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# Studying the Nutritive Profile of Guar [*Cyamopsis tetragonoloba* (L.) Taub.] Harvested at Different ages and Its Potential as a Summer Forage Legume in Egypt

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THE CURRENT study was carried out at the experimental station of the faculty of agriculture, Alexandria University, Alexandria, Egypt, during the summer of 2013 and 2015. The study aimed to assess the nutritive value of guar cut at three plant ages; 45, 60 and 75 days after sowing (DAS), to be used as alternative animal feed for low quality cereal fodder crops in the summer season in Egypt.Guar harvested at 45 and 60 DAS had higher nitrogen (N) accumulation and lower concentration of cell wall components; especially, neutral detergent fiber (NDF), acid detergent fiber (ADF) and cellulose, showing superior quality compared with that harvested at 75 DAS. On the other hand, the dry matter (DM) content significantly increased with maturity, whereas it was significantly low in plants harvested at 45 DAS (232.54 g $kg^{-1}$) and 60 DAS (265.87 g $kg^{-1}$) making them not suitable for ensiling. The hay quality indices; namely, relative feed value (RFV), and relative forage quality (RFQ) were also evaluated along the three harvesting ages. Results demonstrated that,despite the statistical significance in RFV and RFQ in favour of the early harvests, all harvests produced hay of similar quality according to the American Forage and Grassland Council (AFGC) for hay quality standards. The three harvesting intervals of guar produced “Grade 1” and “Premium” category hay, with regard to the RFV and RFQ grading, respectively. Guar, in general, is a short duration, drought tolerant, high quality leguminous forage crop, that could be grown in Egypt to supply the ruminants with relatively high protein and low fiber feed during the summer season, especially when cut at early age (45 and 60 DAS).

**Keywords:** Guar, Harvesting age, Fiber fractions, RFV, and RFQ .

The availability of adequate forage material with better nutritive profile throughout the year is prerequisite for achieving the potential production of animals (Ball *et al*., 2001). In Egypt, the demand for livestock products such as milk and meat is increasing due to the increase in the population and the change in the consumption habits of the people. However, due to the marked seasonal fluctuations in feed supply and pasture quality, there is an inconsistent seasonal

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pattern in the quantity and quality of the produced milk and meat. In the winter season, Egyptian livestock depends mainly on Egyptian clover (*Trifolium alexandrinum* L.) as key forage crop (EL-Nahrawy, 2008a and b). However, a feed shortage peak occurs during the summer season and demands for forage species that could provide the livestock with better nutritional options.

Guar [*Cyamopsis tetragonoloba* (L.) Taub.], also known as cluster bean, is a member of the Leguminosae (Fabaceae) family and is economically the most important of the four species in the genus (Whistler & Hymowitz, 1979). Although doubts remain about its center of origin, whether in Africa (Arain, 2013) or in the arid areas of the Indo-Pakistan subcontinent (Whistler & Hymowitz, 1979), it was intensively grown in India (USDA, 2014). It was spread after that in many other countries as vegetable, fodder and green manure crop (Ali *et al*., 2004). Guar is a deep rooted summer annual legume that needs a hot climate, benefits from irrigation (Alexander *et al*., 1988) and fertilization (Omer *et al*., 1993), has high tolerance to drought (Garg & Burman, 2002), salinity (Francois *et al*., 1990 and Ashraf *et al*., 2005) and a good capability to fix atmospheric nitrogen (Ahmad, 2008). Being a short duration and fast growing crop, guar fits well into most of the prevailing summer cropping systems (Ashraf *et al*., 2002). In Egypt, Farrag & Abd El-Latif (1997) stated that guar might be a promising summer forage crop that could be grown to fill the gap between the available and required forage crops for livestock feeding in the summer, especially that guar showed very good adaptation in other Mediterranean environments (Sortino & Gresta, 2007). There is still, however, lack of a complete nutritive profile of guar cultivated in Egypt as summer forage legume and cut at different plant ages.

The aim of this study was to assess the nutritive value of guar cut at three plant ages to serve as an alternative animal feed in the summer season in Egypt. In this paper the forage quality indicators of guar; namely, dry matter, total nitrogen and cell wall components were presented and discussed. In addition, the relative feed value and relative forage quality representing the hay quality indices were also evaluated.

## Materials and Methods

Guar seeds were obtained from the Agricultural Research Center, Giza and grown in the experimental station of the Faculty of Agriculture, Alexandria University, Alexandria, Egypt. Field trials were carried out on the summer seasons of 2013 and 2014, however, due to the exceptional unfavorable environmental conditions of 2014 growing season, data were excluded and the field trial was repeated in summer 2015 in the same location. The soil of the experimental site was sandy loam in texture, moderately alkaline (pH 8.4), with 1.5% of organic matter and EC 1.30 $dSm^{-1}$.Field trials were laid out in a randomized complete block design (RCBD) with three replicates. Sowing was done on1$^{st}$and 7$^{th}$of June in 2013 and 2015, respectively. Each plot consisted of 8 ridges, each was 3 m in length. The distance between two successive ridges within the same plot was 0.6 m and, thus, the total plot size was 14.4 $m^2$. Seeds were drilled in rows on one side of the ridge with the recommended seeding rates by the Egyptian Ministry of Agriculture and Land Reclamation, amounting to 40 kg $ha^{-1}$.All plots received N fertilizer ($NH_4NO_3$)with the rate of 60 kg $ha^{-1}$, applied 15 days after sowing. Phosphorous ($P_2O_5$) and potassium ($K_2O$) were added once before sowing.Weeds were hand-removed from plots and no serious incidence of insects or diseases was observed. A single cut was taken from all plots at three different plant ages; 45, 60 and 75days after sowing (DAS). At the time of harvesting, plots were manually cut with a sickle directly above the soil surface. A representative sub-sample of about 500 g of fresh matter per plot was dried at 60$^{o}$C until constant weight to determine the dry matter (DM) concentration (g $kg^{-1}$).

The dried sub-samples were uniformly ground to a particle size of 1-mm. The concentrations of neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined sequentially using the semiautomatic ANKOM$^{220}$ Fiber Analyzer (ANKOM Technology, Macedon, NY, USA) as described by Van Soest*et al*. (1991). The NDF and ADF were analyzed without a heat stable amylase and included residual ash, while ADL content was corrected after the residual ash content. Ash was determined by combusting the sub-sample in a muffle oven at 550$^{o}$C for 3h (AOAC, 2012). Hemicellulose was then calculated by subtracting the ADF from the NDF, and cellulose was calculated by subtracting the lignin from the ADF. The nitrogen content was analyzed by the Kjeldahl procedure (AOAC, 2012). Dry matter intake (DMI) as % Body Weight (BW) was calculated based on the laboratory analyses for NDF. In addition, digestible dry matter (DDM) and total digestible nutrients (TDN) as %DM were calculated from the ADF values (NRC, 2001). Finally, relative feed value (RFV), and relative forage quality (RFQ), were calculated as proposed by Rohweder*et al*. (1978) and Moore & Undersander (2002a and b), respectively.

Test of homogeneity of variance (Winer, 1971) was performed, and revealed that the error of the variance between the two experimental seasons was not significantly different, therefore, data from 2013 and 2015 growing seasons are presented in a combined analysis. Analysis of variance (ANOVA), for the investigated parameters (P) at the three harvesting ages, was done using the Proc Glimmix of SAS 9.4 (SAS Institute, Inc., 2012) according to the following model:

$$P_{ij} = \mu + HA_i + B_j + e_{ij}$$

where µ is the overall mean, $HA_i$ is the harvesting age's effect ($i$ = 1,2 and 3), $B_j$ is the block's effect ($j$ = 1,2 and 3), $e_{ij}$ is the experimental error.

Significance was declared at $P < 0.05$ and means were compared with the least significant difference (L.S.D.) procedure.

## Results and Discussion

Statistically analysing the variations among the three harvesting ages revealed that all the investigated parameters were significantly influenced by the harvesting age, except lignin and hemicellulose concentrations. Means presented in Table 1 and Fig.1 demonstrate that plots that were early harvested at 45 DAS and at 60 DAS accumulated the highest significant nitrogen concentration amounting to 29.39 and 27.40 g $kg^{-1}$, for the two respective harvesting ages. While cutting at 75 DAS significantly decreased the total N concentration in the plants to 24.20 g $kg^{-1}$. It was observed from the same table that DM content and fiber fractions (NDF, ADF and cellulose) increased with increasing the harvesting age. Cutting at 60 DAS and 75 DAS produced the highest significant concentrations of DM, NDF, ADF and cellulose, which maximum values were280.45, 420.47, 282.91 and 242.47 g $kg^{-1}$, respectively. In their investigation on the cell wall components of fourteen guar genotypes grown in India, Das *et al*. (1975) reported similar values for the NDF, ADF and cellulose. They reported, however, relatively higher lignin and, consequently, lower hemicellulose values to those reported here. This difference in the lignin and hemicellulose contents is attributed to the late maturity stage at which they harvested their tested genotypes (50% flowering stage – first appearance of pods). The dry matter percentage of forages linearly increase with age at which the forage is harvested (Reid *et al*., 1959 and Gomide *et al*., 1969). Consequently, the guar harvested at 45 DAS produced the lowest significant dry matter. Moreover, the decreased nitrogen concentration and increased cell wall components of the produced herbage at the late harvesting ages is correlated with the decrease in its quality, this might be largely attributed to the reduced leaf to stem ratio with plant maturity. Leaves have better nutritional quality than stems, in terms of higher amounts of total nitrogen and lower amounts of cell wall fractions. Since the early harvestings are characterized by higher proportion of leaves than the late harvesting, that usually occurs in the productive stage, they are preferred than the late harvestings due to their nutritional benefits to the animal. Similar response of the forage quality attributes to late harvesting was reported for fodder sorghum (Ayub *et al*., 2002 and Atis*et al*., 2012), fodder maize (Shehzad *et al*., 2012), millet (Tariq *et al*., 2011), and forage turnip (Tiryakioglu & Turk, 2012). Despite of the high quality of the fresh herbage harvested at 45 DAS, its low dry matter concentration makes it unsuitable for ensiling, as the minimum dry matter concentration for ensiling is 247 g $kg^{-1}$ (Castle & Watson, 1973). Thus, in the current study the dry matter content of the herbage harvested at 60 DAS was slightly above the critical level for ensiling, while that harvested at 45 DAS was slightly below. It is therefore, recommended, in case of ensiling, to delay the harvest time to 75 DAS for the presence of enough dry matter to ensure a successful ensiling process.

**TABLE 1. Means ofdry matter (DM), total nitrogen (N), neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), cellulose and hemicellulose concentrations (g kg$^{-1}$) for the three harvesting ages (HA).**

| HA | DM | N | NDF | ADF | ADL | Cellulos | Hemicellulos |
|---|---|---|---|---|---|---|---|
| 45 | 232.54 b* | 29.39 a | 342.89 b | 250.49 b | 33.53 a | 216.96 b | 92.40 a |
| 60 | 265.87 ab | 27.40 a | 384.66 ab | 270.49 a | 35.09 a | 235.40 a | 114.18 a |
| 75 | 280.45 a | 24.20 b | 420.47 a | 282.91 a | 40.44 a | 242.47 a | 137.56 a |

* Means followed by different small letter(s) within the same column are significantly different according to the L.S.D. test at 0.05 level of probability.

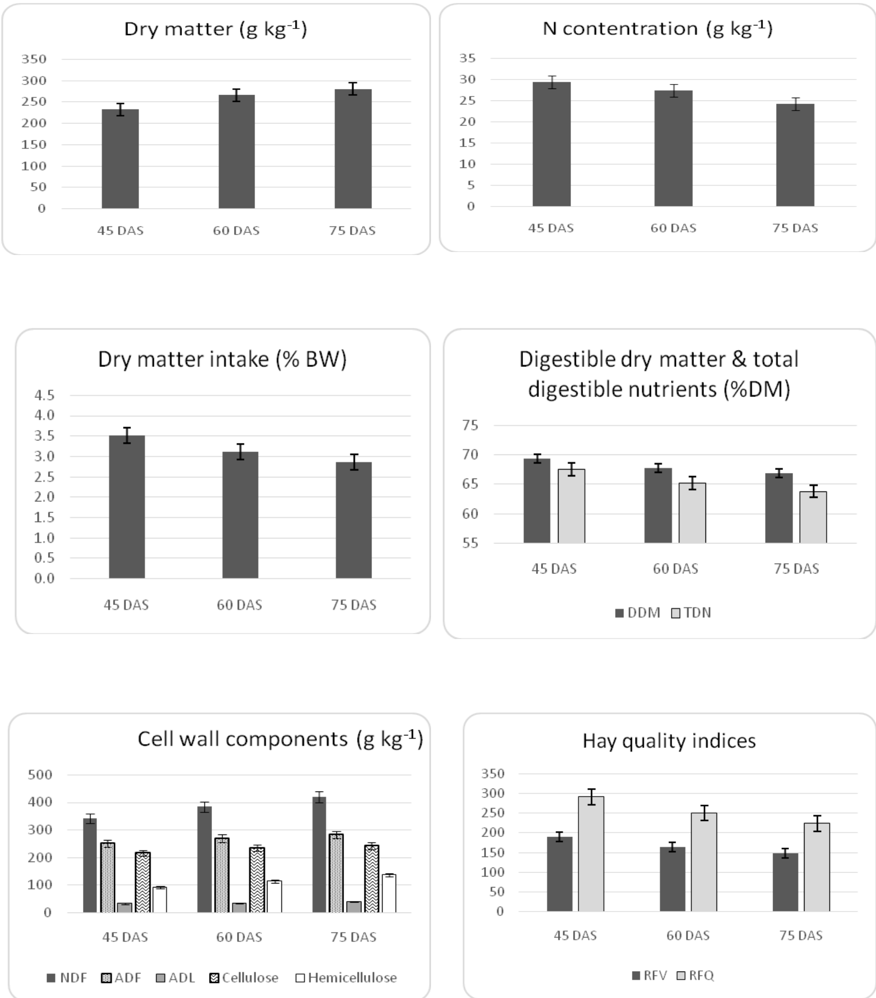


**Fig. 1. Variations in the investigated quality parameters of guar as affected by the three ages at harvesting.**

Means of the hay quality indices, namely; DDM, DMI, TDN, RFV and RFQ, presented in Table 2 and Fig. 1, indicate that harvesting at 45 DAS produced the highest significant amounts of DDM and TDN, amounting to 69.39 and 67.54 % DM, respectively. While there was no significant difference between harvesting at 45 DAS and at 60 DAS for DMI, RFV and RFQ, where both harvestings produced higher values for the three parameters than the late harvesting at 75 DAS. Despite of the higher significant RFV and RFQ for the early harvesting, the three harvesting ages produced hay of similar quality according to the American Forage and Grassland Council (AFGC) hay quality standards. With regard to their RFV records, the three harvesting ages of guar produced Grade 1 category hay (Rohweder *et al*., 1978). Similarly, the RFQ grading system graded the guar hay harvested at the three different harvesting intervals as “Premium” hay (Moore & Undersander, 2002a and b).Under similar experimental conditions, Salama & Nawar (2016), investigated the variations of the different cell wall components of a group of multi-cut, summer grasses and legumes and their mixtures. Their results revealed that the summer legumes cut at 55 DAS produced similar values of NDF, ADF and ADL to guar cut at 60 DAS in the current study. Comparing the nutritive profile of guar to other summer forage grasses and legumes grown in Egypt reveals that guar exhibits similar forage and hay quality attributes to other summer forage legumes especially forage cowpea (Salama & Zeid, 2016). It, however, had higher nitrogen concentration and lower cell wall components than the common forage grasses like Sudan grass and pearl millet (Salama & Zeid, 2016) and fodder maize (Dahmardeh *et al*., 2009).

**TABLE 2. Means of digestible dry matter (DDM % DM), dry matter intake (DMI % BW), total digestible nutrients (TDN %DM), relative feed value (RFV) and relative forage quality (RFQ) for the three harvesting ages (HA).**

| HA | DDM | DMI | TDN | RFV | RFQ |
|---|---|---|---|---|---|
| 45 DAS | 69.39 a* | 3.51 a | 67.54 a | 188.94 a | 291.85 a |
| 60 DAS | 67.83 b | 3.12 ab | 65.23 b | 164.05 ab | 250.37 ab |
| 75 DAS | 66.86 b | 2.86 b | 63.81 b | 148.04 b | 224.18 b |

* Means followed by different small letter(s) within the same column are significantly different according to the L.S.D. test at 0.05 level of probability.

## Conclusion

It is clear from the current results that guar grown under the Egyptian agricultural conditions is characterized by fodder and hay quality comparable to other summer forage legumes, yet higher than summer forage grasses. These results suggest that growing guar on a large scale would help solving the feed shortage problem during the summer season by providing the livestock with a high quality feed with better nutritional value. Guar is characterized by its high

RFV and RFQ, which makes it suitable for the high-producing dairy cows and young calves. Harvest at 45 to 60 DAS is more recommended because of higher nitrogen concentration and low cell wall components at early ages. However, for successful ensiling, guar should not be harvested before 75 DAS.

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# دراسة القيمة الغذائية للجوار [ *Cyamopsis tetragonoloba* (L.) Taub.]عند الحش على ثلاث اعمار مختلفة للنبات و تقييم قدرتة كمحصول علف بقولى صيفى فى مصر

**هبـه صبرى عطيه سلامه و على عيسى نوار**
قسم علوم المحاصيل – كلية الزراعة – جامعه الاسكندرية – الاسكندرية – مصر.

تم اجراء هذه الدراسة خلال الموسم الصيفى لعامى ٢٠١٣ و ٢٠١٥ فى محطة البحوث الزراعية بأبيس، التابعة لكلية الزراعة، جامعة الاسكندرية. كان الهدف من الدراسة هو تقييم القيمة الغذائية للجوار عند حصاده على ثلاثة اعمار مختلفه للنبات و هى: ٤٥، ٦٠ و ٧٥ يوم بعد الزراعة، بهدف الحكم على قدرته ليكون غذاء بديل للنجيليات منخفضة القيمة الغذائية للحيوان فى فصل الصيف. أظهرت النتائج انه عند حصاد الجوار عند عمر ٤٥ و ٦٠ يوم بعد الزراعة، تميز المحصول الناتج بارتفاع محتواه من النيتروجين و انخفاض محتواه من مكونات الجدار الخلوى المختلفه خاصة الألياف المقاومة للتحلل فى المحلول المتعادل (NDF)، الألياف المقاومة للتحلل فى المحلول الحمضى (ADF) و السليولوز، لذلك كان مرتفع الجوده مقارنة بالجوار الذى تم حشة عند عمر ٧٥ يوم بعد الزراعة. زاد محتوى الماده الجافة معنويا عند التأخر فى الحش، فأنتج الجوار الذى تم حشه مبكرا عند عمر ٤٥ و ٦٠ يوم بعد الزراعة محتوى مادة جافة أقل معنويا من الجوار الذى تم حشة متأخرا عند عمر ٧٥ يوم بعد الزراعة. بذلك يصبح الجوار الذى تم حشة مبكرا غير صالح لتصنيع السيلاج. تم ايضا تقييم مقاييس جودة الدريس و هى القيمه النسبية للاعلاف (Relative Feed Value) و الجودة النسبية للأعلاف (Relative Forage Quality). أظهرت النتائج فروق معنوية فى تلك الصفات بين أعمار النبات عند الحش، حيث تفوقت الحشات المبكرة على الحشة المتأخرة. على الرغم من الفروق المعنوية احصائيا بين أعمارالنبات عند الحش، أنتجت الثلاث حشات دريس متشابه فى الجوده تبعا لمقاييس American Forage and Grassland Council (AFGC). حيث نتج عن أعمار الحش الثلاثه دريس بدرجة1 Grade و Premium و ذلك بالاشارة إلى RFV و RFQ، على التوالى.