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Proximate Chemical Composition and Extraction of Essential Oil from Different Commonly Grown Gourd Fruits

Roshanlal Yadav[1], Baljeet S. Yadav[2]*
[1,2]Department of Food Technology, Maharshi Dayanand University, Rohtak, Haryana, India

Abstract: This study examines the proximate chemical composition and essential oil extraction from seven commonly grown gourd fruits in Northern India, including *Momordica charantia, Lagenaria siceraria, Luffa acutangula, Luffa cylindrica, Trichosanthes dioica, Cucurbita maxima* and *Cucurbita pepo*. Standard AOAC methods were used to analyze moisture, ash, crude protein, lipid, fiber, and carbohydrate content. Significant variation was observed among the species, with *C. pepo* and *L. siceraria* showing the highest protein and fiber content, respectively. Essential oils were extracted using methanol, ethanol and butanol, with methanol and ethanol yielding higher extraction efficiencies. Carbohydrates showed a positive correlation with oil yield, while protein and moisture had negative correlations. These results highlight the nutritional richness of gourds and the influence of chemical composition and solvent choice on essential oil extraction.

Keywords: Proximate Composition, Gourd Family, Crude Protein, Crude Fibre, Essential Oil

INTRODUCTION

The Gourd family is a distinct family without any close relative. This family contains 121 genera and about 1760 species; most of the species are climbers or trailing herbs, usually with tendrils, and are rarely shrubs or trees [1]. Gourd or cucurbitaceae are usually hairy climbers with simple or branched tendrils, yellow or whitish unisexual flowers, inferior ovary with parietal placenta and numerous relatively large seeds [2]. They are considered to be Asian origin and probably originated in the Late Cretaceous some 60 million years ago [3]. These plants are cultivated in tropical and subtropical regions with hotspots in South Asia, West Africa, Madagascar and Mexico. The principal fruit species into Gourd family are bitter gourd (*Momordica charantia*), bottle gourd (*Lagenaria siceraria*), ridge gourd (*Luffa acutangula*), sponge gourd (*Luffa cylindrica*), pointed gourd (*Trichosanthes dioica*), pumpkin (*Cucurbita maxima*) and summer squash (*Cucurbita pepo*). The gourd ftruits are considered as common men vegetables having traditional impotence in Indian Ayurveda since ancient times. The medicinal usefulness of these fruits are due to the presence of bioactive constituents such as amino acids, alkaloids, flavonoids, sterols, terpenoids, saponins, cucurbitacins aglycones and phenyl amines [4]. Cucurbitaceae fruits are unique in nature having composition of the entire essential constituents required for good health [5]. Among healthy plant foods, with health benefits crops from the family gourd (also known as Cucurbitaceae) have the focus of numerous epidemiological and clinical studies [6]. Gourd fruits, in particular those included into the order cucurbitals are good source of a variety of nutrients and heath promoting phytochemicals [7]. Gourd fruits such as *L. siceraria, L. cylindrica, Luffa acutangula* and *Cucurbita pepo* have been reported for the presence of secondary metabolites such as alkaloids, flavonoids, glycosides, steroids and saponins, which possess antioxidant activity [8]. Cucurbitacins mainly found in the cucurbitace family, having great interest because of the wide range of biological activities like antioxidants, anti-inflammatory and inhibit the proliferation of cancer cells [9]. Some cucurbits have ribosome inactivation proteins (RIPs), which are well known for the selection of biological activities and possess antiviral, antitumor, and immunomodulatory activities [10]. Bases upon these facts, the proximate chemical composition of commonly cultivated gourd fruits in northern India are investigated in this study; moreover the effect of different solvents on extraction of essential oils was also studied.

MATERIALS AND METHOD

Freshly harvested fruits of gourd family namely bitter gourd (*Momordica charantia*), bottle gourd (*Lagenaria siceraria*), ridge gourd (*Luffa acutangula*), sponge gourd (*Luffa cylindrica*), pointed gourd (*Trichosanthes dioica*), pumpkin (*Cucurbita maxima*) and summer squash (*Cucurbita pepo*) (Figure 1) were purchased from the local market in Rohtak during the month of June. All the chemicals and reagents used in the present study were of analytical grade with high purity and all were purchased from Himedia (India).

The proximate chemical compositions of all the samples were determined by using the standard methods of analysis approved by the Association of Official Analytical Chemists, 1990 [11]. The moisture, total ash, acid insoluble ash, crude fibre, crude protein, crude lipids were analysed and the procedures are described below:

Bitter gourd (*Mamordica charantia*)

Bottle gourd (*Lagenaria siceraria*)

Sponge gourd (*Luffa cylindrica*)

Ridge gourd (*Luffa acutangula*)

Pointed gourd (*Trichosanthese dioica*)

Pumpkin (*Cucurbita maxima*)

Summer squash (*Cucurbita pepo*)

Figure 1. Gourd fruits selected for the study

Moisture Estimation

Exactly 10 g (dwb) of all gourd sample were placed in a hot air convection oven at 105^{o}C for 6 hours. On cooling, the sample was weighed and the weight loss was recorded by using the following equation.

$$\text{Moisture content \%} = \frac{(B-A) - (C-A)}{(B-A)} \times 100$$

Where A = weight of clean dry petriplate (g); B = weight of petriplate + wet sample (g); C = weight of petriplate + dry sample (g).

Determination of Crude Protein

Ground sample of 1 g (dwb) was placed in a Kjeldahl digestion flask containing 1.5 g CuSO4, 1.5 g of Na2SO4 and 20 ml of concentrated H2SO4. The flask was placed on an electric heater, boiled and allowed to stand until the solution became clear. On cooling, 90 ml distilled water and 2 g of Na2SO4 was added, stirred and allowed to stand until a green colouration was observed. To aid the formation of two layers, few glass bead and 80 ml of 40% NaOH solution was added to the flask and further distillate. The distillate was then titrated against 0.1 M HCl until the solution changed from blue to reddish brown. Finally, the total nitrogen and crude protein was calculated by using following equations.

Total Nitrogen % =100 (A X B/C) X 0.014
Crude protein (%) = Total nitrogen in sample X 6.25
Where A = volume of acid used in the titration (ml); B = concentration of acid; C = weight of the sample (1 g); 6.25 = conversion factor (equivalent to 0.16 g nitrogen per gram of protein).

Crude Lipid Estimation

The ground sample (5g) was placed in an extraction thimble of a Soxhlet extractor containing petroleum ether (40-60 oC) and placed in the extraction unit. This was heated with refluxing for 6 hours. Thereafter, the petroleum ether was evaporated in a drying oven and the retained lipids was weighed and recorded as percent crude lipid.

Determination of Crude Fibre

The defatted sample (10g) was placed in a flask containing 200 ml of 1.25% H2SO4, boiled for 30 minutes and filtered. The residue was washed with hot water and transferred to a flask containing 200 ml of warm 1.25% NaOH solution and reheated for another 30 minutes. The resulting solution was filtered with boiling water, 1 M of HCl solution, boiling water again and petroleum ether. A crucible was dried in the oven and weighed. The crucible with the residue was weighed and placed in a furnace at 550^{o}C for 1 hour. On cooling, the crucible was weighed again and the weight loss was recorded as the crude fibre content of the sample.

Determination of Total Ash

Total ash content was measured by igniting 10 g of the dried samples in a muffle furnace at 500^{o}C for 4 hours. The difference in weight served as the ash content and the result was expressed as % total ash.

$$\text{Total ash (\%)} = \frac{(W2 - W1)}{W} \times 100$$

Where W = Total weight of sample; W1= Weight of empty crucible; W2 = Weight of crucible with ash (after igniting)

Estimation of Acid Insoluble Ash

The ash in the dish was treated with 25 mL of dilute hydrochloric acid, covered with a watch glass, and heated on a water bath for 10 minutes. After cooling, the contents were filtered through ash-less whatman filter paper (No. 42). It was then ignited in a muffle furnace at 550°C until a white or grey ash was obtained. The filtrate was dried in an oven at 103±2°C for 30 minutes, cooled in a desiccator, and weighed. To ensure it was free from chloride or acid, a few drops of 2M nitric acid and 0.1M silver nitrate solution were added; no precipitate or turbidity was observed. Finally the acid insoluble ash content was determined by following equation.

$$\text{Acid Insoluble Ash (\%)} = \frac{(W2 - W)}{W1 - W} \times 100$$

Where, W2 = weight in g of dish with the acid insoluble ash W =Weight in g of empty dish W1 =Weight in g of the dish with the dried material.

Total Carbohydrate Content Estimation

Available carbohydrate content in all the samples were determined by difference method after subtracting the moisture content, total lipid, crude protein, ash, acid insoluble ash and crude fibre values from 100 as given below:
Carbohydrate (%) = 100 – (a + b + c + d + e + f)
Where a = total moisture content (fwb), b= total crude lipid, c= amount of crude protein, d = ash, e= acid insoluble ash, f= crude fibre.

Extraction of Essential Oil

All the fruit samples were minced using waring blender. After blending, macerates were extracted in 400 ml of absolute methanol, ethanol and n-butanol separately for 6 days at room temperature with intermediate shaking. The extracts

were filtered through muslin cloth, centrifuged (9800 g for 5 min.) and then filtered through filter paper (whatman No.1). The filtrate was concentrated using rotary evaporator at 45^0C under reduced pressure (97.3 kPa) until the weight became constant and result was expressed as % yield.

RESULT AND DISCUSSION

Proximate Chemical Composition

The proximate analysis was carried out to determine the complex nature of the particular fruit. The proximate analysis estimates the chemical constituents present in the food samples. The present study revealed the quantitative differences in various chemical constituents among the various selected gourd fruits. The results of the proximate analysis of selected gourd fruits are presented in Table 1. The moisture content of all the selected gourd fruit ranged from 8.9 to 14.7 g/100 g (dwb) and being maximum in *C. pepo* and minimum in *T. dioica*. The results showed that total ash and acid insoluble ash content varied from 5.5 to 8.9 g /100 g (dwb) and 1.4 to 2.6 g /100 g (dwb) respectively with less amount estimated in the *L. cylindrica*. The crude protein content varied from 9.1 to 22.8 g /100 g (dwb) in the selected fruits and a significantly ($p<0.05$) higher concentration was estimated in *C. pepo* in comparison to other fruits. The crude fat analysis showed that fruits were deficient in fat content and the fat content in *L. acutangula* and *C. maxima* (2.9 g /100 g dwb) was higher than the rest of the studied fruits. The crude fiber content in *L. siceraria* was reported as 24.0 g /100 g (dwb) and its concentration was significantly higher ($p<0.05$) than the rest of the selected fruits. The carbohydrate content as measured by difference method ranged from 35.9 to 63.6 g/100g (dwb) and it was found maximum in *T. dioica*, whereas its minimum concentration was reported in *L. siceraria*.

As the most of the part in fruits is water, therefore, more than 85% (fwb) moisture was observed in all the selected gourd fruits and this is in agreement with the previous studies, which show moisture content more than 90% in gourd vegetables [12, 13, 14].

Table 1. Proximate chemical composition of different gourd fruit (g/100g of dry weight of fruit)

Crops	Moisture	Ash	AIA	Crude Protein	Crude Lipid	Crude Fibre	Carbohydrate*
M. charantia	12.8 ± 0.07^{c}	5.7 ± 0.10^{ab}	1.8 ± 0.20^{ab}	16.3 ± 0.58^{c}	2.6 ± 0.06^{b}	11.0 ± 1.00^{c}	49.7 ± 0.56^{c}
L. siceraria	9.6 ± 0.52^{ab}	8.7 ± 0.22^{cd}	2.6 ± 0.13^{c}	17.4 ± 1.04^{cd}	1.7 ± 0.12^{a}	24.0 ± 1.00^{e}	35.9 ± 2.50^{a}
L. cylindrica	14.2 ± 0.91^{c}	5.5 ± 0.09^{a}	1.4 ± 0.19^{a}	18.2 ± 0.91^{d}	2.7 ± 0.07^{bc}	8.9 ± 0.12^{b}	49.1 ± 1.15^{c}
L. acutangula	10.3 ± 1.02^{ab}	7.9 ± 0.06^{c}	2.2 ± 0.25^{bc}	14.4 ± 0.56^{b}	2.9 ± 0.10^{c}	13.8 ± 0.28^{d}	48.3 ± 0.86^{c}
T. dioica	8.9 ± 0.71^{a}	5.7 ± 0.17^{ab}	2.2 ± 0.12^{bc}	9.1 ± 0.05^{a}	2.6 ± 0.03^{b}	7.9 ± 0.06^{b}	63.6 ± 0.87^{d}
C. maxima	12.9 ± 0.84^{c}	8.9 ± 0.52^{d}	1.5 ± 0.10^{a}	20.1 ± 0.04^{e}	2.9 ± 0.10^{c}	5.2 ± 0.25^{a}	48.4 ± 0.76^{c}
C. pepo	14.7 ± 0.54^{c}	6.2 ± 0.25^{b}	$2.2\pm0.25b^{c}$	22.8 ± 0.63^{f}	1.7 ± 0.10^{a}	9.20 ± 0.75^{b}	43.0 ± 0.79^{b}

Values are presented as mean ±SD (n=3) and referred to the dry weight.

Means in the same column with different letters are significantly different ($p < 0.05$)

*Difference method

AIA- Acid insoluble ash

Excluding the water these fruits are the good source of carbohydrates, proteins and fiber, but a poor source of ash and fat contents. The ash content of the fruits is the measure of their mineral content [15]. Ash content ranging from 5.5 to 8.9 g/100g (dwb) in the gourd fruits observed in the present study was in agreement with the previous study reporting ash content in *M. charantia* and *L. acutangula* were 8.9 and 8.0 g/100g (dwb) respectively [16]. Bello *et al.* [17] reported the mineral contents present in the gourds in order of Na > Ca > Fe > Zn > K > Mn, with sodium being the most abundant mineral found in the fruits. The protein and crude fiber contents of the gourds ranged from 9.1 to 22.8 and 5.2 to 24.0 g/100g (dwb) respectively and the comparable values of the protein and fat content in gourds have been reported by Kochhar *et al.* [14] and Hussain *et al.* [16]. Protein is essential component of diet needed for survival of human beings. Its basic function is to supply adequate amounts of required amino acids for nutrition [18]. The crude fibres have been regarded as a bioactive compound with functional properties and worked as nutraceuticals that enhances human physiological performance by preventing or treating diseases and disorders [19]. They undergo fermentation in the digestive tract and accelerate bowel movements, reduce cholesterol synthesis and absorption, increase mineral absorption, improve the antioxidative defence system and help to prevent some disorders such as constipation and colorectal cancer [20]. The crude fat contents of the gourds were typically low (less than 3g/100g). This is an advantage as consumption of high fat diet has been implicated in several health related complications. Thus, the gourd fruits might be suitable for those requiring low fat diet.

Yield of Essential Oil

The recovery of essential oil from plant materials is usually proficient through various extraction techniques because of the uneven distribution and different chemistry of the antioxidant compounds in the plant matrix. The soluble and

insoluble phenolics have different diffusion pattern in the plant matrix [21]. Therefore, it is hard to select an appropriate solvent for the extraction of phenolic compounds from the test samples. In this study, three solvents namely methanol, ethanol and butanol have been used for the extraction of phenolic compounds from gourd fruits. The yield of essential oil extracted from different raw gourd fruits are depicted in Figure 2. Three extracting solvents namely methanol, ethanol and butanol were evaluated for their effectiveness to extract phytochemicals from raw fruit. The extraction yield was also considerably affected by the solvent.

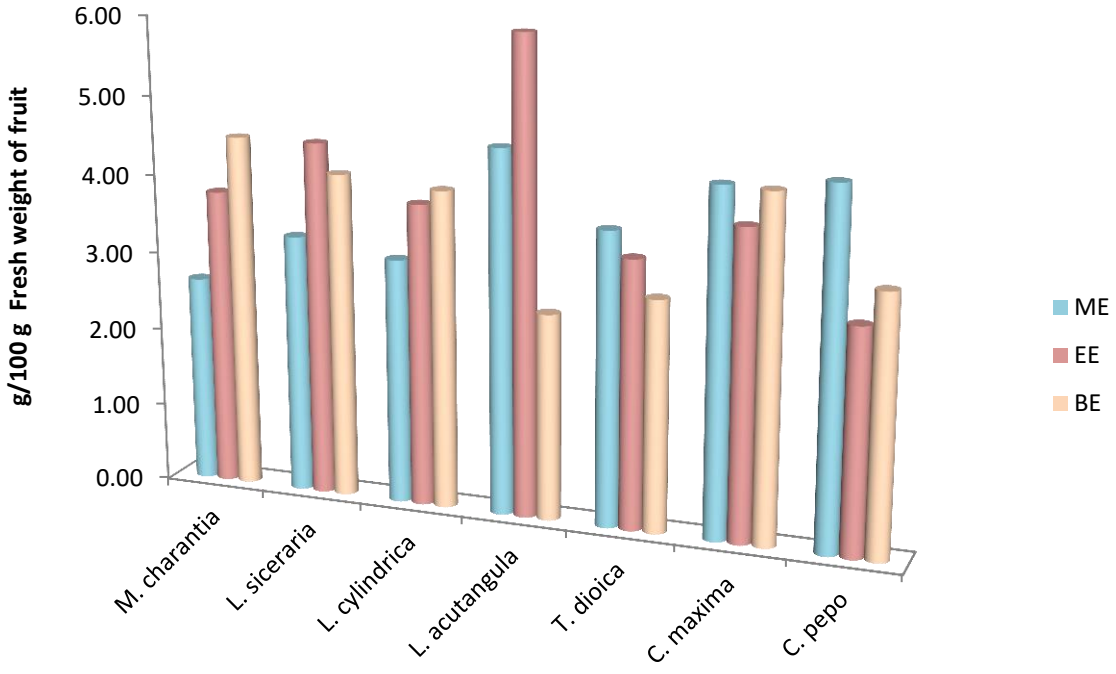

Figure 2. Yield of essential oil in different gourd fruits (ME- methanolic extract; EE- ethanolic extract; BE- butanolic extract)

However, this effect of extraction solvent on the extraction yield varied among different crops. Methanol solvent was observed most effective in extraction of essential oil in case of *T. dioica*, *C. pepo* and *C. pepo*; ethanol was most effective solvent in case of *L. siceraria, L. acutangula* and *L. cylindrica*, whereas butanol was effective in case of *M. charantia* and *L. cylindrica* in extracting out the plant essential oil. The wide variation in the essential oil yields from the tested gourd fruits in the present study might be attributed to the diverse availability of extractable components, resulting from the varied chemical composition and structure of plant matrix [22]. Therefore, the low yield of *M. charantia* extracts may be due to the presence of high crude fiber content. The extraction yield is also correlated with the plant cell wall separation caused by pectinase and cellulase, although the latter did not cause the degradation of polysaccharide. Amongst other contributing factors, the efficiency of the extracting solvent to dissolve endogenous compounds might also be very important [23; 24]. Most of the samples in the present study have higher extraction yield in ME and EE as compared to BE. This may be due to the fact that butanol has a lower polarity index and higher viscosity as compared to the methanol and ethanol, which makes it less efficient in regards to the extraction yield [25]. This indicated the possible influence of extracting solvent on total phenolic contents.

The correlation between proximate composition and yield of essential oil as presented in Table 2 indicate that carbohydrates present in the fruits are strongly and positively related with the extraction power of essential oils, whereas crude protein and moisture are negatively related with extraction of essential oil from all the selected gourd fruits.

Table 2. Correlation between proximate composition and yield of essential oils

Chemical components	Correlation with yield
Moisture	-0.780
Total Ash	-0.295

Acid Insoluble Ash	0.262
Crude Protein	-0.995
Crude Lipid	0.340
Crude Fibre	0.060
Carbohydrates	0.714

CONCLUSIONS

Gourd fruits from the *Cucurbitaceae* family exhibit diverse and valuable nutritional profiles, making them important components of a healthy diet. The study confirms that these fruits are low in fat and rich in protein, fibre and carbohydrates, with significant variation between species. Moreover, the choice of solvent plays a crucial role in the efficiency of essential oil extraction, with methanol and ethanol proving most effective. The positive correlation between carbohydrate content and extraction yield suggests that nutrient composition influences oil recovery potential. These findings can guide the selection of gourd types and solvents for nutraceutical and food processing applications, supporting their traditional and functional use in dietary and medicinal systems.

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