INTRODUCTION

*Abelmoschus esculentus* is an important vegetable that is commonly found in various countries of the world (Muneerappa, 2018). The language which assigned it the name as *A. Esculentus* originates from the Niger-Congo group. In Twi language, nkuruma is the specific name of it (Sindhu and Puri, 2016). *Abelmoschus esculentus* has a wide potential range in earning crops of the foreign exchange crops countries. In India, its export is about 60% which accounts of fresh vegetables (Adelakun et al., 2017). In terms of nutritious matter, its dried seeds are used to make vegetable curds. It can be used as coffee preservative in roasted and ground form (Benchasri, 2011). In this process, sugar is being absorbed from the intestinal tract at the regular rate. The polysaccharides present in *A. Esculentus* possesses antifungal, anti-inflammatory, hepatoprotective, antidiabetic, antiulcer, anticancer, laxative, antihyperlipidemic and analgesic activities. In recent studies, some quercetin derivatives and well-known
antioxidants were also identified and separated from *A. esculentus*. The most nutritious part of *A. Esculentus* plant is the dried seeds. The oil of *A. Esculentus* seeds is eatable and its residual meal is rich in protein contents (Doreddula *et al.*, 2014).

**MATERIALS AND METHODS**

**Collection of Plant Materials**

Different parts of *Abelmoschus esculentus* i.e. leaves and seeds were obtained from the vicinity of Lahore Garrison University, Lahore, Pakistan.

**Pretreatment and Extraction of Bioactive Compounds**

Pretreatment and extraction of bioactive compounds by four solvent systems (100% methanol, 80% methanol, 100% ethanol and 80% ethanol) was done by following the method of Hassan *et al.* (2016).

**Phytochemical Studies of Medicinal Plant**

**Determination of Total Phenolic Contents (TPC)**

The method which was used to determine the Total phenolic contents of medicinal plant was based on the procedure of (Zafar *et al.*, 2016). Folin-Ciocalteu, a reagent that was used to to determine the phenolic contents.

**Determination of Total Flavonoid Contents (TFC)**

The procedure of Dewanto *et al.* (2002) was followed in order to determine the total flavonoid contents with minor changes.

**RESULTS AND DISCUSSION**

**Percentage Yield (g/100g DW) of Extracts**

The percentage yield of plant extracts is based on different factors like amount of solvent used, nature of plant and method of extraction (Hsu and Coupar, 2006). However, the nature of extracting solvent is most important for extract yields and resulting antioxidant abilities of the plant materials. So it is strongly dependent on the nature of solvent system used might be ascribed the presence of antioxidant compounds of different chemical characteristics and possessing different polarities i.e. may or may not be soluble in a particular solvent. Polar solvents are frequently employed for the recovery of polyphenols from a plant matrix. (Sultana *et al.*, 2009). Methanol is known as a better solvent due to the presence of antimicrobial and natural antioxidative components extracted from plants and are widely used (Vaghasiya and Chanda, 2007; Anwar *et al.*, 2010).

The extraction yields from leaves and seeds of *Abelmoschus esculentus* in different solvent systems are presented in Table 1. Comparatively, 80% methanol exhibited significantly ($p<0.05$) high extraction yields in leaves (38.1%). The extraction ability of different solvent systems for recovering extractable components from leaves followed the order: 80% methanol > 80% ethanol > absolute methanol > absolute ethanol. Yield extracts of seeds followed the order: 80% methanol > absolute methanol > 80% ethanol > absolute ethanol.

The higher extract yields obtained in the present study with 80% methanol were in good agreement with the previous findings of Shabir *et al.* (2011). Who reported the highest extract yield from *Moringa oleifera* leaves.
using 80% methanol (Fig. 1). Similarly, the maximum extract yields from different parts of medicinal plant were also obtained by using 80% methanol (Felhi et al., 2017). Moreover, Altemimí et al. (2017) also reported that highly polar solvents such as methanol possess high extraction ability of bioactive constituents.

Namvar et al. (2017) also investigated that the highest extraction yield was observed in 80% methanol (27.33%) as compared to extracts in other solvent systems. Similarly, Sultana et al. (2014) also determined that aqueous methanolic extract showed maximum percentage yield from various medicinal plant parts. This significant (P < 0.05) variation of percentage yield of extracts among various solvents and plant parts is might be ascribed to the availability of different extractable components in each part of plant as well as varied polarity of the solvents.

Table 1: Percentage Yield (g/100g DW) of Extracts of Abelmoschus esculentus Parts

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Solvent System</th>
<th>Percentage yield (g/100g DW)</th>
<th>Leaves</th>
<th>Seeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>80 % Methanol</td>
<td>38.1±0.52(^a)(_a)</td>
<td>28.4±0.46(^a)(_b)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>80 % Ethanol</td>
<td>35.7±0.43(^b)(_a)</td>
<td>26.0±0.34(^b)(_b)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>100 % Methanol</td>
<td>31.3±0.50(^c)(_a)</td>
<td>26.8±0.40(^b)(_b)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>100 % Ethanol</td>
<td>29.2±0.35(^d)(_a)</td>
<td>24.1±0.29(^c)(_b)</td>
<td></td>
</tr>
</tbody>
</table>

Values are mean ± SD of three samples analyzed individually in triplicate at \(p < 0.05\). Superscripts alphabets within the column depicted significant difference among different solvent system. Superscripts alphabets within the rows depicted significant difference among different plant parts.

Fig. 1: Percentage Yield (g/100g DW) of Extracts of Abelmoschus esculentus Parts
Phytochemical Analysis of *Abelmoschus esculentus*

**Total Phenolic Content**

In plants, phenolic compounds present that are considered to be the most important antioxidants (Sakihama et al., 2002). They play a vital role in scavenging free radical activity (Agbo et al., 2015). Scavenging activity of the potent free radical of phenolic compounds is due to the presence of their hydroxyl groups and it directly contributes to antioxidant potential (Wojdylo et al., 2007). *Abelmoschus esculentus* fruits are superior due to presence of phenolic compounds. Significantly, total phenolic level in *Abelmoschus esculentus*, increases with increasing the size of fruit (Olivera et al., 2012). Determination of total phenolic contents of natural products is based on Folin-Ciocalteu method. Its mechanism is based on oxidation and reduction reactions. In this reaction, the process of oxidation occur by Folin-Ciocalteu reagent (phosphomolybdic-phosphotungstic acid) that gives a coloured product having max yield at 765 nm (Alali et al., 2007). Gallic acid equivalent is used to express the results of total phenolics (Stankovic, 2011).

Phenolic contents results of the medicinal plant A.E are given in Table 2. Significantly (*p* <0.05) total phenolic content in seed sand leaves of *Abelmoschus esculentus* was found to be varied from 27.3-31.2 and 23.7-26.8 (mg GAE/g DW), respectively. It was investigated that maximum TPC were obtained from leaves in 80% methanolic extract followed by: absolute methanol>80% ethanol>absolute ethanol. It was revealed that maximum TPC were extracted from seeds in 80% methanol solvent system followed by: 80% ethanol> absolute methanol> absolute ethanol. Overall, results showed that the maximum phenolic contents were obtained from leaf extracts than that of seed extracts.

Our results are supported by the previous study of Butsat and Siriamornpun (2016) who reported that higher phenolic contents were obtained from 80% methanol, than 80% ethanol for plant extracts. Liao et al. (2012) also determined the phenolic contents in different parts of *Abelmoschus esculentus* of the methanol extracts. The maximum phenolic contents were obtained from the flower then from leaves and seeds of *Abelmoschus esculentus*. Namvar et al. (2017) examined that 80% methanolic extract was found to possess higher total phenolic contents than other extracts. Thus for extraction of phenolic compounds, aqueous methanolic solvent system is being used that is better and efficient solvent (Fig. 2).

**Table 2: Total Phenolic Contents (mg GAE/g DW) of *Abelmoschus esculentus* Leaves and Seeds**

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Solvent System</th>
<th>Total phenolic contents (mg GAE/g DW)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Leaves</td>
</tr>
<tr>
<td>1</td>
<td>80 % Methanol</td>
<td>31.2±0.56&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>2</td>
<td>80 % Ethanol</td>
<td>28.9±0.58&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>3</td>
<td>100 % Methanol</td>
<td>30.1±0.43&lt;sup&gt;ab&lt;/sup&gt;</td>
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<td>27.3±0.35&lt;sup&gt;c&lt;/sup&gt;</td>
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Values are mean ± SD of three samples analyzed individually in triplicate at *p* <0.05. Superscripts alphabets within the column depicted significant difference among different solvent system. Superscripts alphabets within the rows depicted significant difference among different plant parts.
Total Flavonoid Contents

Flavonoids are small molecular secondary metabolites produced by plants with several biochemical and antioxidant properties. Due to these properties, they are capable of participating in plant interactions with other organisms like insects, animals and other micro-organisms. Most of their functions are due to their strong antioxidative properties (Mierziak et al., 2014). One of the most important natural components that are found in plants are flavonoids. These components are considered as the polyphenolic compounds possessing many properties like inhibition of oxidative enzymes, free radical scavenging activity, anti-inflammatory action and inhibition of hydrolytic enzymes (Atanassova et al., 2011). *Abelmoschus esculentus* is found to be rich in flavonoids with anticancer, cardiovascular protection, lower blood sugar properties (Liu et al., 2017). The results of total flavonoid contents of present investigated medicinal plant parts are expressed as Catech in equivalent (CE) and given in Table 3. The values obtained for the concentration of flavonoids as expressed in mg CE/g DW. Flavonoid contents in leaves and seeds of medicinal plant varied from 39.2– 41.5 and 29.7–32.1(mg CE/g DW), respectively. It was revealed that total flavonoid contents of *Abelmoschus esculentus* leaves were significantly (*p* <0.05) higher in 80% ethanolic extract followed by: 80% methanol > absolute methanol > absolute ethanol. It was also found that maximum TFC were extracted from seeds in 80% methanol solvent system followed by: 80% ethanol > absolute methanol > absolute ethanol (Fig. 3).

Present outcomes are in consensus with the reported method of Ahiakpa et al. (2013) who described that total flavonoids in pods of *Abelmoschus esculentus* were observed to be higher in ethanolic extracts than in the aqueous and other extracts,
indicating that the ethanolic extraction system was more effective than the aqueous extraction system. It suggests that pods of *Abelmoschus esculentus* possesses the flavonoids which have more solubility in organic solvents than in aqueous solvent. Sajid *et al.* (2012), investigated that total flavonoids contents (24.6 mg/100 g quercet in equivalent) in aqueous methanolic extract of leaves of *P. pinnata*.

However, present results are not in contract with results of Nwachukwu *et al.*, (2014) who examined the higher TFCs (80 mg CE/g) in *Abelmoschus esculentus* leaves and relatively lower TFCs (0.07mgCE/g) in seeds than current study. Some environmental conditions like solvent system used for extraction, soil and other plant parts may cause the difference in flavonoid contents with present study.

Table 3: Total Flavonoid Contents (mg CE/g DW) of *Abelmoschus esculentus* Leaves and Seeds

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Solvent System</th>
<th>Total flavonoids contents (mg CE/g DW)</th>
<th>Leaves</th>
<th>Seeds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>1</td>
<td>80 % Methanol</td>
<td>40.5±0.56&lt;sup&gt;c&lt;/sup&gt;</td>
<td>32.1±0.43&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>80 % Ethanol</td>
<td>41.8±0.58&lt;sup&gt;a&lt;/sup&gt;</td>
<td>31.7±0.55&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>100 % Methanol</td>
<td>39.7±0.43&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>31.2±0.39&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>100 % Ethanol</td>
<td>39.2±0.35&lt;sup&gt;b&lt;/sup&gt;</td>
<td>29.7±0.50&lt;sup&gt;b&lt;/sup&gt;</td>
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![Fig. 3: Total Flavonoid Contents (mg CE/g DW) of *Abelmoschus esculentus* Leaves and Seeds](image)

*Fig. 3: Total Flavonoid Contents (mg CE/g DW) of *Abelmoschus esculentus* Leaves and Seeds*
CONCLUSION

Phenolics and flavonoids are known to act as antioxidant and different extracts from *Abelmoschus esculentus* showed good phytochemical constituents. Therefore, supplementing a balanced diet with *Abelmoschus esculentus* extracts may provide health-promoting effects. It will also be important to study the synergistic effect of different phenolic compounds contained in *Abelmoschus esculentus* extracts.

REFERENCES


Evaluation of A. esculentus Extracts

increasing total antioxidant activity J Agri Food Chem. 50 (10): 3010-3014.


