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Chemical composition of rose, sunflower and calendula flower petals for human food use

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Abstract

There is a concern for the chemical characterization of foods with economic and nutritional potential, especially those of low caloric value, in their constitution of proteins, lipids, carbohydrates, minerals, and vitamins, important for a healthy diet. Among these foods, edible flowers are distinguished for their beauty and for flavoring dishes; furthermore, they also have nutritional and medicinal properties. In this context, the aim of the study was to characterize chemically the petals of three species, rose (*Rosa x grandiflora* Hort.), sunflower (*Helianthus annuus* L.), and calendula (*Calendula officinalis* L.) for use in human nutrition. The plants were cultivated in a protected environment and in an open field, and after harvest, physicochemical analyses were carried out (ash, carbohydrates, ethereal extract, fiber, moisture, and protein). In the current study, high water content was observed (higher than 80 %); sunflower showed a higher ash content (1.2 %), calendula presented a higher ethereal extract content (1.2 %) and rose had a higher fiber content (3.2 %). Rose, sunflower and calendula flower petals had a chemical composition with essential nutrients, being able to be included in the daily human diet because they contain essential nutrients for a healthy diet.

Key words: *Calendula officinalis*, food crops, *Helianthus annuus*, proximate composition, *Rosa x grandiflora*

Introduction [T2]

Some edible flowers, in addition to possessing the beauty of color and the shape of their petals, also possess nutritional and medicinal properties. The best-known and most commonly used edible flowers are cauliflower (*Brassica oleracea* var. *botrytis* L.), broccoli (*Brassica oleracea* var. *italica* Plenck.) (Brassicaceae), artichoke (*Cynara scolymus* L.) (Asteraceae) and pumpkin flower (*Cucurbita* spp.) (Cucurbitaceae). Similarly, other species are also edible, such as garden nasturtium (*Tropaeolum majus* L.) (Tropaeolaceae), rose (*Rosa x grandiflora* Hort.) (Rosaceae), begonia (*Begonia cucullata* Willd.) (Begoniaceae), calendula (*Calendula officinalis* L.) (Asteraceae), wild pansy (*Viola tricolor* L.) (Violaceae), everfew or bachelor's buttons (*Pyrethrum parthenium* (L.) Sm. or *Chrysanthemum parthenium* (L.) Bernh.) (Asteraceae), tulip (*Tulipa x hybrida* Hort.) (Liliaceae), and lavender (*Lavandula angustifolia* Mill.) (Lamiaceae). Among the less common, carnation or clove pink (*Dianthus caryophyllus* L.) (Caryophyllaceae) and lemon verbena or lemon beebrush (*Aloysia citrodora* Paláu) (Verbenaceae) are also used (Santos, Melo, & Menegaes, 2012).

Eating flowers is a common practice in Europe, and extremely popular in the French and Swiss cuisine, as well as in Asia. In Brazil, supermarkets, stores, and shops specializing in culinary products have been selling edible flowers, which are used in salads, soups, pizzas, canapés, and jellies, both in sweet and savory dishes (Franzen et al., 2016).

Edible flowers have traditionally been used for human consumption in various cultures. They improve the appearance, taste and aesthetic value of food, aspects that consumers appreciate, justifying the growing trend of sales of high-quality fresh flowers around the world. However, consumers also demand foods with beneficial health properties, in addition to the nutrients they contain, in search of functional qualities such as antioxidant and antimicrobial properties (Fernandes, Casal, Pereira, Saraiva, & Ramalhosa, 2017).

Flower cultivation has been an important line in the economy and export since the end of the nineties. The use of flowers has not been merely for decorative purposes since some species are used as food for wild animals, meanwhile, others have phytotherapeutic properties and produce oils and essences, which are used in perfumery and cosmetics, or are used in cooking (Barbieri & Stumpf, 2005).

Currently, there are few studies that prove the edibility of flowers when they are related to compounds of nutritional interest since there is no tradition of using flowers in food, in addition to the lack of research regarding the toxicity of some species (Franzen et al., 2016).

Since ancient times, flowers have been used for edible and medicinal purposes in a very specific way. For example, *Althaea officinalis* L. of the Malvaceae family is known in English as marshmallow, and has been used in salads and, from the mucilage of the roots, sweets were elaborated, besides being served as food, even though the flower had laxative properties (Prata, 2009; Stancato, 2014).

Furthermore, English women in the Victorian era served sophisticated dishes with crystallized rose (*Rosa x grandiflora*) petals. Currently, rose is offered in salads, jellies, and cakes (Stancato, 2014).

According to Prata (2009), the Brazilian gastronomic culture has not stimulated the use of flowers in food, finding these "foods" in exotic culinary recipes and at a high cost, unlike European countries in which gastronomy uses commonly the flowers for food products.

The nutritional needs required by the human body in health and disease states has been the object of intense research in recent years, as well as the concern regarding the chemical characterization of foods with economic and nutritional potential, especially those of low caloric value, since obesity and chronic degenerative diseases have led the discussions on public health. Therefore, the study of the chemical composition of food is extremely important (Ohse et al., 2012; Oliveira & Marchini, 2008).

The natural substances of plant origin make the food more attractive to the consumer, besides increasing the useful life by the bacteriostatic and bactericidal capacity, slowing the beginning of the deterioration and the growth of undesirable microorganisms (Pereira et al., 2006). In parallel, industrialized foods that contain high levels of preservatives to reduce the microbial load are undesirable. Demand from consumers is turning towards greater production of fresh foods with natural preservatives and a higher safety guarantee (Forsythe, 2013).

From the perspective of phytochemical research, it is possible to know the chemical constituents of plant species or assess their presence in these. When chemical studies on the species of interest are not available, this type of analysis can identify the relevant secondary metabolite groups (Simões, 2006). Edible flowers, as well as fruits and vegetables, contain various compounds with antioxidant properties, which can be more efficient and less expensive than synthetic supplements to protect the body against diseases (Prata, 2009).

For example, rose is a species native to Asia and is considered one of the most popular flowers in the world (some articles date its emergence to more than 5,000 years ago), besides being the most cultivated flower worldwide. Scientifically, roses belong to the Rosaceae family and to the *Rosa* genus, with more than 100 species and thousands of varieties, hybrids and cultivars. The plant is classified as woody and has a size of 1 to 2 m in height. The species has simple leaves divided into 5 or 7 lobes, and solitary flowers of the most varied colors (Bellé, 1999; Prata, 2009).

Rose flowers are widely used in Arabic cuisine and can be consumed in creams, mousses or combined with fruit juices, salads, desserts, jams and drinks such as lemonade and orange juice, to give an exotic touch. In addition, the flowers can be served in cake decorations. Normally, an infusion is made first to concentrate the flavor (Franzen et al., 2016; Prata, 2009). Because rose petals are very rich in vitamins, it has a regenerative effect on the skin and can also be used to fight colds and flues, as well as for digestive problems, freeing the body of toxins, as they have analgesic, anti-inflammatory, antipyretic, soothing, healing and diuretic properties (Prata, 2009).

Sunflower (*Helianthus annuus* L.) (Asteraceae family), as it is popularly known due to its heliotropism, has its origin in culinary over 3,000 years ago, used by indigenous peoples in northern Mexico, where the oil from its seeds was used. The plant is rich in proteins and vitamins of the B complex, and today, in addition to the oil, flower buds can be used served with asparagus and its flowers in salads (Franzen et al., 2016). According to Reis, Queiros and Froes (2004), the main properties of this species are the regulation of cholesterol in the blood, improvement in cardiovascular health, fighting degenerative problems, and helping hormone formation for the proper functioning of the digestive system.

The species popularly known as calendula (*Calendula officinalis*) belongs to the Asteraceae family and its origin is probably in the Mediterranean region (Bellé, 1999; Lorenzi & Souza, 1999). This plant has been used since ancient times for medicinal purposes and as a textile dye. Recently, it has assumed the function as an edible flower. Its petals have been used in decorations for cakes, sweets and savory coverings. The use of this species in food requires removal of the pollen since it can cause allergic reactions. Calendula flowers are rich in substances such as carotenoids and essential oils and has a spicy palate, which can be used in rice, fish, cheeses, butter, yogurt, and tortillas, often replacing the saffron flavor (Reis et al., 2004).

In this context, the alternative use of natural products obtained from plants has attracted attention, mainly because these products have chemical and functional properties, in addition to the fact that edible flowers have a mild flavor, which changes very little the characteristics of the products with which they are combined. Hence, the need to investigate the chemical composition of flower species with potential use in human nutrition. Therefore, the aim of this study was to evaluate the chemical composition of rose, sunflower and calendula flower petals for future application in food.

Materials and methods [T2]

The experiment was carried out in the period from March to October 2017 in two stages, the first was the production of flowers and the second was their chemical characterization. The first stage was carried out in the Floriculture Sector of the Department of Plant Breeding of the Universidade Federal de Santa Maria (UFSM), located in Santa Maria, Rio Grande do Sul (Brazil) at 29°43′S and 53°43′W, and at an altitude of 95 m.a.s.l.

Sunflower (*H. annuus*) was planted in plastic cups with a capacity of 5 L in commercial substrate H-Decker, with 3 plants/beaker and with 10 experimental units. Each experimental unit comprised three vessels cultivated in a vegetation house. Flowering began 65 days after sowing (DAS) and the harvest occurred between the periods of 69 to 73 DAS, with one flower per plant being harvested.

Calendula (*C. officinalis*) was planted in open beds with dimensions of 10 m in length and 1 m in width, with 30 plants/m^2, containing 10 experimental units; each unit had dimensions of 1 m × 1 m. The flowering started 60 DAS and the harvest occurred between the periods of 60 to 85 DAS, with 5 flowers/plant being harvested.

The flowers of the hybrid rose (*Rosa x grandiflora*) were collected from plants grown in the greenhouse, with two years of cultivation and 16 experimental units; each unit had dimensions of 1 × 1.2 m, containing 3 plants/m^2, and 8 flowers/plant were harvested. All species were irrigated daily and cultivated without the use of fertilizers or chemical products. The flowers were harvested manually in the morning and placed in thermal packaging; subsequently, they were transported to the physicochemical laboratory of Departamento de Tecnologia e Ciência Alimentar of UFSM, where triple washing was carried out under running water, sanitized with 1 % sodium hypochlorite and manually centrifuged.

The second stage of the experiment was carried out in the physiochemical laboratory in the Department of Technology and Food Science of the UFSM, where the removal of the petals as well as the analyses were carried out, including the following. Humidity was determined gravimetrically, by greenhouse weight loss at 105 °C up to a constant weight; ashes were obtained by incineration of the muffling material at 550-600 °C; ethereal extracts were obtained by continuous extraction in the Soxhlet equipment, using petroleum ether as an organic solvent (Association of Official Analytical Chemists [AOAC] International, 2005; Zenebon, Pascuet, & Tiglea, 2008) (figure 1).

Figure 1. a. Rose flower (*R.* x *grandiflora*); b. Sunflower inflorescence (*H. annuus*); c. Calendula inflorescence (*C. officinalis*).

The method used for the determination of total nitrogen was Kjedahl, composed of three stages: 1) digestion of the sample, 2) distillation, and 3) titration. Copper sulfate and selenium were used as catalysts, and boric acid as the ammonia receptor solution in the distillation process (AOAC, 2005; Zenebon et al., 2008). Likewise, the determination of crude fiber was carried out employing the filter analysis method in filter bags (AOCS Ba 6a-05) as proposed by AOAC (2005) and Zenebon et al. (2008). Carbohydrates were obtained by subtracting the values of moisture, gray, protein, ether extract, and crude fiber, and the gross caloric value (GCV) of the petals analyzed was obtained using the traditional conversion factors of 4 kcal/g for carbohydrates and proteins, meanwhile for lipids, 9 kcal/g was used (Agência Nacional de Vigilância Sanitária, 2003).

The chemical composition of the flower petals was determined in triplicates following the methods recommended by the AOAC (2005) and the Analytical Standards of the Adolfo Lutz Institute (Zenebon et al., 2008). The data obtained was subjected to a statistical treatment through an analysis of variance (Anova), and means were compared to each other through the Tukey test at the level of 5 % significance employing the IBM® SPSS® Statistics System program (version 20). The means of the results and the standard deviation were calculated in Excel®.

Results and discussion [T2]

Table 1 shows the moisture, dry matter, ash, ethereal extract, crude protein, crude fiber, carbohydrate and GCV percentage contents (g/100 g) of the flower petals of the species assessed. It is observed that the chemical constituents analyzed showed a significant difference ($p < 0.05$) between flower species.

Table 1. Average percentage of the centesimal composition and total caloric value of rose (*R. x grandiflora*), sunflower (*H. annuus*) and calendula (*C. officinalis*) petals, values expressed on a wet basis

Nutrients** (%)	Rose	Sunflower	Calendula
Moisture	$84.56^{*c} \pm 0.122$	$86.45^{b} \pm 0.377$	$89.34^{a} \pm 0.100$
Dry matter	$15.44^{a} \pm 0.122$	$13.55^{b} \pm 0.377$	$10.66^{c} \pm 0.100$
Ash	$0.72^{c} \pm 0.008$	$1.25^{a} \pm 0.005$	$0.93^{b} \pm 0.005$
Ethereal extract	$0.23^{c} \pm 0.005$	$0.86^{b} \pm 0.013$	$1.32^{a} \pm 0.015$
Protein	$1.88^{a} \pm 0.042$	$1.75^{b} \pm 0.011$	$1.20^{c} \pm 0.014$
Raw fiber	$3.20^{a} \pm 0.095$	$2.12^{b} \pm 0.045$	$1.59^{c} \pm 0.105$
Carbohydrates	9.41	7.57	5.62

Caloric value***	60.03	53.50	45.52

Data are means ± standard deviation; * Means within the same line with different letters are significantly different at the 5 % level, by the Tukey test ($p < 0{,}05$); ** = (g/100 g); *** = (kcal/100 g).

Source: Elaborated by the authors

The humidity percentage of flower petals was 89.34 %, 86.45 % and 84.56 % for calendula (*C. officinalis*), sunflower (*H. annuus*) and rose (*R. x grandiflora*), respectively. This shows a considerable amount of water present in the flower petals, a quality that helps hydration and also improves intestinal functioning. As water is an essential component of all body tissues necessary for all reactions and physiological processes as digestion, absorption and excretion, it can be ingested as part of the food (Mahan & Escott-Stump, 2005).

The ash content (table 1) refers to the total amount of minerals present in the plants, showing a percentage in flower petals that varied statistically ($p < 0.05$) from 1.25 % to 0.72 % on a wet basis between species. Sunflower (*H. annuus*) presented a higher ash content. Silva, Wiest and Carvalho (2016) observed the ash percentage for the Chinese hibiscus or shoeblackplant (*Hibiscus rosa-sinensis* L.) and Rose of Sharon (*Hibiscus syriacus* 'Totus Albus') (Malvaceae) of 0.74 % and 0.80 %, respectively, similar to the results found for rose (*R. x grandiflora*) and calendula (*C. officinalis*) in this experiment.

The contents of the ethereal extract in flower petals (table 1) varied from 1.32 % for calendula, to 0.23 % for rose, presenting a low ethereal extract content. Takeiti, Antonio, Motta, Collares-Queiroz and Park (2009), as well as Rocha et al. (2008) in their investigations with Barbados gooseberry, leaf cactus, or ora-pro-nóbis leaves (*Pereskia aculeata* Mill.) obtained lipid contents of 4.1 g% and 3.64 g%, respectively. Within the contents of ethereal extract, there are not only lipids but also other organic substances soluble in ether, such as pigments, fatty acids, waxes, among others.

Villas-Boas, Oliveira, Oliveira, and Lima (1999) determined that lipid values lower than 1 % can be indicated for weight reduction diets since this value is found in most of the fruits, leafy vegetables and edible flowers. Monteiro (2009) verified that the integral consumption of vegetables can increase the consumption of good quality fats, within the limits of recommendation for lipids, collaborating in the prevention of cardiovascular diseases.

Table 1 also shows differences in the amounts of protein on a wet basis between the species, in which calendula presented a lower quantity (1.20 %) compared to rose and sunflower (1.88 % and 1.75 %), respectively. Based on these results, it was verified that flower petals showed low levels of protein, and should not be considered as good protein sources to achieve nutritional needs since they are of low biological value (Ohse et al., 2012; Oliveira & Marchini, 2008).

In the characterization of raw fiber (table 1), rose petals were the ones that showed the highest amount (3.20 %), followed by sunflower (2.12 %) and calendula (1.59 %). Rose petals can be characterized as a source of fiber, since according to RDC No. 54 (Ministry of Saúde, 2012), for a food to be characterized as a source of fiber it must have a minimum of 3 g of fiber/100 g (solids).

Elleuch, Bedigian, Roiseux, Besbes, and Blecker (2011) emphasize that food fibers, when added to products, increase water retention capacity, fat retention capacity, emulsification, and gel formation. In addition, it prevents syneresis, i.e. the separation of liquid from a gel caused by shrinkage and improves the shelf life of the products.

Kinupp and Barros (2008) emphasize that unconventional vegetables such as anise-scented sage or hummingbird sage (*Salvia guaranitica* A.St.-Hil.ex Benth.) (Lamiaceae), swamp hibiscus (*Hibiscus diversifolius* Jacq.) (Malvaceae), cumari pepper or locoto (*Capsicum baccatum* L. var. *baccatum*) (Solanaceae), the tomatillo, husk tomato, low ground-cherry or hairy groundcherry (*Physalis pubescens* L.) (Solanaceae), among others, sometimes have higher concentrations of fibers, antioxidant compounds and proteins, compared to the sources of conventional vegetables such as lettuce (*Lactuca sativa* L.) (Asteraceae), arugula or rocket (*Eruca sativa* Mill.) (Brassicaceae), and tomato (*Solanum lycopersicum* L.) (Solanaceae), among others, favoring a better nutritional quality diet.

The edible flowers of rose, sunflower and calendula showed 9.41 %, 7.57 % and 5.62 % of total carbohydrates, respectively (table 1). The average carbohydrate content was calculated by differences from the nutrients found, classifying the edible flowers as a group A vegetable, according to the proposal published by Ornellas (1988) for having about 5 % of total carbohydrates (Franzen et al., 2016). Rodrigues (2016) in his work with samples of dehydrated ora-pro-nóbis leaves (*P. aculeata* Mill.) (Cactaceae), obtained a value of 8.49 g% for carbohydrates, values that resemble those found in this research.

The edible flowers of rose, sunflower and calendula showed caloric values of 60.03 %, 53.50 % and 45.52 %, respectively. Regarding the caloric value calculated by the four macronutrients mentioned above (carbohydrates, fiber, protein and lipids), the amounts indicated for flower petals on a wet basis are oriented as low-calorie food, as described by Reis et al. (2004), where edible flowers, in general, have 40 calories per 100 g.

Monteiro (2009) verified for broccoli flowers (*B. oleracea* var. *italica*), 4.83 g of fibers per 100 g of fresh vegetable, meanwhile for cauliflower (*B. oleracea* var. *botrytis*), the value was 1.74 g of proteins and 2.08 g of fiber per 100 g of fresh vegetables. These values corroborate the results of the current study for rose, sunflower, and calendula.

Souza, Curado, Vasconcellos and Trigo (2007) evaluated the centesimal composition of raspberry (*Rubus idaeus* L.) (Rosaceae) and discovered that 100 g of fruit contains 83-87 g of water, 51-62 kcal, 0.4-0.7 g of proteins, 0.5 g of lipids, 11.4 g of carbohydrates, 1-1.5 g of fiber and 0.19-0.25 g of ash, values that are similar to those found in flower petals, showing that nutritionally, edible flowers are similar to some fruits and even comparable to other conventional vegetables.

Moura, Souza, Oliveira, Lira and Silva (2009) in their study on the chemical composition of moringa flowers (*Moringa oleifera* Lamarck) (Moringaceae) as a food source in natura, showed contents of 83.40 % moisture, 8.55 % carbohydrates, 2.54 % proteins, 2.50 % ash and 3.00 % lipids, results that were superior to flower petals only in contents of proteins, ash and lipids.

Franzen et al. (2016) characterized eight ornamental flower species in terms of chemical composition and caloric value of the petals, and found, for each 100 g of fresh rose petals, the following proportions: 72 calories, 10.9 g of carbohydrates, 1.84 g of proteins, 0.28 g of ether extract, and 3.5 g of fiber. For sunflower, they found: 61.8 calories, 8.57 g of carbohydrates, 1.74 g of proteins, 0.85 g of ether extract, and 2.07 g of fibers; for calendula, they found 49.1 calories, 6.16 g of carbohydrates, 1.18 g of proteins, 1.20 g of ether extract, and 1.35 g of fibers. All these values are similar to those found in the current study, confirming again the nutritional potential of these species as ingredients, or for *in natura* consumption, in culinary dishes or menus.

Furthermore, Rosa (2017) also evaluated the centesimal composition of cranberry (*Vaccinium* spp.) (Ericaceae) showing contents of moisture of 85.26 %, ash of 0.18 %, crude protein of 0.63 %, lipids of 0.32 % and carbohydrates of 12.93 %. These results are similar to the values reported by Souza et al. (2007) and Souza, Pereira, Silva, Lima and Queiroz (2014), who obtained results of 87.70 % for moisture, 0.08 % for ash, 0.48 % for protein, 0.19 % for lipids and 11.54 % for carbohydrates, being lower the values found for proteins and lipids.

The edible flowers of rose, sunflower and calendula show chemical characteristics similar to conventional vegetables such as broccoli and cauliflower flowers, small fruits such as cranberry and raspberry, and unconventional vegetables such as anise-scented sage, swamp hibiscus, cumari pepper, tomatillo or husk tomato, among others, according to the literature consulted, as food products applied in the diet or as food ingredients.

Conclusions [T2]

The edible flower petals of the three species analyzed, rose (*Rosa* x *grandiflora* Hort.), sunflower (*Helianthus annuus* L.) and calendula (*Calendula officinalis* L.), showed in their chemical composition relevant contents of moisture, protein, and fiber. At the same time, they showed low ethereal extract content and low caloric value, an adequate feature for the constitution of special diets. In addition, the petals contain ash contents that indicate the presence of important minerals for nutrition. Thus, the edible flowers of rose, sunflower and calendula are promising raw materials for human consumption as ingredients, or for in natura consumption.

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Disclaimer [T2]

All authors made significant contributions to the document and agree with its publication; further, all authors state that there are no conflicts of interest in this study.

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