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Ecophysiological Responses of Three Species of *Acacia*

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Abstract

Three species of *Acacia* (*A .gerrardii, A. oerfota and A. origena*) were evaluated for their ecophysiological behavior characteristics. Succulent, pigments contents, minerals and some metabolic products were determined. The obtained data clearly showed highest value of succulent (9.6%) in case of *A. gerrardii*. Concerning pigments contents, current investigation revealed high contents of both chlorophyll a (1.72) mg/g fresh weight and carotenoids (0.67) mg/g fresh weight in *A. gerrardii* as compared to the other two species. The obtained data recorded high content in chlorophyll b (1.36) mg/g fresh weight in *A. oerfota* as compared to other species. With regard to mineral composition, the obtained data show that the highest mineral percent was Calcium (3.8%) which detected in *A. gerrardii* followed by Potassium and Magnesium. Generally, *A. gerrardii* recorded highest percentages of all detected minerals. As regard to metabolic products, *A. origena* shows highest contents of total carbohydrates (46.47%) as well as total lipids (4.83%) as compared to the other species, while the highest crude protein value (34.77%) was recorded in *A. gerrardii*.

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INTRODUCTION

The Leguminosae forms the third largest plant family in the world, comprising about 650 genera and 18000 species [1]. *Acacia* is the most significant genus of the subfamily Mimosoideae. It is estimated that there are roughly 1380 species of *Acacia* worldwide [2]. *Acacia* is effective when used as a coating on pills to make the bitterness easier to swallow or digest. It is important for food industry as a flavor, fixative and emulsifier. This plant has been used in traditional medicine to treat high cholesterol, cancer, diabetes, mouth sores and indigestion in children [3]. Its germinated seeds are eaten after cooking. Its leaves, tender shoots and pods are readily consumed by goats, sheep and cattle. *Acacia* bark has a foul smell and its fibers are used to make fish nets and rough rope. The bark yields water soluble gum of fair quality [4] which is used as emulsifying agent. Bark is used for purification and preparation of dyes as well as against snake bites [5,6]. The seed sprouts are consumed as a vegetable in some parts of Indonesia. *Acacia* is a good reforestation plant for poor soils in low rainfall areas [7]. The leaves are believed to possess antimicrobial effects while the gums have demulscent properties [8]. Many investigations were carried out on nutritional value of some wild plants [9-22]. Eco-physiological Studies on some *Acacia* species are still lacking. Thus, extensive work has been done to evaluate some ecological as well as physiological parameters of some *Acacia* species. The aim of this research was to determine succulent percentage, photosynthetic pigments, minerals (Mg, P, K, and Ca) total carbohydrates, crude protein and total lipids) of three species of *Acacia* (*A. girrardii, A. oerfota and A. origena*).

MATERIALS AND METHODS

The plant materials of *Acacia* species were collected, during the flowering stage, from selected plants growing naturally in their habitats. Materials were collected from three localities in Al Baha region in Kingdom of Saudi Arabia.

Succulence degree

The percentage of leaf succulence (LS) was determined according to Holbrook and Putz using leaf fresh and dry weight ratio (FW/DW) [23].

Colorimetric photosynthetic pigments determination

Pigments were extracted using pure acetone according to Fadeel [24]. The optical density of extracted pigments was measured calorimetrically at 665, 649 and 445 nm for chlorophyll a, chlorophyll b and carotenoids, respectively. The chlorophyll and carotenoids content (referred as mg/g fresh weight) were calculated according to Cherry [25].

Minerals contents

The collected plant materials were washed then dried in an electric oven at 80°C to constant weight. The dried materials were ground to fine powder then analyzed. After acid digestion (a mixture of 2 nitric acid/1 perchloric acid), the samples were used for elemental analysis. The analytical estimation of Potassium was carried out by (Flame Photometer Model-EEL). An atomic absorption spectrometer, ICP-MS (Inductively Coupled Plasma-Mss Spectrometer): NexION 300D (Perkin Elmer, USA), was used

to measure Calcium and Magnesium. Phosphorus was determined by the Phospho vanado molybdate method [26]. The ICP-MS calibration was carried out by external blank solutions. High purity water obtained from Millipore Milli-Q water purification system.

Metabolic products determination

Total carbohydrates: Total carbohydrates were estimated according to Yemm and Willis using spectrophotometer (Jenway 7305, Cole Parmer, Staffordshire, UK) [27].

Crude proteins: Crude protein was determined using Kjeldahl method (A.O.A.C) [28].

Total lipids: Known weight of the dried plant powder was extracted using petroleum ether (40-60°C): ether (1:1) for 24 hrs using Soxhelt [29] (A.O.A.C). The lipid content was obtained by distilling off the solvent.

Statistical analysis of data

Results were expressed as mean values (±) standard deviations of three replicates for each experiment.

RESULTS AND DISCUSSION

Succulence percentage

The results presented in (Table 1,2, Figure 1,2) show high percentages of succulence of the three studied species. The highest value (9.6%) was recorded in case of *A. gerrardii.* Generally, some investigators reported that the highest ratio of succulence was related to the high soil moisture content which resulted in healthy feature of plants as big volume, green color and flowering [30]. In this respect, Hess et al. [31], stated that the high water content was related to the increasing in vascular size that provide a greater storage volume for electrolytes and improving the physiological state of plants**.** Our results are consistent with those reported by Waisel [32] and Flowers et al [33]. In this regard, Bray and Reid [34] reported that succulence is one of the most common features of many obligate and facultative halophytes as well as some xerophytes. Also, it is often considered as an adaptive response that contributes to the avoidance of high internal salt concentration.

Photosynthetic pigments

The present investigation clearly showed maximum content (1.72) mg/g.fr.wt. of chlorophyll a in *A .gerrardii* while the minimum average value (1.03) was observed in *A.origena.* As regard to chlorophyll b, the obtained date the maximum value (1.36) mg/g.fr. wt. in *A.oerfota* as compared to the lowest value (0.89) in *A. gerrardii*. It is clear from current results that the maximum carotenoids content (0.67) mg/g.fr.wt. was recorded in *A. gerrardii* while the minimum value (0.33) was determined in *A. origena.* The present study indicates that there was a wide variation in photosynthetic pigments among the studied three species of *Acacia.* The obtained data of current investigation consistent with those reported out by Charu and Vandana [35] indicated wide variation in photosynthetic pigments of few medicinal plant species of Jhansi. Other studies on estimation of photosynthetic pigments indicated clearly variation in pigments contents and exhibit seasonal alteration among three species of Mesembryanthemum [21]. So it was conducted from present investigation that the higher values of pigments exhibits a potential productivity and can be used as precursors of some vitamins and play an important function of protecting of photosynthetic apparatus from environmental destruction [36].

Table 1: The average of succulence value (%) of *A. species.*

A. species	Succulence (%)
A. gerrardii	9.60 ± 0.67
A. oerfota	7.37 ± 0.93
A. origena	7.83 ± 1.37

± Mean value of standard deviation

Table 2: The average of photosynthetic pigment contents (mg/g F.W.) of *A. species.*

A. species	Chlorophyll a	Chlorophyll b	Carotenoids
A. gerrardii	1.72 ± 0.08	0.89 ± 0.06	0.67 ± 0.09
A. origena	1.03 ± 0.33	1.07 ± 0.32	0.33 ± 0.05
A. oerfota	1.18 ± 0.54	1.36 ± 0.10	0.47 ± 0.08

± Mean value of standard deviation

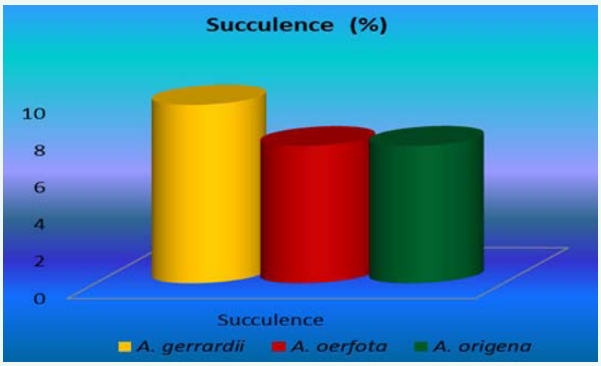

Figure 1 Succulence values of *Acacia* species.

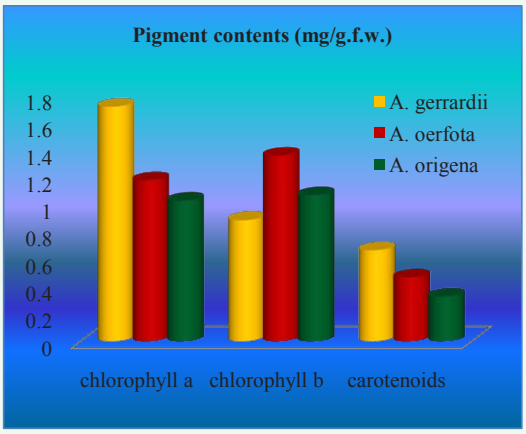

Figure 2 Pigment contents (mg/g.f.w.) species.

Mineral ions composition

Regarding mineral contents, the highest value was determined for Calcium, followed by, Potassium, Magnesium and Phosphorus (Table 3, Figure 3). The highest values of Calcium

(3.8%), Potassium (3.4%), Magnesium (1.5%) and Phosphorus (1.3%) were attained in *A. gerrardii* while the lowest contents were detected in *A. origena.* Other investigators confirmed our results [12,20,22,37-41]. Calcium ion is one of the important mineral ions for the construction of the cell wall. Therefore it is generally absorbed in greater amounts than the other cations. High levels of Calcium are required during growth and lactation of animals. With regard to Potassium element Steve et al. [39], reported that the bioavailability of Potassium in *Acacia* species become an important parameter when investigating the potential nutritional consequences of *Acacia* diet. The Magnesium contents of different *Acacia* species under investigation were nearly invariable. The availability of Magnesium is comparable to its availability in cooked legume seeds if we assume that 50% of the ionized form (in the legume) is bioavailable [39,42]. Such higher values of mineral ions appeared to be essential for securing high osmotic potential which is the driving force for water flow from the soil into plant tissues [43]. *Acacia* species investigated are rich source of minerals and may be added as mineral supplement in ruminant diets where considered essential for various physiological functions of browsing animals [3]. The metal contents of *Acacia* species are mostly variable due to some factors such as differences in plant species, geographical area and conditions of the drying process and confirmed the high nutritional value of *Acacia* species [22].

Metabolic products detection

Total carbohydrates: Data represented in (Table 4, Figure 4) clearly showed highest percentage of total carbohydrates (46.47%) in case of *A. origena* followed by *A. gerrarddi* (42.73%) and *A. oerfota* which recorded (39.23%). Many investigators studied the nutritional assessment and chemical composition of some *Acacia* species [12,39,40]. It has been demonstrated that *Acacia leucophloea* contained highest value (57.5%) of total carbohydrates Vijayakumari and Steve et al. [39,12], studied the chemical composition of *Acacia colei* and *Acacia tumida* and investigated that total carbohydrate percentage was highest in *A. tumida* as compared to *A.colei*. The high percentage of carbohydrates appeared to be essential for securing high osmotic potential which is the driving force for water flow from soil into plant [20,43].

Crude proteins: The obtained results (Table 4, Figure 4) clearly showed that *A. gerrardii* contains the highest value of crude protein (34.77%) followed by *A. origena* (33.87%), while the lowest value (29.77%) was recorded in *A. oerfota*. In this concern, Vijayakumari [12] reported high value of crude protein in *Acacia leucophloea*. Steve et al. [39], stated that crude protein recorded the highest value (23.4%) in case of *Acacia colei* as compared to the lowest value (20.4%) for *Acacia tumida.* Also, Chrispinus et al. [40], investigated that crude protein varied among selected *Acacia* species. It is clear therefore that most *Acacia* species are characterized by high values of carbohydrates and proteins, those results explained why some people used it as a food for animals and as a source of some drugs [39].

5.4.3. Total lipids: Lipids revealed (Table 4, Figure 4) highest value (4.83%) in case of *A. origena*, while the lowest percent (3.07%) was detected in *A. oerfota*. Lipids are relatively compacting anhydrous and have much calorific value than

Table 3: Minerals percentages (%) of *A. species.*

A. species	Calcium	Potassium	Magnesium	Phosphorus
A. gerrardii	3.8 ± 0.44	3.4 ± 0.32	1.5 ± 0.06	1.3 ± 0.01
A. oerfota	3.4 ± 0.89	1.7 ± 0.02	1.3 ± 0.02	0.9 ± 0.01
A. origena	2.6 ± 0.65	1.5 ± 0.05	1.3 ± 0.07	0.5 ± 0.06

± Mean value of standard deviation

Table 4: Percentages of some metabolic products (%) of *A. species.*

A. Species	Total carbohydrates	Crude protein	Total lipids
A. gerrardii	42.73 ± 0.60	34.77 ± 0.85	4.20 ± 0.30
A. oerfota	39.23 ± 0.96	29.17 ± 1.16	3.07 ± 0.15
A. origena	46.47 ± 1.36	33.87 ± 0.65	4.83 ± 0.38

± Mean value of standard deviation

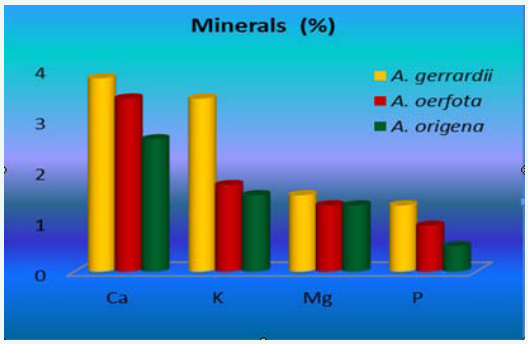

Figure 3 Minerals percentages of Acacia species.

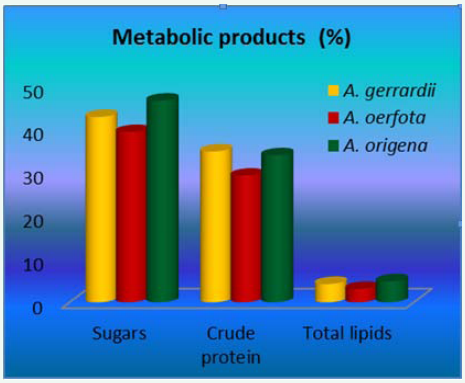

Figure 4 Metabolic products of Acacia species.

proteins and carbohydrate. High lipids and fatty acids can be used as drying agents, cosmetics and plastic manufacture [36]. Usually, the nutritional value of plants varies depending on the cultivars, climatological conditions, maturity, water and fertilizer application as well as selectivity intake of nutrients by plant [44]. So it was conducted from current investigation that the high contents of both minor elements (Ca, P, Mg and K) as well as major metabolic products (total carbohydrates, crude protein and total lipids) confirmed the high nutritional value of the investigated *Acacia* species for animals and can be used as a source of many

drugs. Synthesis of complex molecules of proteins, carbohydrates and lipids acts as defense agent in the plants for survival against animal predation and adaptations in their environments. Further phytochemical studies must be done for specification of the biologically active assessment.

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