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Effect of Dehydration Techniques over the Morpho-Physiological Characters in African Marigold (*Tagetes erecta* L.)

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A B S T R A C T

The influence of different drying methods on biochemical properties and visual characters of African marigold (*Tagetes erecta* L.) cultivar "Seracole", was carried out. The petals of marigold flowers were dried by five different methods viz. sun drying, shade drying, oven drying, cabinet drying and infrared drying. The biochemical constituents were analyzed on total chlorophyll (mg.g^{-1}f.w), lycopene (mg/100g sample) and total phenols (mg of GAE/g). Infrared dried petals exhibit a high yield of total chlorophyll ($T_{11;}$ 0.120 mg.g^{-1} f.w) and lycopene ($T_{10;}$ 55.92 mg/100g sample) followed by sun drying ($T_{0;}$ 0.060 mg.g^{-1} f.w and $T_{0;}$ 41.17 mg/100g sample respectively). Highest content of total phenol was found in cabinet drying ($T_{6;}$ 56.33 mg of GAE/g), whereas minimum total phenol were found in Sun drying ($T_{0;}$ 44.29 mg of GAE/g). There was found to be significant increase in overall infrared dried samples retained better biochemical properties than other drying methods.

Introduction

African marigold (*Tagetes erecta* L.) is one of most important flowers belongs to the family of Asteraceae, which grows in warm, temperate and Mediterranean region. The pharmacological activities of marigold are related to the content of several classes of secondary metabolites. New researches and reviews concerning the composition and nutritional value of edible flowers are also important and represent a sufficient reason for their consumption (Koike *et al.*, 2015). The edible flowers reveal as pharmacological resource possessing the following properties - antianxiety, anticancer, antidiabetic, anti-inflammatory, anti-oxidant, diuretic, anthelmintic, immunomodulatory, antimicrobial along with its effective dosage (Rigane *et al.*, 2013). A recent study reveals that flowers with higher total phenolics content are *Antigonon leptopus*, *Bougainvillea glabra*, *Tagetes erecta*, *Cosmos sulphureus*, *Prunus mume* and *Sophora viciifolia* with values >100 mg/g dw (Cavaiuolo *et al.*, 2013). Many studies have reported that phenolic compounds possess other biological activities such as anti-inflammatory, antiulcer, antispasmodic, antisecretory, antiviral, antidiarrhoeal, antitumor, etc. (Carlo *et al.*, 1999).

Drying is an important process for handling raw materials in order to prolong shelf life, as the drying process inhibits enzymatic degradation and limits microbial growth

(Ahrne´ *et al.*, 2007). Far-infrared radiation (FIR) has been reported to be successfully applied in the drying of foods (Sandu, 1986) and agricultural products since the main components of these products have their principal absorption bands in the far-infrared region (Meeso, 2008). Unlike hot air drying, FIR generates internal heating through molecular vibration of the material, bringing about excited vibration when molecules absorb the radiation of certain wavelengths and energy (Sandu, 1986). Fresh petals contain biochemicals as well as dried petals. Keeping the fresh petals for longer period is problematic due to higher moisture content which accelerates the multiplication of fungal growth. Hence, studies were carried out to identify the most suitable drying methods for maximum recovery of biochemical properties for African marigold (*T. erecta*).

Materials and Methods

The experiment was conducted at Department of Floriculture and Landscaping, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India in 2016 to 2017. African marigold (*Tagetes erecta* L.) flower specially "Seracole" variety was collected from Mondouri farm, BCKV. Besides the laboratory studies were carried out at Dept. of Floriculture and Landscaping laboratory, BCKV. Total Chlorophyll content were measured by DMSO {Dimethyl sulfoxide, $(CH_3)_2SO_4$} method and calculated using following formula.

$$\text{Total Chlorophyll (mg.g}^{-1}\text{f.w)} = \frac{(20.07 \times \text{OD 645 nm}) + (8.02 \times *\text{OD 663 nm}) \times \text{volume} \times \text{dilution}}{1000 \times \text{weight of sample}}$$

*Optical Density

For lycopene analysis, the dried flower **s**ample (1.0-1.5 g powder) was extracted with 10mL acetone-petroleum ether (50% v/v). The upper lycopene-containing organic layer was removed by means of a pipette and collected in test tube. Extraction was repeated. The extracts were combined, washed with 15mL saturated aqueous sodium chloride (NaCl) and removed the aqueous wash with a micropipette. The extract was washed with 10mL of 10% aqueous potassium carbonate (K_2CO_3) and removed the aqueous wash. The lycopene-containing organic layer was dried with a drying agent (calcium chloride). The excess solvent was allowed to evaporate at room temperature for a few minutes in the dark. The tubes containing lycopene extracts were covered with aluminium foil and stored in freezer until further analysis (Shahzad *et al.*, 2014). The samples were read at 503 nm in UV-VIS spectrophotometer (VARIAN CARY®, USA) and the calculated using following formula.

$$\text{Lycopene (mg/100g sample)} = \frac{3.1206 \times \text{OD at 503 nm} \times \text{volume made up} \times \text{dilution} \times 100}{1000 \times \text{weight of sample}}$$

The total phenolic content (TPC) was determined using the Folin–Ciocalteu reagent according to Stintzing *et al.*, with some modifications. Basically, 5 g sample was taken and extracted with 20 ml ethanol (80%) using homogenizer (POLYTRON® PT 1600 E). Then it was centrifuged (SIGMA 3K30, UK) at 10,000 rpm for 15 min at 4°C. The supernatant was stored at - 20°C. 100 µl sample was taken and the volume was made up to 3 ml by adding 2.9 ml distilled water in a test tube.

0.5 ml Folin ciocaltcu's reagent was added and after 3 min, 2 ml of 20% sodium carbonate was added and filtered it. The test tube was then placed in boiling water for 1 min. After boiling, it was cooled and volume was increased 10 times by adding water. Then it was observed at 750 nm against reagent blank. The measurements were compared to a standard curve of prepared Gallic acid (GA)

solution, and the total phenolic content was expressed as milligrams of Gallic acid equivalents (GAE) per gram of dry weight.

For Estimation of colour, the dried petals from each drier were analyzed with RHS colour chart (Royal Horticultural Society, Great Britain).

The experimental data collected from four different types of drying methods were subjected to the statistical analysis appropriate to completely randomized designs (CRD). The critical difference between the entries was at 5% level of significance.

Results and Discussion

A significant and wide variation was recorded for anti-oxidants in dried marigold petal extract of twelve treatments (Table 1). The biochemical estimation revealed that the petal extract of T_{11} contained highest chlorophyll (0.120 mg g^{-1} f.w) followed by T_{10} (0.119 mg g^{-1}f.w) and T_9 (0.113 mg g^{-1} f.w); the lowest were exhibited by the T_0 (0.060 mg g^{-1}f.w), T_1 (0.061 mg g^{-1}f.w) and T_2 (0.061 mg g^{-1}f.w). Petrova *et al.,* (2016) reported that among the investigated flowers samples *Geranium macrorrhizum* L. 95 % ethanol extracts were evaluated as the richest source of total chlorophylls (41.5 µg/g f.w) followed by *Tagetes erecta* L. (23.6 µg/g f.w), *Calendula officinalis* L. (22.5 µg/g f.w) and *Helianthus tuberosus* L. (0.5 µg/g f.w).

The distributed estimation revealed the maximum lycopene concentration was recorded in T_{10} (55.92 mg/100g sample) and T_6 (55.64 mg/100g sample); the lowest lycopene was exhibited by the T_0 (41.17 mg/100g sample). Near about similar results had been reported by Siriamornpun *et al.,* (2012). They evaluated the sample of *Tagetes erecta* L. from FIR-HA drying and found highest amount lycopene (58.7 mg/100 g DW) (Increased by 54% compared to fresh materials) followed by the HA and FD samples with concentrations of 51.2 and 48.7 mg/100 g DW respectively.

Table.1 Treatments of sun drying, shade drying, oven drying, cabinet drying and infrared drying

Treatments	Types of drying	Conditions of drying
T_0	Sun drying	February (30˚C + 70% RH + 10 days)
T_1	Shade drying	February (22˚C + 65% RH + 15 days)
T_2	Shade drying	December (19˚C + 65% RH + 15 days)
T_3	Oven drying	60˚C + 4 hours + 30% RH
T_4	Oven drying	60˚C + 6 hours + 30% RH
T_5	Oven drying	60˚C + 8 hours + 30% RH
T_6	Cabinet drying	55˚C + 2 hours + 70% RH
T_7	Cabinet drying	55˚C + 4 hours + 70% RH
T_8	Cabinet drying	55˚C + 6 hours + 70% RH
T_9	Infrared drying	50˚C + 1 hour + 70% RH
T_{10}	Infrared drying	50˚C + 2 hours + 70% RH
T_{11}	Infrared drying	50˚C + 3 hours + 70% RH

Table.2 Total chlorophyll, Lycopene and Total phenol content in Different types of drying methods

Treatments	Total Chlorophyll (mg. g^{-1}f.w)	Lycopene (mg/100g sample)	Total phenol (mg of GAE/g)
T_0	0.060	41.17	44.29
T_1	0.061	46.23	46.40
T_2	0.061	47.68	46.58
T_3	0.063	53.60	55.92
T_4	0.090	54.23	54.49
T_5	0.087	55.46	53.51
T_6	0.069	55.64	56.33
T_7	0.084	53.42	55.40
T_8	0.083	50.53	54.71
T_9	0.113	50.75	53.19
T_{10}	0.119	55.92	52.82
T_{11}	0.120	50.50	52.46
SEm (±)	0.00016	0.523	0.194
CD (5%)	0.00047	1.540	0.571

Table.3 RHS colour chart with different dried flower samples

Types of drying	RHS colour chart
Sun dried samples	Brown orange (RSH 171B) + Orange brown (RHS 170A)
Shade dried samples	Brown orange (RHS 171B) + Orange brown (RHS 170A)
Oven dried samples	Brown orange (RHS 171B) + Brown orange (RHS 169C)
Cabinet dried samples	Brown orange (RHS 171B) + Brown orange (RHS 169C)
Infrared dried samples	Red brown (RHS 172A) + Brown orange (RHS 171B)

Phenols are produced in response to certain pathogen and are considered essential for the growth and reproduction of plants. In Table 2 shows that total phenol content decreased significantly in dried samples as compared to fresh samples. The cabinet drying viz. T_6 (55˚C for 2 hours with 30% RH) gave 56.33 mg of GAE/g (max.) followed by T_3 (55.92 mg of GAE/g) and T_7 (55.40 mg of GAE/g), whereas minimum was recorded in T_0 (44.29 mg of GAE/g). Ahluwalia *et al.,* (2014) reported the total phenol content in Pusa Basanti was 109.4 mg GAE/g in fresh which decreased to 20.2 mg GAE/g in vacuum dried, 16.63 mg GAE/g in cabinet dried 45.8 mg GAE/g in fan dried, 47.4 mg GAE/g in solar dried sample. In Pusa Narangi the value for total phenol content for fresh sample was 112.2 mg GAE/g which decreased to 71.6 mg GAE/g for vacuum dried, 60.8 mg GAE/g for cabinet dried 46.4 mg GAE/g for fan dried, 45 mg GAE/g for solar dried sample.

The results for colour parameters in different dried petals were presented in Table 3. From the observation results, brown orange (RSH 171B) and orange brown (RHS 170A) colour were found in sun dried samples. The shade drying samples also gave brown orange (RSH 171B) and orange brown (RHS 170A) colour. The oven and cabinet dried samples were closely related in terms of colour (brown orange; RHS

171B and brown orange; RHS 169C). Whereas infrared dried samples had shown red brown (RHS 172A) and brown orange (RHS 171B) colour.

The results revealed that the infrared drying gave the best results from the preservation of quality with respect to chemical and functional constituents' point of view.

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