and Jach (2014).using the statistical package for social scientist (spss) software program. Means measured by the least significant difference (LSD) and Duncan's multiple range tests at 5%significant level.

RESULTS AND DISCUSSION

Flesh and peel polyphenol (mg):

As we can see in Table 2, determined values of total polyphenol content in the flesh of three different potato varieties were in range from 37.95 mg to 57.83mg/100g fresh weight compared to79.94mg to 92.02mg for the peel of potato tubers (Lady Rossetta, Cara and Burn), respectively. The highly polyphenol content in the flesh and peel was recorded with cv. Burn. The variation among potato cultivars for polyphenol contents may be referred to the genetic variation. Many researchers have confirmed that the total phenols (TP) are affected by genetic makeup. (Pawelzik *et al.* (1999) Navarre *et al.* (2011) and Volnová *et al.* (2016)

The planting date in Sept.26th showed the highly significant increase both in flesh (52.23mg) and peel (84.20mg) of potato tubers. Also, the data showed significant effect of SA concentrations on the polyphenol content of the flesh and peel of potato tubers. The highest concentration of SA at 200ppm showed the lowest values in the polyphenol of tuber flesh and SA at 100ppm and 200ppm for the polyphenol of tuber peel. The best values were recorded with the control treatment both in tuber flesh and tuber peel and only with SA at 100ppm for tuber flesh of potato cultivars. This result is in harmony with that reported by *(Osama et al. (2019) and Huang et al. (2022).* The authors stated that *Ammi visnaga* L. plants when grown in drought stress, and treated with SA, the total polyphenolic content was increased and also, SA encourage the radical scavenging activity.

Regarding to the interaction effects, the data in Table 3 showed that planting date of cv. Cara at Sept. 26 without treatment of SA showed the highest polyphenol content in the flesh of potato tubers (70.65mg) and with cv. Burn for the peel of potato tubers (116.59mg).

Potatoes are a good source of phenols, with a higher content than other widespread of fruits and vegetables (i.e. tomatoes, carrots, onions) due to its high

Table 2. Flesh and peel polyphenol (mg/100g FW) of some potato cultivars as affected by date of planting and foliar spraying with SA treatment.

Cultivars (A)	Planting dates(B)	Treatment (SA ppm) (c)	potato flesh polyphenols	Potato peels polyphenols
		0.00	59.13cd	113.17b
	Sept.12	100	64.14b	93.30d
		200	31.17l	82.12h
		0.00	62.43bc	116.59a
Burn	Sept.26	100	65.96b	62.05m
		200	56.48d	98.17c
		0.00	56.45d	93.15d
	Oct.12	100	65.55 b	74.23j
		200	59.13cd	95.35d
		0.00	38.14 h-k	66.73|
	Sept.12	100	50.13 e	84.57g
		200	40.38 hi	76.38ij
		0.00	70.65 a	81.57h
Cara	Sept.26	100	46.93ef	70.38k
		200	49.86ef	87.47ef
		0.00	47.91ef	89.41e
	Oct.12	100	48.74ef	66.87|
		200	45.88fg	54.63n
		0.00	42.28gh	88.02ef
	Sept.12	100	32.21l	67.24l
		200	34.15kl	85.81fg
		0.00	37.12ijk	64.06m
LadyRosetta	Sept.26	100	39.50hi	87.57ef
		200	41.1hi	89.90e
		0.00	38.52hij	78.70i
	Oct.12	100	42.18gh	89.77e
		200	34.51jkl	68.36jkl
	Burn		57.83a	92.02a
Mean of A	Cara		48.74b	75.34c
	Lady Rosetta		37.95c	79.94b
	Sept.12		43.53c	84.15c
Mean of B	Sept.26		52.23a	84.20a
	Oct.12		48.77b	87.94b
	0.00		50.29a	87.93a
Mean of C	100		50.59a	77.33c
	200		43.63b	82.02b

Values with similar alphabetical letter don't significantly differ from each other, using Duncan's Multiple Range test, at 0.05 levels.

Consumption rates (Chun *et al.* (2005). The obtained results are in agree with that reported by (Ezekiel *et al.* (2013) who showed that the phenolic compounds are found in both

the peel and flesh of potato tubers and the peel is reported to contain the highest amount of phenols. Also, (Brazinskiene *et al.* (2014) potato tuber content of the phenolic acids significantly depends on the genetic variation and growing conditions variation from year-to-year.

Flesh and peel flavonoids (mg):

Data presented in Table 3 showed that flavonoids of potato tubers (flesh and peel) were affected significantly by potato cultivars, planting dates and SA concentrations. Potato cv. Burn showed the highest values (61.02mg for flesh flavonoids and 219.57mg for peel flavonoids tubers). The study by (Lombardo *et al.* (2013) founded that the genotype of potatoes has more effect on the phenolic content than the location. The sowing at the early in 12th and 26th of Sept. gave the highest significant increase in flesh (58.67 mg) and in peel (199.67mg), respectively. This result confirmed that the date planting play role in the flavonoid content of potato tubers. This result are in harmony with that reported by *(André et al. (2009)* who stated that during tuber development, the environmental conditions may influence the phenyl propanoid pathway and the polyphenolic composition in potato tubers.

Table 3. Flesh and peel flavonoids (mg/100g FW) of some potato cultivars as affected by date of planting and foliar spraying with SA treatment.

Cultivars (A)	Planting dates (B)	Treatment (SA ppm) (C)	Flesh flavonoid (ABC)	Peel flavonoid (ABC)
Burn	Sept.12	0.00	84.94ab	167.56h
		100	63.23fg	240.28c
		200	62.15gh	230.97d
	Sept.26	0.00	50.33jk	153.16j
		100	47.38kl	201.43f
		200	82.05bc	294.56a
	Oct.12	0.00	35.33n	153.84j
		100	87.48a	244.51bc
		200	72.61d	289.84a
Cara	Sept.12	0.00	55.35i	163.93hi
		100	37.33n	107.93l
		200	46.97l	92.07m
	Sept.26	0.00	60.07h	212.30e
		100	48.84jkl	107.07l
		200	64.94efg	250.64b
	Oct.12	0.00	37.89n	113.84l
		100	50.79j	156.71ij
		200	67.30e	128.42k
Lady Rosetta	Sept.12	0.00	80.48c	162.78hi
		100	41.17m	196.94fg
		200	56.43i	241.84c
	Sept.26	0.00	59.89h	201.23f
		100	43.87m	243.28bc
		200	49.38jkl	133.53k
	Oct.12	0.00	65.61ef	217.84e
		100	53.82i	248.00bc
		200	47.38kl	189.53g
Mean of A	Burn		65.05a	219.57a
	Cara		52.17c	148.08c
	Lady Rosetta		55.34b	203.89b
Mean of B	Sept.12		58.67a	178.25c
	Sept.26		56.31c	199.67a
	Oct.12		57.57b	193.61b
Mean of C	0.00		58.87b	171.83c
	100		52.66c	194.02b
	200		61.02a	205.69a

Values with similar alphabetical letter don't significantly differ from each other, using Duncan's Multiple Range test, at 0.05 levels.

Also, the spraying with SA concentrations play role for enhancing flavonoids concentration both in flesh (61.02mg) and peel (219.57mg) when compared to control treatment (58.87mg and 194.02mg), respectively. Concerning the interaction effect, potato cv. Burn planted in Oct, 12th and sprayed three times with SA (100ppm) showed the highest value flesh flavonoids (87.48mg) and SA (200ppm) for peel flavonoids (289.84mg). *(Akyol et al. (2016)* reported that presence of flavonoids influences the color and flavor of vegetables and fruits. These results confirmed that polyphenol content in the peel is more doubled than in the flesh of potato tubers and potato cultivars were varied among them for its content. Flavonoids were more than 30 mg per 100 g fresh weight in white fleshed potatoes and this level is nearly doubled in red and purple fleshed potatoes as a result of anthocyanins Perla *et al.* (2012).

Reducing and non - reducing sugars content (%):

There was significant variation observed on the effect of potato cultivars, date of planting and SA concentrations on reducing and non-reducing sugars content of potato tubers (Table 4).

Table 4. Reducing and non - reducing sugars content (mg) of some potato cultivars as affected by date of planting and foliar spraying with SA treatment.

Cultivars (A)	Planting dates(B)	Treatment (SA ppm) (c)	Reducing sugars %	Non - reducing sugars %
Burn	Sept.12	0.00	2.17 kl	3.84jk
		100	3.37abc	3.29k
		200	2.93d-h	2.35lm
	Sept.26	0.00	1.91l	4.71hij
		100	2.18 kl	4.25j
		200	3.56ab	1.91m
	Oct.12	0.00	2.66 f-j	5.84f
		100	2.58 h-k	6.90e
		200	2.59 g-k	5.77fg
Cara	Sept.12	0.00	2.54 h-k	9.4b
		100	1.79 l	7.39de
		200	2.33jk	10.66a
	Sept.26	0.00	2.75 e-j	8.75bc
		100	3.02c-g	8.94bc
		200	2.48 h-k	8.65bc
	Oct.12	0.00	2.89d-i	11.41a
		100	3.71 a	5.65fgh
		200	3.14 b-e	8.19cd
Lady Rosetta	Sept.12	0.00	2.38jk	5.89 f
		100	2.72e-j	5.44fghi
		200	2.41ijk	4.799g-j
	Sept.26	0.00	2.89d-i	3.19kl
		100	3.05c-f	4.53ij
		200	3.40abc	4.51ij
	Oct.12	0.00	3.52ab	1.80m
		100	3.31a-d	0.71n
		200	2.55h-k	5.73fg
Mean of A	Burn		2.66 b	4.32b
	Cara		2.74 b	8.78a
	Lady Rosetta		2.91 a	4.07c
Mean of B	Sept.12		2.52 c	5.90a
	Sept.26		2.81 b	5.49b
	Oct.12		3.00a	5.78ab
Mean of C	0.00		2.64 b	6.096a
	100		2.86 a	5.24b
	200		2.82 a	5.84a

Values with similar alphabetical letter don't significantly differ from each other, using Duncan's Multiple Range test, at 0.05 levels.

Among potato cultivars tested, cv. Lady Rossetta has a higher content of reducing sugar (2.91) than cv. Cara (2.74) and cv. Burn (2.66). The highest significant increase in non-reducing sugar was recorded with cv. Cara (8.78) compared to cv. Burn (4.32) and cv. LadyRossetta (4.07).

Concerning to date of planting effect, the late sowing date in 12th Oct. show the highest significant increase in both reducing and non-reducing sugar. While, the early planting in Sept, 12th gave the best value in non-reducing sugar (5.90). The highly significant increase in reducing sugar was achieved with SA at 100 and 200ppm with insignificant differences between them. While, the best value for non-reducing sugar was shown with the control treatment (6.96) with insignificant differences between them. This result are in the same reported by *(Luo et al. (2014) and Sharma et al. (2020)*. The authors reported that exogenous application of SA enhanced the amount of polysaccharides and sugars and improving their plant growth.Regarding to the interaction between potato cultivars, date of planting and SA treatments showed a significant effect with SA at 200ppm. The authors *(El-Tayeb et al. (2006) and Wasti et al. (2012)* reported that plants treated with SA, soluble sugars was increased.

Total Anthocyanin content in potato tubers peel:

The anthocyanin content in potatoes is varied and some reported to be from 0.055 to 0.35 mg /100g FW; some authors report the range to be from 0.02 to 0.40 mg /100g FW. It's dependent on the potato cultivar. *(Burgos et al. (2013)* stated that the color of red and purple potatoes is derived from anthocyanins. The reported data in Table 5 show that the individual potato cultivars differ in the total amount of anthocyanins content. Potato cv. Lady Rossetta had the highest significant anthocyanin content in peel (6.86 mg/100g FW) than cv. Cara (0.61 mg/100g FW) and cv.Burn (0.05 mg/100g FW). The skin colour of the potato cv. Lady Rossetta is red and this is the nature of the cultivar. *(Zhao et al. (2009)* reported that the colored of tuber skins are referred to the accumulation of anthocyanins. Potato anthocyanins are health benefits and help to protect human against free radicals (Hung *et al.* (1997*)* and Brown *et al* (2004). The late of planting dates at 12th of Oct. and also, the early planting at 12th of Sept. play role for increasing anthocyanins content without significant differences between them.

The lowest concentration from SA at 100ppm showed the best values for anthocyanins content in the peel of potato tubers (2.92 mg/100g FW) compared to SA at 200ppm (2.21 mg/100g FW) and control treatment (2.39 mg/100g FW).

Regarding the interaction of potato cultivars x date of planting x SA treatments, the data revealed that potato cv. Lady Rossetta when planted in 12th of Oct. and foliar treated with SA at 100ppm, the recorded data showed the highest significant increase in anthocuanins content of potato tuber peels (10.71 mg/100g FW) with this treatment. Potato researchers are interested to develop potato cultivars contain high levels of anthocyanins to increase the nutritional and health benefit and to industrial made (*Brown et al (2004)*

Total sugar content (%):

Data presented in Table (5) show the main effect of cultivars, date of planting and SA treatments on total reducing sugars content (%). Potato cv. Cara exhibited the highest value (11.7%) compared to cv. Burn and Lady Rossetta (6.98 %). Also, concerning to planting dates, the data of planting dates at 12th of Oct. recoded a significant increase in the total sugar content (8.88%) than the others. Salicylic acid treatment at 200ppm and control treatment showed the highest values without significant differences between them.

The interaction effect of potato cultivars, sowing dates and SA treatment showed significant effect. The best values was achieved with cv. Cara when planted early at 12th of Oct. with control treatment (14.30 %) without significant differences when planted at 12th of Sept. and foliarly treated with SA at 200ppm (13.66%). The color of red and purple potatoes is derived from anthocyanins *(Burgos et al. (2013)*.

Table 5. Total sugar content (mg) anthocyanin content (mg) and Dry mater/FW % of some potato cultivars as affected by date of planting and foliar spraying with SA treatment.

Cultivars (A)	Planting dates (B)	Treatment (SA ppm) (c)	Total sugar %	Anthocyanin mg/100g FW	Dry mater/ FW%
Burn	Sept.12	0.00	6.01klm	0.02 i	16.92hi
		100	6.65ijk	0.03 i	15.08i
		200	5.29m	0.03i	17.08hi
	Sept.26	0.00	6.62ijk	0.04i	18.41fgh
		100	6.42jkl	0.04i	21.66abc
		200	5.47lm	0.03i	18.57fgh
	Oct.12	0.00	8.51d-g	0.21hi	18.92e-h
		100	9.49d	0.04 i	19.43c-h
		200	8.35efg	0.06i	19.48c-h
Cara	Sept.12	0.00	11.96bc	0.39gh	18.99d-h
		100	9.19def	0.52 fg	20.66a-f
		200	13.66a	0.54 fg	17.56gh
	Sept.26	0.00	11.50bc	0.62 fg	19.98b-g
		100	11.97bc	0.52 fg	21.73abc
		200	11.13c	0.76 f	20.85a-f
	Oct.12	0.00	14.30a	0.67 fg	20.51a-f
		100	9.37de	0.67 fg	20.35a-f
		200	12.23b	0.79 f	21.59a-d
Lady Rossetta	Sept.12	0.00	8.28e-h	7.71 b	20.54a-f
		100	8.16fgh	6.12 c	22.5ab
		200	7.21hij	7.71 b	21.38a-e
	Sept.26	0.00	6.08klm	5.67 d	21.99abc
		100	7.58ghi	7.66.b	21.66abc
		200	7.91gh	5.53d	22.61ab
	Oct.12	0.00	5.32m	6.21 c	22.72a
		100	4.02n	10.71a	22.33ab
		200	8.29e-h	4.46.e	22.99a
Mean of A	Burn		6.98b	0.05c	18.39c
	Cara		11.70a	0.61b	20.25b
	Lady Rosetta		6.98b	6.86a	22.08a
Mean of B	Sept.12		8.49b	2.56a	18.97b
	Sept.26		8.30b	2.32b	20.83a
	Oct.12		8.88a	2.64a	20.92a
Mean of C	0.00		8.73a	2.39b	19.88a
	100		8.10b	2.92a	20.59a
	200		8.84a	2.21c	20.23a

Values with similar alphabetical letter don't significantly differ from each other, using Duncan's Multiple Range test, at 0.05 levels.

Dry matter %:

The potato cultivars exhibited differential dry matter % ability at planting dates and with SA foliar treatments (Table 5). Potato cv. LadyRossetta produced highest significantly dry matter % (22.08%) followed by cv. Cara (20.25%) and the lowest dry matter % was recorded with cv. Burn (18.39%). Planting dates at 12th and 26thSept showed the best significant increase in dry matter % while, the late of planting dates at Oct, 12 showed the lowest dry matter%.

Concerning SA treatments, the data revealed not significant effect for dry matter %.

Regarding to the interaction effect, the data in Table 6 show that the sowing of cv. Lady Rossetta lately at Oct. 12th gave the highest significant increase in dry matter % with SA 200ppm (22.99%) with insignificant differences among SA 100ppm (22.33%) and control treatments (22.72%). *(Khalel et al. (2021)* showed that spraying potato plants of salicylic acid at 500 mg L gave the highest mean of dry weight in tuber.

Color parameters of potato tuber flours:

Potato cultivars effect:

The hunter color parameters of potato flour was affected significantly by potato cultivars (Table 6). Potato cv. Lady Rossetta showed the highest significant increase in the degree of lightness (L*) (83.26) and hue angle (86.85). Potato cv. Cara recorded the best values for color parameter of redness (a*), yellowness/greenness (b*) and Chroma (1.63, 22.23 and 22.29) respectively, while cv. Burn showed the best value only for a*. The results indicated that the flesh color of potato cv. Lady Rossetta is more lightness and near to color of wheat flour followed by cv. Cara. The finding by (Michael and Wilson (1997) showed that the yellow color is attributed to carotenes.

Table 6. Effect of potato cultivars on the color parameters of flour of potato tubers

Cultivars	L*	a*	b*	Chroma	Hue angle
Burn	77.41b	1.51a	19.68b	19.75b	85.59b
Cara	78.45b	1.63a	22.23a	22.29a	85.59b
Lady Rossetta	83.26a	1.23b	19.96b	20.00b	86.85a

Values with similar alphabetical letter don't significantly differ from each other, using Duncan's Multiple Range test, at 0.05 levels.

Date of planting effect:

Data presented in Table 7 show that color parameters of tuber flour were affected significantly by planting dates. The highest values and improvement for color parameter L* = 82.95 (nearest to wheat flour L*=87.07) and hue angle (86.07). The late of planting date at 12th of Oct. increase the color of a*, b* and chroma. *(Shih, et al. (2009*) reported that chroma as indicator of color intensity of sweet potato flour.

Table 7. Effect of planting dates on the color parameters of flour of potato tubers.

Planting dates	L*	a*	b*	Chroma	Hue angle
Sept.12	81.02b	1.35b	19.86b	19.91b	86.29a
Sept.26	82.95a	1.23b	17.71c	17.74c	86.07a
Oct.12	75.14 c	1.78a	24.30a	24.39a	85.67a

Values with similar alphabetical letter don't significantly differ from each other, using Duncan's Multiple Range test, at 0.05 levels.

Salicylic acid treatments effect:

The results in Table 8 showed significant differences for the color parameters of potato flour at different concentration of SA treatments. Potato plants foliar treatment three times with SA at 100ppm showed the highest increase in the value of lightness L* (81.50) when compared to control treatment (78.45). While, SA at 200ppm and control treatment encourage the values of a*, b* and chroma without significant differences between them. The values of hue angle showed insignificant differences among SA concentrations and control treatment.

Table 8. Effect of SA treatments on the color parameters of flour of potato tubers.

SA treatments Ppm	L*	a*	b*	Chroma	Hue angle
0.00	78.45b	1.52a	21.47a	21.54a	85.93a
100	81.50a	1.35b	18.529b	18.59b	86.037a
200	79.162b	1.49a	21.87a	21.93a	86.075a

Values with similar alphabetical letter don't significantly differ from each other, using Duncan's Multiple Range test, at 0.05 levels.

Combined effect:

Data presented in Table 9 show that the color parameters (L,a,b,c and hue angle) of potato tubers flour was significantly affected by combined effect of potato cultivars x date of planting x SA treatments.

Table 9. Combined effect of potato cultivars, date of planting and SA treatments on color parameters of potato tuber flours.

Cultivars (A)	Planting dates(B)	Treatment (SA ppm) (c)	L*	a*	b*	Chroma	Hue angle
Burn	Sept.12	0.00	76.9h-l	1.63e-h	19.56fg	19.6fgh	85.33d-h
		100	81.06efg	0.73 kl	16.83ij	16.86ij	87.33bc
		200	86.3bcd	0.93jk	15.4jk	15.46jk	86.67 b-e
	Sept.26	0.00	75.53jkl	1.33hij	24.16bc	24.2bc	87bcd
		100	80fgh	1.7d-h	15.03jk	15.1jk	83.33i
		200	75.47jkl	2.03cde	21.6de	21.73de	84.67f-i
	Oct.12	0.00	74.1kl	1.33hij	20.76def	20.86def	85.67c-g
		100	77.33h-l	1.6fgh	21.2def	21.26def	85.67c-g
		200	69.97m	2.33bc	22.53cd	22.67cd	84.67f-i
Cara	Sept.12	0.00	73.9l	2.67ab	26.26a	26.47a	83.67hi
		100	83.1def	1.5gh	15.57jk	15.6jk	84.33ghi
		200	77.63g-k	1.27hij	25.63ab	25.63ab	87.33bc
	Sept.26	0.00	80.1fgh	1.8 d-g	17.63hi	17.73 hi	84ghi
		100	86.4bc	0.67 kl	16.23ij	16.23ij	87.67ab
		200	80.067fgh	1.43gh	20.13efg	20.13efg	85.67c-g
	Oct.12	0.00	76.27i-l	1.46gh	26.7a	26.73a	87.33bc
		100	70.23m	2.9a	26.53a	26.7a	83.67hi
		200	78.37g-j	0.97jk	25.33ab	25.4ab	86.66 b-e
Lady Rossetta	Sept.12	0.00	83.63cde	1.5gh	18.83gh	18.9gh	85.33d-h
		100	92.03a	0.43l	14.03k	14.03 k	89.33a
		200	74.63kl	1.5gh	26.55a	26.6a	87.33bc
	Sept.26	0.00	89.3ab	0.6kl	15.2jk	15.2jk	88ab
		100	89.4ab	0.57kl	14.07k	14.06k	88ab
		200	90.36a	1ijk	15.3jk	15.3jk	86.33b-f
	Oct.12	0.00	76.36i-l	1.4ghi	24.1bc	24.13bc	87bcd
		100	73.97l	2.07cd	27.27a	27.4a	85e-i
		200	79.67f-i	2c-f	24.3bc	24.4bc	85.33d-h
Wheat flour			87.07	4.33	10.52		

Values with similar alphabetical letter don't significantly differ from each other, using Duncan's Multiple Range test, at 0.05 levels.

The combined effect of potato cv. Lady Rossetta x planting dates at 12th and 26th of Sept. x SA, 100ppm showed the best values for the degree of lightness (L*) without significant differences between them. The maximum values for redness (a*) 2.9 , for blueness b* (26.53) and for Chroma C* (26.7) was found to be the treatment of cv. Cara when planted at the late of planting date (12th, Oct.) and foliarly treated three times of SA at 100ppm. Hue angle values of the treatments of cv. Lady Rossetta x planting dates at 12th and 26th of Sept. x SA at 100ppm were found statistically higher (89.33 and 88.0) without significant differences between them. SA, a potent plant hormone, signaling molecule and potential non-enzymatic antioxidant *(Dawood et al. (2012)* accumulates in plant tissues under unfavorable environments and helps regulate plant growth and metabolism *(Hussein et al*. (2007).

CONCLUSION

The obtained data revealed that: A great variation of potato cv.s tested for phytochemical content. These differences were found related to genotype, SA treatments and date of planting.

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البولي فينول وصفات الجودة لبعض أصناف البطاطس وتأثرها بميعاد الزراعة ومعاملات حمض السالسليك

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[٢]مركز البحوث الزراعية

الملخص

أجريت هذه التجربة لتقيم تأثير مواعيد الزراعة ومعاملات حمض السالسيلك على المحتوي الكيميائي لقشرة ولحم درنات أصناف البطاطس (ايدي روزيتا - برن - كارا) في المزرعة التجريبية والمعمل المركزى للزراعة العضوية بمحطة البحوث الزراعية بملوي- مركز البحوث الزراعية - الجيزة - مصر وذلك خلال موسم ٢٠٢٢. حيث تم زراعة ثلاث مواعيد زراعة (١٢ سبتمبر -٢٦ سبتمبر -١٢ أكتوبر) وتم استخدام تركيزين من حمض السالسيلك (١٠٠ و٢٠٠ جزء من المليون) بالإضافة إلي الكنترول وتم الرش ورقيا ثلاث مرات على أصناف البطاطس. لقد أظهرت البيانات المأخوذة على أصناف البطاطس أن صنف برن أعطى أعلى قيمة في البولي فينول والفلافونويد في اللحم (٥٧,٨٣ و ٦٥,٠٥ مليجرام /١٠٠جرام وزن طازج) .وتم الحصول على أعلى قيمة للسكريات غير المختزلة والسكريات الكلية مع الصنف الكارا. كما وجد تراكم لمادة الأنثوسيانين في القشرة ودرجه أعلى فى البياض للون اللحم (L) في الصنف ليدي روزيتا.وقد وجد ان ميعاد الزراعة المبكر في ١٢و٢٦ سبتمبر سجلت المحتوى الأعلى للبولي فينول والفلافونويد في القشرة واللحم. وجد ان استخدام السالسيلك بتركيز٢٠٠ جزء من المليون كان فعالا في زيادة المحتوى من الفلافونويد والسكريات في درنات البطاطس بينما استخدامه بتركيز ١٠٠ جزء من المليون كان فعالا في زيادة محتوى البولي فينول وتراكم الأنثوسيانين في القشرة .أما بخصوص التأثير التفاعلي – فإن النباتات المزروعة في موعد متأخر (١٢ أكتوبر) لصنف كارا الغير معامل بحمض السالسيلك والميعاد المبكر (١٢ سبتمبر) المعامل بتركيز(٢٠٠ جزء من المليون) وجد بها زيادة في محتوى البولي فينول والسكريات الكلية والغير المختزلة.