Effect of Drying on the Antioxidant Capacity and Concentration of Phenolic Compounds in Different Parts of the *Erythrina americana* Tree

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The *Erythrina americana* tree has been widely studied for its antioxidant and antimicrobial activity, principally of the seeds. Few studies have focused on the other tree parts. This work evaluated the effect of drying on the proximate chemical composition, IC₅₀, and total phenolic content (TPC) of different parts of the plant from *Erythrina americana*. Proximate chemical composition showed significant differences between parts of the plant. Tree bark (TB) exhibited higher protein content, crude fiber, and ash. The IC₅₀ value was significantly different in all parts of the plant; the leaves exhibited lower amounts necessary to reach this value. The drying process had a positive influence on the antioxidant activity in all parts of the plant, with mature flowers (MF) and young flowers (YF) samples. These were the samples that required the lowest concentration of all dry samples to reach the IC₅₀ value. The TPC values showed significant differences between fresh and dry samples except for MF, according the ANOVA and Tukey test (P≤0.05). In conclusion, the drying process has potential for retaining the antioxidant activity in YD and MF.

**Keywords**: Antioxidants; Phenolic compounds; Erythrina; Drying

**INTRODUCTION**

The *Erythrina* tree is a pantropical legume belonging to the sub-family Papilionoideae (Sousa et al. 2003), which is divided into 5 sub-genera and 26 sections (Neill 1988; Neill 1993), that comprises 115 species, including trees, shrubs, and some herbs. In Mexico, *Erythrina americana* is found as wild plants in Veracruz, Hidalgo, Morelos, Guerrero, Puebla, and Oaxaca states (Bonilla and Villaseñor 2003; Ruiz Montiel et al. 2012). However, some commercial plantations have also been reported in Michoacán, Chiapas, San Luis Potosí, Coahuila, Nuevo León, Tabasco, and Campeche (García-Mateos et al. 2001).

The *E. americana* is used mostly as a shade tree (Rivera et al. 2008), nitrogen fixer, animal feed, support tree, and ornament. The *E. americana* flowers are frequently used as human food (Sotelo et al. 2007) or in the preparation of infusions. Seeds of *E. americana* are used in the medical area as analgesic, tranquilizer, and muscle relaxant.
(Garín-Aguilar et al. 2000; Sánchez-Herrera et al. 2001). In addition aqueous extracts from its leaves have been used as sedatives (Ratnasooriya and Dharmasiri 1999).

The seeds have high alkaloids content, which increases throughout the maturation of the pod (García-Mateos et al. 1996, 2004a). In many cases the alkaloids are differentiated according to species (García-Mateos et al. 1998; Miguel-Chávez et al. 2006). For this reason the alkaloids have been extensively studied, mainly for their antioxidant (Ibarra et al. 2011), antimicrobial (Soto-Hernández et al. 2011), and pharmacological activities.

However, the alkaloids not only are present in the seeds of *E. americana*; several authors, have reported low quantities of these compounds in flowers, leaves, and tree bark. Alkaloids, α-erythroidine, β-erythridine, 8-oxo-α-erythroidine, erythralin-N-oxid, ersodine, erythaline, erythratine, erythbidin, crystamidine, and β-D-グルコースイソピン have been isolated from flowers (Sánchez-Herrera et al. 2001; Reimann 2007). Erysoline and erythbidin have been found in leaves, while only erythratidine have been reported in the tree bark (García-Mateos et al. 1998). The difference in the type and content of alkaloids in each part of the plant is the principal reason for the diverse applications in the medical area. For example, the tree bark is used as a contraceptive and abortifacient; the seeds are used as central nervous system depressor (Garín-Aguilar et al. 2000; Shoaib et al. 2000), muscular relaxant, sedative (Sánchez-Herrera et al. 2001), toxin against mosquitoes (García-Mateos et al. 2004b), and antimycotic (Estrada et al. 2009); the flowers are used to treat insomnia. The leaves, seeds, and flowers are used as hypnotics and to treat inflammation of arms, legs, and eyes, as well as to treat insect bites, ulcers, and abscesses, while the whole plant is used to treat malaria, to clean the liver, kidneys, and lungs, and to treat back, teeth and ear pain (Hastings 1990; Gheno-Heredia et al. 2011; Araújo-Júnior et al. 2012). Some of the beneficial effects found in the *Erythrina* genus are due to the antioxidant activity of the alkaloids and phenolic compounds, which are distributed across all sections of the plant, including fruit, leaves, seeds, roots, and tree bark (Pratt and Hudson 1990).

In addition to the beneficial effects of alkaloids reported to be in the *Erythrina* genus, some authors report that the phenolic compounds could also be responsible for beneficial medical treatments such as analgesic, anti-inflammatory, prevention and treatment of cancer, osteoporosis, diabetes mellitus, cardiovascular disorders and neurodegeneration (Balasundram et al. 2006; Sumbul et al. 2011). In the food industry, the phenolic compounds are used due to their antioxidant activity, to slow down the oxidative degradation of lipids, and as antimicrobial agents (Cowan 1999; Mathew and Abraham 2006; San Miguel-Chávez et al. 2007).

Currently, the main problem in the pharmaceutical, food, and medical industries is the preservation of the raw material with high nutraceutical potential. For this reason, many methods have been used to prolong the shelf life, without losing the nutraceutical properties. One of the methods most widely used to achieve this objective is the drying process (Sagar and Kumar 2010; Hincapié et al. 2014). Convection drying is the most popular to the dehydration of fruits and vegetables, since a simultaneous mass and heat transfer process favors the transference of water by means of diffusion, based on moisture content and temperature, respectively, from the interior of the material to the air-food interface, and from there to the convection air current (Márquez and Ciro 2002).

While many studies have been conducted recently on the alkaloids and antioxidant compounds obtained from *E. americana* and their effects on health, few studies have focused on the effect of processing on the chemical composition and the
nutraceutical properties of the different structures of this plant. For this reason, the objective of this study was to determine the effect of drying on the proximate chemical composition, antioxidant activity, and the total phenolic compound content in the different sections of the *E. americana* plant.

**EXPERIMENTAL**

**Physical and Chemical Characterization**

*Vegetable material*

The vegetable material was collected in Tulancingo, Hidalgo, Mexico. Samples were taken from tree bark (TB), leaves (L), and at three stages of flower development: floral bud (FB), young flowers (YF), and mature flowers (MF). Each sample was analyzed before and after the convection drying process.

*Proximate chemical analysis*

The proximate chemical analysis was conducted according to the methodology established in AOAC (1990). Protein content was calculated by converting the nitrogen content, determined by the micro-Kjeldahl method (method 955.04, factor Nx6.25), crude fiber was quantified with alkaline and acid digestion (method 962.09), crude fat were extracted in a Soxhlet extractor using petroleum ether (method 920.39C), moisture content was determined by drying the samples in an oven (Felisa, Model 243AD, México) at 105 °C until a constant weight was obtained (method 934.01), and ash content was obtained by calcination in muffle furnace (Thermolyne 1400, model FB1415M, USA) at 550 °C (method 923.03). Carbohydrate content was determined as the weight difference using protein, lipid, fiber, moisture, and ash content data.

**Convection Drying**

Drying was undertaken in a forced convection-drying oven (BINDER, model FD115-UL, USA). The samples were placed in the oven for a period of 48 h at 40 °C until the complete elimination of moisture. Tree bark samples of an approximate area of 5 x 5 cm were placed in the dryer, while the leaves and flower samples were placed whole in the dryer.

**Determination of Antioxidant Activity (DPPH Method)**

The DPPH method was used according to Brand-Williams *et al.* (1995), in which the stable radical 2,2-diphenyl-1-picrylhydrazyl (DPPH, Sigma-Aldrich, St. Louis, MO, USA) is used. In order to determine the IC$_{50}$ values, the concentration profiles studies were carried out in the range 30 to 700 mg of sample*mL$^{-1}$ of methanol. Each sample was vortex-mixed for 2 min and then centrifuged at 1000 x g for 20 min and 0.1 mL of the supernatant was placed in vials. Then 3.9 mL of DPPH in methanol (6x10$^{-5}$ M) was added. The reduction of absorbency was determined at 515 nm from time 0, and then every 10 min until the reaction has been completed using a spectrophotometer (Thermo Fisher Scientific Inc., Waltham, MA, USA).

Inhibition (% I) of DPPH radical was calculated using the equation,

\[
I(\%) = \frac{A_0 - A_s}{A_0} \times 100\%
\]

where $A_0$ is the absorbance of the control, and $A_s$ is the absorbance of the test sample.
The IC\textsubscript{50} values were calculated from the graphs by the percentage of inhibition of the DPPH versus samples concentrations. IC\textsubscript{50} denotes the concentration of the compound required to inhibit the initial DPPH value of 50\% to an absorbency of 515 nm.

**Total Phenolic Content (TPC)**

The TPC of each sample was quantified using the Folin-Ciocalteu methodology (Singleton et al. 1999). The extraction of phenolic compounds was carried out using 0.5 mg of each sample (fresh or dry), to which was added 2 mL of methanol (at 80\%) containing 1\% HCl. The prepared dissolution was placed in an orbital shaker (Eberbach Corporation, Ann Arbor, MI, USA) (200 rpm) for 2 h at room temperature. The mixture was centrifuged at 1000x\textit{g} for 15 min in a centrifuge (Hermle Z200A, Germany), and the supernatant was placed in vials. The precipitate was used to carry out a second extraction under the same conditions. The resulting supernatants for both extractions were mixed and used to carry out the quantification of PCC. An aliquot of the extract (100 \(\mu\)L) was mixed with 0.75 mL of the Folin-Ciocalteu reagent (Hycel of México SA de CV, México) (previously diluted in distilled water) and was left to stand at room temperature for 5 min, after which 0.75 mL of sodium bicarbonate was added, for a concentration of 6\%. The absorbency was then read at 725 nm after 90 min of rest at room temperature.

The results were expressed as the gallic acid equivalents (GAE) in milligrams per gram of sample, using a gallic acid (Sigma-Aldrich, St. Louis, MO, USA) standard curve.

**Statistical Analysis**

All the analyses were undertaken in triplicate and the results expressed as median ± standard deviation, while the analysis of variance (ANOVA) was carried out by means of a Tukey test. The software program Statistical Analysis System (SAS Institute Inc., Cary, NC, USA) v. 8.0 was used for the statistical analysis of the data.

**RESULTS AND DISCUSSION**

**Physical and Chemical Characterization**

*Vegetable material*

The measurements for the samples used in this study were as followed: Leaves (L), between 10 and 14 cm in length and 9 and 12 cm in width; floral bud (FB), between 0.7 and 1.5 cm; young flowers (YF), between 2 and 2.4 cm; and mature flowers (MF), between 5.5 and 6.0 cm in length.

*Proximate chemical analysis*

The proximate chemical composition of *Erythrina americana* showed that exist statistically significant differences (\(P\leq0.05\)) among most parts of the plant (Table 1).

The moisture content for all samples was found to be between 68\% and 87\%, a range comprising samples from the various stages of flower development. The flowers and leaves were the samples with highest moisture levels, which could be attributed to the fact that water is transported through the xylem to the leaves, seeds, flowers, and fruit (Raven et al. 1992). In contrast, the tree bark (external cortical layer), comprised principally of cellulose and lignin, and is the structure that accumulates the lowest amount of water (Nutsch 1996).
In particular, the moisture levels in the *Erythrina americana* flowers analyzed were similar to those reported for the same species by Sotelo *et al.* (2007), and lower than those reported by García-Mateos *et al.* (1996). Some authors attributed these variations to the development stage, since there are reports that indicate an inverse relationship between the development stage and moisture levels of the plant (García-Mateos *et al.* 1996, 2005).

**Table 1.** Proximate Chemical Composition of *Erythrina americana* (g*100 g*⁻¹)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Moisture</th>
<th>Dry Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Proteins</td>
</tr>
<tr>
<td>L</td>
<td>75.09±0.48</td>
<td>20.28±0.92</td>
</tr>
<tr>
<td>FB</td>
<td>84.47±0.15</td>
<td>25.73±0.29</td>
</tr>
<tr>
<td>YF</td>
<td>87.25±0.20</td>
<td>24.70±0.47</td>
</tr>
<tr>
<td>MF</td>
<td>83.48±0.24</td>
<td>20.97±0.55</td>
</tr>
<tr>
<td>TB</td>
<td>68.12±0.10</td>
<td>26.12±0.38</td>
</tr>
</tbody>
</table>

Different letters in each column indicate significant statistical differences (*P*≤0.05). The values are means±SD of triplicate measurements.

On the other hand, the leaves of *E. americana* presented lower moisture levels than the leaves of *E. crista* (Maisuthisakul *et al.* 2008). However, in comparison with the other parts of the tree, the moisture content is lower than the flowers at the several developmental stages, due principally to the dynamic water interchange in the leaves that regulate the evaporative demand of water (Lambrecht and Dawson 2007). The moisture content in the leaves is higher and more stable than in the tree bark. This is because in the tree bark, the water and solutes may buffer the daily or seasonal fluctuations in water availability in the tree tissues (Rosell *et al.* 2014).

The leaves in comparison with the flower at different developmental stage, showed lower protein and carbohydrates content, which confirmed the reports by other authors, who described how the products of the photosynthesis undertaken by the leaves are translocated mainly to the flowers, fruits, and seeds (Maisuthisakul *et al.* 2008).

The protein content in all parts of the plant analyzed was higher than 20%; the leaves (L) and mature flowers (MF) showed the lowest protein content. Higher protein content was observed in the FB and YF, which probably were due to the fact that during these developmental stages high protein levels are required for the elongation of its tissues. On the other hand, it has been demonstrated that during plant development, there is a translocation of nitrogenous compounds, such as proteins, alkaloids, amino acids, and amides from the leaves to the flowers, fruit, and seeds (García-Mateos *et al.* 2004a; Verduzco *et al.* 2008).

Comparing the results of protein content, obtained for *E. americana* with those obtained by other authors, it was observed that the mature flower of the *E. americana* presented a protein content similar to that reported for *E. edulis* (Barrera 1994) but 6.2% lower than the protein content reported for *E. americana* in other studies (Sotelo *et al.* 2007). These results showed that protein content not only varies among species, but also within the same species as a consequence of the geographic zone of development. In
In both fresh and dry samples, according to the one-way ANOVA, statistically significant differences exist between all parts of the plant for the IC$_{50}$ value ($P<0.05$). For this reason the IC$_{50}$ value of *E. americana* samples was dependent on the plant part analyzed (Table 2). Leaves exhibited the lower amount necessary to reach the IC$_{50}$.

According to the classification proposed by Kuete and Efferth (2010), the values of antioxidant activity obtained for *E. americana* in all parts of the plant analyzed, are considered as samples with low antioxidant activity, considering that all parts of the plant showed a value of IC$_{50} > 0.1 \text{mg/mL}$. The results showed that the drying process positively influenced the antioxidant activity in all parts of the plant. The drying of samples (MF and YF) diminished the required sample in comparison with the fresh sample to reach the IC$_{50}$ value (Table 2), which could have been due to the fact that melanoids derived from the Maillard reaction could have been generated and accumulated during the process (Vega-Gálvez et al. 2009).
The sample amount necessary of the different parts of the plant were found in the range between 38.5 and 650 mg*mL⁻¹. To reach the IC₅₀ value, many authors have indicated that the antioxidant activity of *Erythrina* species is due principally to the high bioproduction of alkaloids in seeds, flowers, and pods of *Erythrina* species (Juma and Majinda 2004; Ibarra *et al.* 2011).

Although the results obtained for TPC showed a decrease after the drying process (Table 3), the antioxidant activity increased in two parts of the plant (MF and YF), due to the high alkaloid content in the flowers (García-Mateos *et al.* 1998). However, in the other parts of the plant (FB, L, and TB), apparently the low content of alkaloids is not sufficient to avoid the oxidation process of other compounds and maintain the antioxidant activity. In addition, these results are important because currently no report has been published about the antioxidant activity and the amount of sample required to reach the IC₅₀ value, from different parts of the plant and the importance of the alkaloids in the protecting effect on the antioxidant activity.

**Table 2. Amount of Sample Required to Reach the IC₅₀ Value in Different Parts of *Erythrina americana* Miller**

<table>
<thead>
<tr>
<th>Structure</th>
<th>IC₅₀ (mg*mL⁻¹)</th>
<th>Fresh</th>
<th>Dry</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mg in fresh basis</td>
<td>mg in dry basis</td>
<td></td>
</tr>
<tr>
<td>MF</td>
<td>650±32.5a</td>
<td>107.3±1.56a</td>
<td>48.5±1.69c</td>
</tr>
<tr>
<td>YF</td>
<td>560±14b</td>
<td>71.4±1.12b</td>
<td>38.5±1.54d</td>
</tr>
<tr>
<td>FB</td>
<td>400±8c</td>
<td>62.12±0.6c</td>
<td>72.0±3.6b</td>
</tr>
<tr>
<td>L</td>
<td>62.6±1.2a</td>
<td>15.59±0.3e</td>
<td>42.0±1.72c,d</td>
</tr>
<tr>
<td>TB</td>
<td>166.7±5.4d</td>
<td>52.92±0.17d</td>
<td>90.0±3.15a</td>
</tr>
</tbody>
</table>

IC₅₀ (mg*mL⁻¹) is the quantity required for generating 50% inhibition of the DPPH after 30 min. Different letters in each column indicate significant statistical differences (*P*≤0.05). The values are means ± SD of triplicate measurements.

The results showed differences in the antioxidant activity in leaves and flowers, which was apparently due to different accessory compounds, principally pigments. For this reason the leaves required the lowest quantity of sample to reach the IC₅₀ value. Thus, this part of the plant has a higher antioxidant activity. Many reports have suggested that in the leaves, the stress level is high; for this reason more pigments quantity are generated, and this protects the leaf tissues from photochemical damage (del Baño *et al.* 2004; Chew *et al.* 2009).

Nevertheless, the amount of sample necessary of *E. americana* leaves to reach the IC₅₀ value is higher than the following: *E. crista* leaves (Maisuthisakul *et al.* 2008); extracts from legume leaves used in the medical industry (Chew *et al.* 2011); extracts of *B. monandra* leaves (Argolo *et al.* 2004); *Cinnamomum verum* leaves (Mathew and Abraham 2006); edible leaves of other genera (Tachakittirungrod *et al.* 2007; Maisuthisakul *et al.* 2008); as well as the essential oils of the leaves of *Ocimum basilicum* (Hussain *et al.* 2008) and *Biden pilosa* Linn var. *Radiata* (Deba *et al.* 2008). This was the case because the extraction processes used for these samples involve the use of solvents
of different polarities, which facilitates the isolation of various antioxidant compounds, thus increasing their antioxidant activity. However, in this research raw vegetal and dry powder was used, therefore multiple interferences could be generated between different compounds.

On the other hand, the results obtained in this study are within the range of the levels reported for the leaves of edible plants of different genera (Odhav et al. 2007). However, in comparison with plants used for medical purposes, the necessary concentration of all *E. americana* parts is high to reach the IC₅₀ value (Bruni et al. 2004; Deba et al. 2008; Maisuthisakul et al. 2008; Lu et al. 2009; Chew et al. 2011).

### Total Phenolic Content (TPC)

A similar comportment in the TPC was observed in both fresh and dry samples. All parts of the plant showed significant differences (*P*≤0.05), with the higher TPC value obtained for the leaves and the lower TPC value for the tree bark. Statistical calculation for ANOVA and Tukey test showed significant differences (*P*≤0.05), between fresh and dry samples, except for the mature flowers.

Phenolic compounds are synthesized as secondary metabolites during the development of plants as a response to stress conditions such as UV radiation, hydric deficit, mechanical damage, and so on. It has been demonstrated that the distribution of phenolic compounds in the plants, both in the structures and at a cellular and sub-cellular level, is not uniform. The insoluble phenolic compounds, for example, are found in the cell walls, while the soluble phenols are present within the vacuoles of the vegetable cells (Randhir and Shetty 2005). The aforementioned fact explains the difference in the concentration of the TPC in each part of the *Erythrina americana* plant analyzed (Table 3).

According to the results obtained, the use of fresh samples to preserve the high content of TPC in all parts of the plant is more effective. All the fresh samples showed a higher TPC compared with the dry samples. The drying process affected the TPC content, apparently due to the fact that during the processing, some phenolic compounds might be suffering thermal or oxidative degradation, combined with the decreased activity of the first committed enzyme in the phenylpropanoids metabolism (Dimberg et al. 1996; Loaiza-Velarde et al. 1997; Ismail et al. 2004; Xu et al. 2007; Wojdylo et al. 2009). Moreover, based on the moisture content, the quantity of fresh sample expressed in dry basis, used for the TPC determination, was in the range of 0.1275 g to 0.3186 g (YF and TB, respectively), 7.8- and 3.1-fold lower that the amounts of drying samples (1 g).

It has been demonstrated that the processing of food could accelerate the release of phenolic compounds due to the breaking down of the cellular constituents. It must be taken into account that, as this is happening, hydrolytic and oxidative enzymes are being released (Wojdylo et al. 2009). Furthermore, it should be noted that the drying temperature used in this research was not sufficiently high to deactivate this set of enzymes. For this reason, it was not possible prevent the loss of phenolic compounds, generating a decrease of TPC in dry samples compared to the fresh samples (Table 3).

On the other hand, the leaf samples presented a higher TPC than the flower samples, which could be explained by the fact that the chlorophylls present in the leaves underwent a process of photosensitization (process of transferring the light energy absorbed). As this process is able to trigger the production of highly reactive chemical species at a cellular level, the leaf tissues are responsible for the generation of highly
effective antioxidants that are capable of eliminating free radicals and minimizing oxidative damage (del Baño et al. 2004; Chew et al. 2009).

The TPC obtained for *E. americana* leaves and flowers was lower than that reported for the extracts of legume flowers and leaves used in medicine (*Bauhinia kockiana*, *Bauhinia purpurea*, *Caesalpinia pulcherrima*, *Calliandra tergema*, *Cassia surattensis*, *Leucaena leucocephala*, *Peltophorum pterocarpum*, *Samanea sama*, and *Acacia auriculiformis*); this was due to the specific extraction of phenolic compounds in these reports (Rakic et al. 2007; Chew et al. 2011), while in the case of the samples, both fresh and dry, analyzed in this study, the entire parts of the plant was analyzed and not an extract, giving rise to the possibility of some interference from other compounds present.

**Table 3.** Total Phenolic Content in different parts of *Erythrina americana* Miller

<table>
<thead>
<tr>
<th>Structure</th>
<th>TPC (mg·g⁻¹ sample)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fresh</td>
</tr>
<tr>
<td>MF</td>
<td>417.44 ± 12b</td>
</tr>
<tr>
<td>YF</td>
<td>393.15 ±12c</td>
</tr>
<tr>
<td>FB</td>
<td>362.61 ± 8d</td>
</tr>
<tr>
<td>L</td>
<td>599.05 ± 3a</td>
</tr>
<tr>
<td>TB</td>
<td>76.42 ± 5e</td>
</tr>
</tbody>
</table>

*TPC is expressed as gallic acid equivalents (GAE) in milligrams per gram of sample. Different letters in each column indicate significant statistical differences (P≤0.05). The values are means±SD of triplicate measurements.

On the other hand, the leaves and the flowers in different stages of development presented a higher level of TPC content compared to those reported for other plants used in human food (Ismail et al. 2004).

The TPC of the tree bark was lower compared to the other parts of the plant. However, although this value was low, some phenolic compounds of interest for both the medical and food industries have been reported both in the tree bark and the root of *Erythrina sigmoides*, *Erythrina eriotricha*, *Erythrina burttii*, and *Erythrina indica*, among which are the following: sigmoidine L; ferulic acid; isoferulic acid; erytrinasinates C, and D; 5,7-dihydroxy-4’-methoxy-3’,5-di-(3-methylbut-2-enyl) flavonone; 5,7-dihydroxy-4’-methoxy-3’-(3-hydroxy-3-methylbut-1-enyl)-5’-(3-methylbut-2-enyl) flavonone; 5,4’-di-O-methylalpinumisoflavone; cajanin; 3-phenylcoumarin (indicanine B, and C); and indicanines D, and E (Nkengfack et al. 1997; Yenesew et al. 1998; Waffo et al. 2000; Nkengfack et al. 2001).

Lastly, a positive significant linear relationship between antioxidant activity and total phenolic content has been reported (Cai et al. 2004). However, this correlation was not observed in this study. This could be due to the conditions of the drying process, which may influence the antioxidant activity and TPC. Other studies have reported that the drying method, temperature and time of the treatment, type of extraction, and interactions among the different antioxidant reactions could be responsible for the difference in responses of the phenolic compounds to the Folin-Ciocalteu method (Balasundram et al. 2006; Que et al. 2008; Vega-Gávez et al. 2009).
CONCLUSIONS

1. The protein content in FB, YF, and TB was higher than 20%, while that for L and MF were around 20%.
2. The concentration of sample required to reach the IC\textsubscript{50} value range was between 38 to 107 mg in dry basis.
3. The concentration of sample from \textit{Erythrina americana} required to reach the IC\textsubscript{50} value was high in comparison with other plants used in the medical area.
4. The TPC levels for L, YF, FB, and MF were higher than those reported for plants used for common consumption.
5. The drying process caused a decrease in TPC content.
6. The drying process resulted in an increase in the antioxidant activity of YF and MF.

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