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PHYSIOLOGICAL AND SANITARY QUALITY OF MAIZE SEEDS TREATED WITH CAMBUCI [*Campomanesia phaea* (O. BERG) LANDRUM] EXTRACT

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ABSTRACT

The control of phytopathogens using plant extracts has been identified as an alternative to organic agriculture, which excludes the use of toxic and synthetic substances. The present study aimed to evaluate the sanitary and physiological potential of organic maize seeds treated with cambuci extract (*Campomanesia phaea*). Two plant extracts were tested, obtained from different tissues of the *C. phaea* species (fruit peel and leaf, fresh and dry), in the following concentrations: 0, 25, 50, 75 and 1000 %. The content of total phenolic compounds was found to be higher in the leaf extract (at 100 % concentration was 409.7 % higher in the leaf compared to the peel), particularly when prepared with fresh tissue. The dry peel extract was observed to increase the percentage and speed index of maize seed germination, without, affecting the biometric variables of the seedlings. Extracts from fresh cambuci leaves demonstrated a reduction in the percentage of fungi of the genus *Fusarium*. However, at a concentration of 50%, a phytotoxic effect of this extract on maize seeds was observed, which resulted in a reduction in germination and the length and dry mass of the seedlings. Our findings suggest that cambuci extract represents a promising strategy in the ecologically correct treatment of organic maize seeds, provided if it is applied at the appropriate concentration.

Additional keywords: Natural treatment, plant extracts, *Zea mays*

RESUMEN

Calidad fisiológica y sanitaria de las semillas de maíz tratadas con extracto de cambuche (*Campomanesia phaea* (O. Berg) Landrum)

El control de fitopatógenos mediante extractos de plantas se ha identificado como una alternativa a la agricultura ecológica, que excluye el uso de sustancias tóxicas y sintéticas. El presente estudio tuvo como objetivo evaluar el potencial sanitario y fisiológico de semillas de maíz orgánico tratadas con extracto de cambuche (*Campomanesia phaea*). Se ensayaron dos extractos vegetales obtenidos a partir de diferentes tejidos de la especie *C. phaea* (hojas y pericarpio, frescos y secos), en las concentraciones de 0, 25, 50, 75 y 100 %. El contenido de compuestos fenólicos totales fue mayor en el extracto de hoja, sobre todo cuando se preparó con tejido fresco (la concentración fue 409,7 % mayor en la hoja que en el pericarpio). El extracto seco de pericarpio aumentó el porcentaje y el índice de velocidad de germinación de las semillas de maíz, sin afectar a las variables biométricas de las plántulas. Los extractos de hojas frescas de cambuche demostraron una reducción del porcentaje de hongos del género *Fusarium*. Sin embargo, a una concentración del 50%, se observó un efecto fitotóxico de este extracto sobre las semillas de maíz, que se tradujo en una reducción de la germinación y de la longitud y masa seca de las plántulas. Nuestros resultados sugieren que el extracto de cambuche representa una estrategia prometedora en el tratamiento ecológicamente correcto de las semillas de maíz ecológico, siempre que se aplique a la concentración adecuada.

Palabras clave adicionales: Extractos de plantas, tratamiento natural, *Zea mays*

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INTRODUCTION

Organic maize production has emerged in recent years, distinguished by its considerable financial return when compared to conventional production systems (Cox et al., 2019). This model adapts processes to local conditions, rather than using external inputs (Reganold and Wachter, 2016; Basnet et al., 2023). It involves the use of natural products, while synthetic fertilizers and

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pesticides are excluded or severely restricted (Durić et al., 2019). Consequently, alternative and ecological measures have been implemented to safeguard plants and seeds (Suteu et al., 2020), as exemplified by the use of plant extracts (Carvalho et al., 2022).

Seed treatment is a crucial aspect of maintaining seed quality and preventing the spread of relevant pathogens in agricultural production fields (Kim et al., 2022). This has been carried out using synthetic pesticides for a wide variety of purposes (Ayesha et al., 2021). Consequently, the development of alternative methods that are less environmentally disruptive and that assist in the control of these phytopathogens in maize seeds is imperative, as seed quality can impede the production of organic cereals (Endres et al., 2022), including in Brazil (Munarini et al., 2021).

In the literature, there are various possibilities for controlling phytopathogens using secondary plant metabolites, with the Myrtaceae family of plants representing a particularly promising research. For instance, the aqueous extract of eucalyptus demonstrated the ability to inhibit the growth of *Alternaria* sp. and *Cladosporium* sp. on wheat seeds, while simultaneously stimulating the growth of the area and root of the seedlings (Baseggio et al., 2019). Conversely, the alcoholic extract of guava demonstrated a significant inhibitory effect on mycelial coverage by *Aspergillus* spp., *Penicillium* sp., *Rhizopus* sp., and *Cladosporium* sp. in peanut seeds, with an inhibition rate of 92.71% (Ferreira et al., 2015).

The brazilian native species *Campomanesia phaea* (cambuci) (Myrtaceae family) is rich in secondary metabolites. These include sesquiterpenes such as (E)-caryophyllene, caryophyllene oxide, and flavonoid compounds such as alpinetin O-dideoxyhexoside, 5,7-dimethoxyflavanone, and alpinetin (Lorençoni et al., 2020). This indicates their potential for controlling fungi (Carvalho et al., 2024). The efficacy of plant extracts in replacing synthetic products remains poorly understood (Godlewska et al., 2021a). It is of the utmost importance to develop sustainable and cost-effective products that can provide high-quality yields in organic farming (Röös et al., 2018; Godlewska et al., 2021b). Given the variety of metabolic compounds present in cambuci and the bioactive potential of phenolic compounds for the control of phytopathogens, it is justified to evaluate its potential for the production of plant extracts.

The objective of this study was to assess the sanitary and physiological potential of organic maize seeds treated with cambuci extract at varying concentrations.

MATERIALS AND METHODS

The research was conducted at the Agricultural Sciences Center of the Federal University of São Carlos, Araras campus, Brazil, between May and October 2022. The maize seeds of the IAC Airan variety were obtained from the Agronomic Institute of Campinas (IAC), while the cambuci fruits and leaves were sourced from the Vale do Paraíba region, in the municipality of Natividade da Serra, SP (23°31' S, 45°27' W, 720 m above sea level).

Two batches of maize seeds were utilized in the experiment, with one testing solely the extracts derived from the peel and the other testing solely the extracts derived from the leaves. All the extracts were tested on fresh and dried tissues at concentrations of 25, 50, 75, and 100 %, in addition to a control treatment (without extract). However, there was a modification to the procedure for preparing the extracts, as follows:

To prepare the dry extract, 18 g of cambuci fruit peel and leaves were utilized. Subsequently, the plant tissue was subjected to a drying process in an oven with forced air ventilation for 72 hours at 60 °C, resulting in the formation of a dry material. Subsequently, the samples were pulverized into a powder, which was then stored in a sealed container at room temperature (about 25°C) until the extraction stage. For the extraction process, 1667 mL of hydroalcoholic solvent (70% alcohol) was added to the material in a glass container lined with aluminum foil. The container containing the mixture (powder and solvent) was then left to stand for a period of 24 hours, during which time the extraction took place. For the dry leaf extract, only the leaf limb was utilized, with the central veins excluded.

The preparation of the fresh extract involved the maceration of 18 g of fresh plant tissue, comprising both peel and leaves (only the leaf limb), using a pistil and mortar, and followed the same procedure as in the dry extract.

Subsequently, the solution of all the extracts was filtered using filter paper, a funnel to collect the filtered material. Following this stage, the extract was placed under low pressure (-550 mmHg) in a rotaevaporator rotating at 70 rpm for 40 minutes at a temperature of 60 °C to extract the alcoholic solvent used. Due to the considerable volume of extract, the rotaevaporation was conducted in three separate batches for each extract.

Following evaporation, the volumes obtained from each batch were combined, homogenizing the crude extract. This was then diluted in water to obtain the requisite concentration treatments for testing.

Subsequently, a portion of the crude extracts was frozen at -10°C in a freezer, while the remainder was thawed for application to the seeds as the tests were being conducted.

For the application of the extracts to maize seeds, the ratio of 10 mL to 200 maize seeds was sufficient for a uniform application of each extract. The extracts and seeds were placed in a plastic bag, mixing them until the application was uniform. The extract was just applied before seeding time. Once the treatments were completed, the seeds were subjected to germination (MAPA, 2009a). The variables measured were germination vigor index-GVI (Maguire, 1962), seedling length, seedling dry matter mass, cold test (Cicero and Vieira, 2020), and health test (MAPA; 2009b).

For the germination test, 4 replicates of 50 seeds for each treatment were made on paper rolls moistened with water at a rate of 2.5 times the dry weight of the paper, and then the rolls were stored at a temperature of 25^{o}C in a germination chamber (Nakagawa, 1999). Counts were made on the fourth and seventh days after sowing. The rate of germination was assessed on the basis of the daily appearance of normal seedlings for each of the treatments analysed, and the GVI was then determined (Maguire, 1962). Since a 50-seed sample size was used, the results were multiplied by a factor of 2 (Brown and Mayer, 1988; Pire and Vargas, 2019).

For seedling length and seedling dry matter, 4 replicates of 20 seeds were made on paper rolls consisting of three sheets, moistened with water at a rate of 2.5 times the dry weight of the paper and then stored under temperature conditions of 25 ^{o}C in the germination chamber. The evaluations were carried out on the seventh day after sowing. To determine the dry mass, the aerial part and the roots were separated into paper bags and kept in a forced-air oven at 65°C for 96 hours. After drying, the material was weighed using an analytical balance with an accuracy of 0.0001 g, separating the root and aerial parts.

For the cold test method, 4 replicates of 50 seeds were made on a roll of paper with soil. The paper was moistened with water at a rate of 2.5 times the dry weight of the paper. The paper rolls were stored in a cold chamber at 10 °C for 7 days. They were then placed in the germination chamber for 7 days at 25 °C. The evaluation was carried out 14 days after installation and the results were expressed as a percentage of normal seedlings (Cicero and Vieira, 2020).

For the health test (blotter test), four replications of 40 seeds were carried out for each treatment. The seeds were sown on three layers of 15-cm diameter filter paper moistened with distilled water in a Petri dish. The petri dishes were then kept at a temperature of 20 ± 2°C under white fluorescent light in chambers with a 12-hour photoperiod for a period of 7 days. The fungi identification related to the seeds was carried out through analysis of the colonies using a stereoscopic microscope and, when necessary, using optical microscope, based on the specifications of the Seed Health Analysis Manual (MAPA, 2009b).

Once the data had been obtained, it was analysed separately for each batch, for the cambuci peel and leaf treatments, using analysis of variance (ANOVA). It was considered for each batch a factorial design 5x2 (concentrations x dried or fresh tissue). If a significant effect was found, the means were then compared using the Tukey test at the 5% probability level.

To quantify the total phenolic compounds, a calibration curve was constructed using gallic acid standards to interpolate the absorbance in the spectrophotometer. The results were expressed in $\mu g \cdot mL^{-1}$ of gallic acid equivalent, in accordance with the methodology proposed by da Silveira et al. (2018), with adaptations.

RESULTS AND DISCUSSION

The results of the seeds treated with the fresh cambuci peel extracts demonstrated that there were no significant differences in germination and root length between the various treatments. To the dried peel extract, the germination percentage was found to be higher in the 25%, 50% and 100% concentrations (Table 1). The results demonstrate that the peel extracts did not negatively affect the treated seeds.

Table 1. Germination percentage, germination vigor index (GVI), aerial part length (APL), and root length (RL) in centimeters of maize seeds treated with dried peel extract (DP) and fresh peel extract (FP) of *Campomanesia phaea*.

Treat.	Germination (%)		GVI		APL (cm)		RL (cm)	
	DP	FP	DP	FP	DP	FP	DP	FP
0%	80.50Bb	88.90Aa	19.62Ab	21.24Aab	7.97Aa	6.78Bab	21.15Aa	19.01Aa
25%	89.00Aa	86.50Aa	22.58Aa	20.60Bb	7.17Aa	7.53Aab	20.12Aa	18.92Aa
50%	91.50Aa	91.45Aa	23.38Aa	23.16Aa	7.23Aa	6.44Ab	21.95Aa	19.27Ba
75%	85.00Aab	87.00Aa	22.82Aa	20.88Bab	7.39Aa	7.73Aa	22.46Aa	19.39Ba
100%	91.50Aa	90.98Aa	23.38Aa	22.98Aab	7.23Aa	7.25Aab	21.95Aa	21.92Aa
CV	3.73		5.52		7.76		8.17	

Means followed by the same uppercase letter in the rows for each test and lowercase in the columns do not differ by the Tukey test at 5% probability. Treat = treatments, CV = coefficient of variation (%).

The application of dry and fresh peel extracts had no negative effect on root length. However, there was a significant variation between the extracts at 50% and 75% concentrations (Table 1). This discrepancy indicates that the dry peel extract exhibited superior performance relative to the fresh peel extract. In a study analyzing other plant species, the ethanolic extract of *Campomanesia sessiliflora* peel demonstrated the potential to reduce root growth in the species *Allium cepa* (Silva et al., 2022), which differs from the results observed in the current study. To the dry mass of both the aerial part and the root, there was also no significant change compared to the control in the fresh and dry peel extract (Table 2). As indicated by Khan et al. (2017), one of the indicators of stimulation is an increase in the mass of fresh and dry matter, as well as an increase in vigor. This increase in mass is related to the interaction of phytohormones, among other factors that benefit the plant's physiology.

Table 2. Dry matter mass of the aerial part (DMM) and root (DRM) in grams, as well as the germination percentage of maize seedlings in the cold test treated with dry peel extract (DP) and fresh peel extract (FP) of *Campomanesia phaea*.

Treat.	DMM (g)		DRM (g)		Cold test (%)	
	DP	FP	DP	FP	DP	FP
0%	0.030Aa	0.030Aa	0.050Aa	0.055Aa	73.5Aa	74.5Aa
25%	0.028Aa	0.028Aa	0.050Aa	0.053Aa	80.5Aa	73.5Aa
50%	0.030Aa	0.020Ba	0.055Aa	0.060Aa	79.5Aa	78.5Aa
75%	0.038Aa	0.028Ba	0.053Aa	0.053Aa	77.0Aa	73.5Aa
100%	0.030Aa	0.030Aa	0.053Aa	0.050Aa	84.0Aa	82.5Aa
CV	20.88		30.62		6.78	

Means followed by the same uppercase letter in the rows for each test and lowercase in the columns do not differ by the Tukey test at 5% probability. Treat = treatments, CV = coefficient of variation (%).

The plant extracts tested had no effect on the results of the cold test (Table 2). It can be concluded that, in general, the peel extracts did not affect the physiology of maize seeds.

To the health test for the dried peel extract, a reduction in the occurrence of *Fusarium* sp. was observed at the 25% concentration. Conversely, the fresh peel extract demonstrated no effect on sanitary (Table 3). The control treatments and the 75% concentration of the fresh and dried peel extracts did not inhibit the presence of *Penicillium* sp. and *Aspergillus* sp. fungi, although the incidence of these fungi was not observed in the other concentrations of the same extracts. Nevertheless, the efficacy of products derived from plants of the Myrtaceae family in combating phytopathogens has been documented in the literature (Duarte et al., 2023).

There was no variation in germination between the two types of extract on leaf (Table 4). To GVI, the fresh leaf extract was found to have an inhibitory effect on germination compared to the control, with a concentration of 50% being the threshold. Additionally, the length of the aerial part was found to be affected, in comparison to the control, at a concentration of 50% for both the fresh and dry leaf extract. Both extracts (dry and fresh) exhibited a harmful effect on root length at the 100% concentration (Table 4). The literature indicates that the genus *Campomanesia*, specifically the extract from the seeds of the species *Campomanesia lineatifolia*, affects the physiology of *Taraxacum officinale* seeds, including germination, GVI, and photosynthetic capacity (Cabeza et al., 2021).

Table 3. Sanitary test, in percentage of fungal incidence, on maize seeds treated with dried peel extract (DP) and fresh peel extract (FP) of *Campomanesia phaea*.

Trat.	*Fusarium* sp.		*Penicillium* sp.		*Aspergillus* sp.		*Acremonium* sp.	
	DP	FP	DP	FP	DP	FP	DP	FP
0%	22.50 Aa	23.75 Aa	1.25 Aa	1.25Aab	0.63Aab	0Aa	0Aa	0Aa
25%	10.00 Bb	20.63 Aa	0.63 Aa	0.00Ab	0Ab	0Aa	0Aa	0Aa
50%	12.50 Bab	26.88 Aa	0.63 Aa	0.00Ab	0Ab	0Aa	0Aa	0Aa
75%	13.13Aab	18.13 Aa	0.00 Ba	2.50Aa	1.25Aa	0Aa	0Aa	0Aa
100%	17.50 Aab	23.13 Aa	0.00 Aa	0.00Ab	0Ab	0Aa	1.25Aa	0Aa
CV	29.39		91.20		72.30		85.52	

Means followed by the same uppercase letter in the rows for each test and lowercase in the columns do not differ by the Tukey test at 5% probability. Treat = treatments, CV = coefficient of variation (%).

Table 4. Germination percentage, germination vigor index (GVI), aerial part length (APL), and root length (RL) in centimeters of maize seeds treated with dried leaf extract (DL) and fresh leaf extract (FL) of *Campomanesia phaea*.

Treat.	Germination (%)		GVI		APL (cm)		RL (cm)	
	DL	FL	DL	FL	DL	FL	DL	FL
0%	88.00Aa	93.50Aa	26.80Aa	29.40Aa	12.25Aa	12.85Aa	21.50Aa	22.07Aa
25%	88.00Aa	87.47Aab	25.70Aa	27.02Aab	11.00Aab	12.00Aab	21.80Aa	22.19Aa
50%	88.00Aa	83.50Ab	24.94a	24.00Ab	9.76Abc	10.35Abc	19.64Aa	20.07Aab
75%	89.50Aa	85.00Aab	26.42Aa	25.00Ab	9.72Abc	10.03Ac	19.02Aa	19.64Aab
100%	87.00Aa	85.50Aab	24.54Aa	24.62Ab	8.49Ac	9.11Ac	14.63Bb	17.40Ab
CV	5.48		8.21		7.92		9.35	

Means followed by the same uppercase letter in the rows for each test and lowercase in the columns do not differ by the Tukey test at 5% probability. Treat = treatments, CV = coefficient of variation (%).

The observed reduction in root length (of both extracts) may be attributed to the inhibitory effect of the phenolic compounds present in the leaves on the plant. This is supported by the findings of Cantanhede et al. (2017), which indicate that phenolic compounds, particularly flavonoids, can reduce seedling growth.

Additionally, the authors noted that the reduction in the length of the root and aerial parts of maize seedlings may be attributed to the phytotoxic potential of the Myrtaceae family. This phenomenon was observed in the study by Imatomi et al. (2015), which demonstrated that certain species within this family exhibited the capacity to affect root growth and cause root damage. In light of these findings, further research is required to ascertain the potential of utilizing the leaves as an alternative to herbicides.

To the mass of root dry matter, no significant change was observed in comparison to the control (for the dry and fresh leaf extract). Nevertheless, a notable decline in the dry matter mass of the aerial part was observed in the 75% and 100% concentrations in comparison to the control (Table 5). Furthermore, the fresh leaf extract demonstrated superior performance in the cold test compared to the dry leaves.

Table 5. Dry matter mass of the aerial part (DMM) and root (DRM) in grams, as well as the germination percentage of maize seedlings in the cold test treated with dry leaf extract (DL) and fresh leaf extract (FL) of *Campomanesia phaea*.

Treat.	DMM (g)		DRM (g)		Cold test (%)	
	DL	FL	DL	FL	DL	FL
0%	0.043Aa	0.045Aa	0.033Aa	0.030Aa	71.11Aa	68.00Ab
25%	0.038Aab	0.043Aa	0.028Aa	0.030Aa	68.00Ba	77.00Aab
50%	0.035Aab	0.040Aab	0.033Aa	0.030Aa	62.5Ba	83.43Aa
75%	0.033Ab	0.033Ab	0.033Aa	0.030Aa	67.5Ba	79.00Aab
100%	0.033Ab	0.033Ab	0.025Aa	0.030Aa	66.0Ba	80.50Aa
CV	12.41		14.91		7.89	

Means followed by the same uppercase letter in the rows for each test and lowercase in the columns do not differ by the Tukey test at 5% probability. Treat = treatments, CV = coefficient of variation (%).

The results of the health test indicate that the dry and fresh leaf extracts were effective in reducing the occurrence of the fungus *Fusarium* sp. from the concentration of 75 % for the dry leaf extract and from 25 % for the fresh leaf extract, in comparison to the control (Table 6). These findings are consistent with those of Duarte et al. (2023), who demonstrated that the antimicrobial efficacy of extracts from plants of the Myrtaceae family on phytopathogenic fungi varies depending on their concentration. The extracts did not show consistent activity against fungi of the genus *Penicillium* and *Aspergillus*.

It was thus determined that the extract of fresh cambuci leaves at a concentration of 25% could serve as an alternative for the partial control of fungi of the *Fusarium* sp. genus. This was evidenced by the observation that the physiology of the treated seeds was not negatively impacted by the extract, and that it was still capable of reducing the percentage of this fungus in the seed (Figure 1).

One potential explanation for these extracts exhibiting effective antifungal properties, particularly against the *Fusarium* genus, may be attributed to the presence of specific groups of phenolic compounds. In the study by Lorençoni et al. (2020), high levels of caryophyllene oxide and the flavonoid alpinetin were identified in cambuci leaves. Consequently, it can be postulated that these compounds may have contributed to the inhibition of fungi on maize seeds. Consequently, further studies are required to ascertain the potential impact of these compounds on seed-bound fungi.

Table 6. Sanitary test, in percentage of fungal incidence, on maize seeds treated with dried leaf extract (DL) and fresh leaf extract (FL) of *Campomanesia phaea*.

Trat.	*Fusarium* sp.		*Penicillium* sp.		*Aspergillus* sp.	
	DL	FL	DL	FL	DL	FL
0%	39.38Bab	51.88Aa	9.38Aa	6.88Ab	0.63Aa	3.13Aab
25%	53.13Aa	30.00Bb	6.25Ba	16.88Ab	0.00Aa	2.50Aab
50%	27.50Abc	26.88Ab	11.25Aa	13.75Ab	1.88Aa	1.88Ab
75%	18.13Ac	19.38Ab	15.63Aa	31.88Aa	1.25Ba	7.50Aa
100%	20.63Ac	26.25Ab	6.25Aa	10.63Ab	1.88Aa	3.13Aab
CV	22.69		52.09		98.41	

Means followed by the same uppercase letter in the rows for each test and lowercase in the columns do not differ by the Tukey test at 5% probability. Treat = treatments, CV = coefficient of variation (%). Titles of figures to be placed below

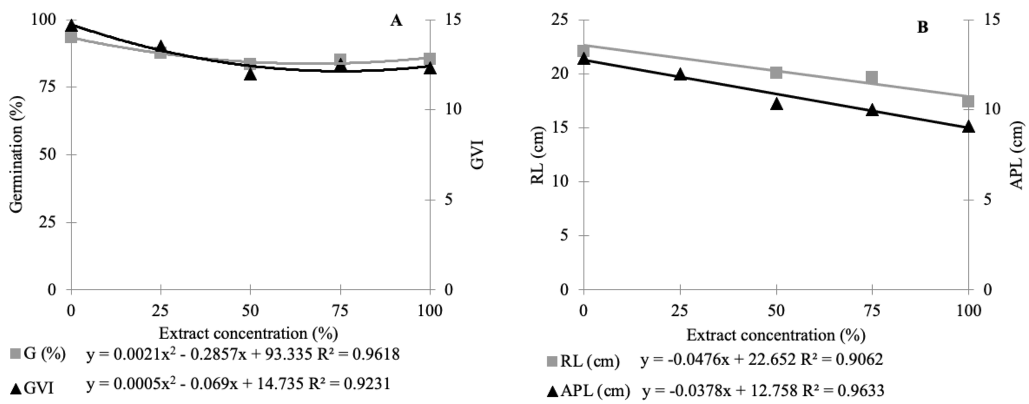

Figure 1. A) Percentage of seed germination and germination vigor index (GVI), and B) Length of the aerial part (APL) and root (RL) in *Fusarium* sp. infected maize seeds treated with a fresh leaf extract of *Campomanesia phaea*.

Determination of the total phenolic compound content in the extracts. To quantify the total phenolic compounds, a linear calibration curve was constructed using gallic acid standards to interpolate the absorbance in the spectrophotometer (Figure 2). Subsequently, the content of phenolic compounds in the respective concentrations in each extract (leaf and peel origin) was determined (Table 7).

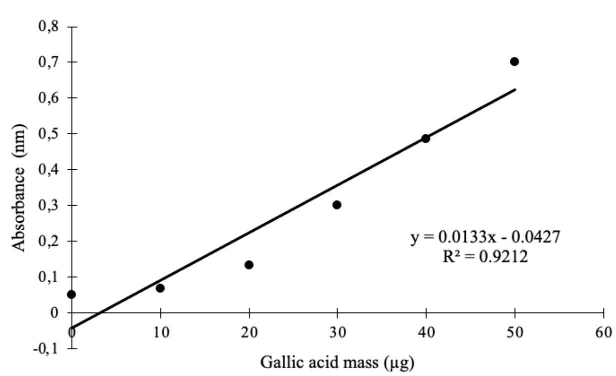

Figure 2. Calibration curve with gallic acid standards.

Table 7. Content of total phenolic compounds in the extracts from fresh peel (FP), dry peel (DP), fresh leaf (FL) and dry leaf (DL) of *Campomanesia phaea*. EAG: gallic acid equivalent

Concentrations	DP	FP	DL	FL
	---------------------- µg de EAG --------------------			
25 %	20.003	18.223	38.493	70.779
50 %	40.005	36.446	109.694	203.529
75 %	60.008	54.669	164.541	305.293
100 %	80.010	72.892	219.388	407.058

It was observed that the leaves exhibited a higher content of phenolic compounds than the peel. Saludes et al. (2022) observed that the content of phenolic compounds was higher in pistachio leaves than in the root. It can be thus concluded that the content of phenolic compounds varies depending on the tissue.

Furthermore, Saludes et al. (2022) observed that pistachio leaf extracts have an inhibitory effect on the germination, growth, and GVI of weeds. This phenomenon was attributed to the allelopathic effect of the leaves, which exhibited a higher concentration of phenolics, including quercetin and gallic acid.

Quercetin and gallic acid are substances that affect metabolic processes. Gonçalves et al. (2010) observed that cambuci fruit has high concentrations of quercetin, which inhibits the alpha-amylase enzyme. Meanwhile, gallic acid inhibits root development (Rudrappa et al., 2007). These substances were also observed in cambuci leaves by Lorençoni et al. (2020). Consequently, the high levels of phenolic compounds observed in the leaves may have influenced the physiology of the maize seeds in this study.

It was observe an association between the greater amount of phenolic compounds in the leaves and the reduction in the length of the aerial part and the root, as the leaves had a more pronounced impact on the vigor of the treated maize seeds than those treated with the extracts from the peel. This indicates the inhibitory effect of gallic acid on the root system, which is indicative of its phytotoxic potential. Additionally, the elevated phenolic content in the leaves resulted in a reduction in the percentage of fungi belonging to the *Fusarium* genus, which was not observed in the seeds treated with peel extracts, which exhibited a lower total phenolic content (Figure 3). Further studies are necessary to identify the specific chemical compounds responsible for this inhibition.

Furthermore, the discrepancy in total phenolic content observed between the peel (fresh and dried) and the leaves (dried and fresh) may be attributed to the way the extracts were prepared. In the study by Pinto et al. (2022), it was observed that the method of preparation can influence the availability of compounds, which can be reduced (due to thermal degradation and oxidative stress) or have their content increased. Consequently, the discrepancy, predominantly observed in the leaves, between the concentrations of phenolic compounds in the dry and fresh leaves, may be attributed to the damage caused by thermal stress during the preparation of the extract.

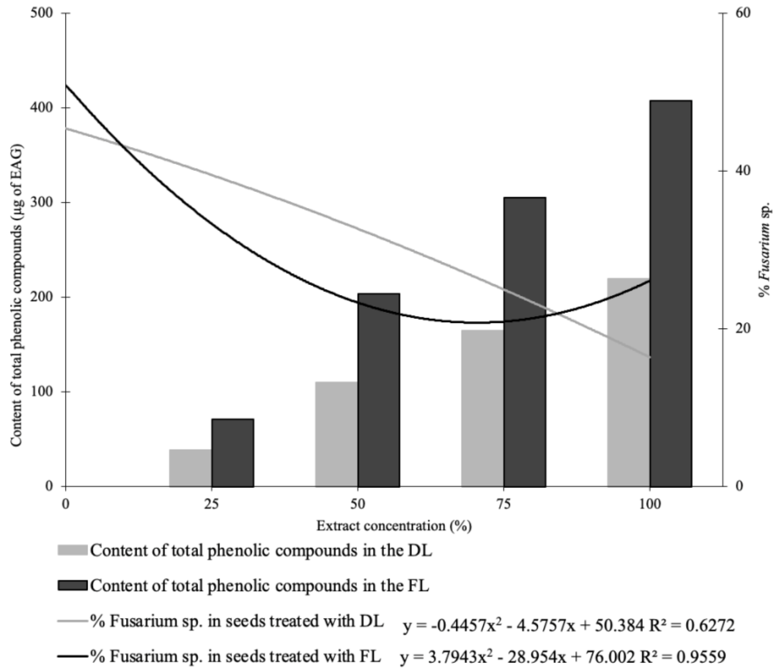

Figure 3. Content of total phenolic compounds in the fresh leaf (FL) and dry leaf (DL) extracts of *Campomanesia phaea* and incidence of fungi of the genus *Fusarium* in maize seeds treated with the extracts.

CONCLUSIONS

The leaves exhibited a higher content of phenolic compounds than the peel, with the fresh cambuci leaf extracts exhibiting the greatest concentration. This may have contributed to a reduction in the percentage of fungi belonging to the *Fusarium* genus. Additionally, the extracts of fresh cambuci leaves exhibited a potential phytotoxic effect on maize seeds at 25 % concentration.

The extract obtained from the dried peel of cambuci at 25 and 50 % concentrations decrease the incidence of *Fusarium* sp. And, at any of the tested concentration, increase the germination percentage and germination vigor of maize seeds. However, length and dry mass of the aerial part and root of maize seedlings remain unaffected.

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