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Publishers Ethic Rules

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Original Article | Open access | Int J Agric For Life Sci (2024) 8(1): 1-4

Identification of Quality Characteristics of Different Blackberry Varieties under Bursa-Kestel Ecological Conditions

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Abstract
Blackberry is one of the most important fruit species. Its production has been increasing in Türkiye in recent years. This study was conducted in the Kestel/Bursa region, where blackberry cultivation is intense in Turkey. In the study, the physical and chemical properties of three blackberry varieties (Chester, Jumbo and Prime-Jim) were examined. Priority results were obtained in terms of fruit quality criteria for the examined traits. According to correlation studies the highest positive correlations were found between fruit weight and Fruit Lenght, TEA, AsA and TPS. In addition to this, some other parameters also had strong positive relationships, such as SSC and pH, DPPH also between TEA and AsA. The examined varieties were found to be significant in both physical and chemical properties. Especially, Jumbo and Chester varieties stood out in terms of fruit size.

Key words
Blackberry, quality, DPPH, total phenolic, Bursa.

Introduction
Blackberry, a berry fruit, is a botanically compound fruit consisting of shrubby plants belonging to the genus Rubus L., which is divided into two subgenera, Ideaobatus and Euabatus, within the Rosaceae family, Rosineae subfamily, and Rosales order (Ağaoğlu, 2003). Blackberries can be found in every region of Türkiye. Blackberry cultivation is especially common in the Marmara Region of Turkiye. It is known that 82% of the production is in the Marmara Region, and approximately 2,739 tons of blackberries are produced in Turkey, with 80.3% of it in Bursa province. It is reported that about 37 tons of blackberries are obtained from approximately 224.5 hectares of land annually (Fidan et al., 2013).
Blackberries are plants with cane-like shrubs. The plant shoots can be thornless (in newly bred varieties) or thorny. They have biennial shoots. Generative shoots (floricanes) grow on two-year-old branches, while vegetative shoots (primocanes) develop on branches formed in the first year. Most varieties do not yield fruit on primocanes. The fruits are obtained from two-year-old branches. After harvest, the two-year-old branches dry up. However, in some newly bred varieties, fruit can be obtained from both one-year-old and two-year-old shoots. These varieties are thornless, highly adaptable, quite productive, show strong growth and quality tendencies, and have the potential for annual shoot formation of 3-4 meters in length (Strik et al., 2007; Thompson et al., 2009; Yetgin, 2013). Blackberries have a wide range of uses not only for fresh consumption but also in the food industry. Therefore, it is known to have a very special place among other fruits. Additionally, certain pigments, flavonoids, flavones, phenols, fibers, and vitamins found in blackberries are highly compatible compared to other fruit types (Kähkönen et al., 1999; Halvorsen et al., 2002). Since 1989, the terms 'functional foods' and 'nutraceuticals' have been used in food products and substances with health or medical benefits. Especially abundant in berry fruits, phenolics such as ellagic acid, anthocyanin, and flavonoids like kaempferol, myricetin, and quercetin are among the most important plant chemicals with "functional foods" or "nutraceutical" value (Costantino et al., 1992; Heinonen et al., 1998). Blackberries are highly important in terms of nutritional value, containing significant amounts of minerals and vitamins beneficial for health. They possess small amounts of vitamins A, B, and C, and their fibrous structures, whether soluble or insoluble, hold great value for the diet. Blackberries contain approximately 4-6 grams of fiber per 100 grams. Due to their high fiber content, they have been found to have protective effects against heart disease and colon cancer. Naturally, blackberries are low in cholesterol, saturated fats, sodium, and calories (Çağlar and Demirci., 2017).
The aim of this study is to evaluate the fruit quality criteria of certain blackberry varieties grown intensively in the Kestel/Bursa region.

Material and Method
The study was conducted in 2023 on blackberry varieties (Chester, Jumbo and Prime-Jim) grown in the Kestel region (Bursa/Turkey). The fruits were collected when they reached harvest maturity and brought to Eskişehir Osmangazi University, Faculty of Agriculture, Department of Horticulture for physical and chemical analysis.

Pomological Properties
Pomological characteristics of 20 fruits of each variety were examined. Fruit weight g (0.01), fruit width mm (0.01), fruit length mm (0.01), fruit color values (L, a, b), Water soluble dry matter (%), pH, TEA values were evaluated pomologically.

Chemical Analysis
Vitamin C
Ascorbic acid contents of the fruit samples were determined with high-performance liquid chromatography (HPLC) method proposed by Cemeroglu (2007) and Geçer et al. (2016). Briefly, 5 mL of fruit extracts were mixed with 2.5% (w/v) metaphosphoric acid (Sigma, M6285, 33.5%) and then centrifuged at 5,500 rpm for 15 min at 4°C. Then, 0.5 mL solution was raised to 2.5 mL (w/v) with metaphosphoric acid. The supernatant was then filtered through a 0.45 PTm PTFE syringe filter (Phenomenex, UK). A C18 column (Phenomenex Luna C18, 250 mm 4.60 mm, 5 mm) was used at 25°C to identify ascorbic acid.

Total Phenolic Content
Using the Folin-Ciocalteu method, the TPC of blackberry juice extract was determined. 1000 mL of extract was added to 4500 mL of deionized water and 500 lL of undiluted Folin-Ciocalteureagent. Following 60 seconds, 4000 mL of 7.5% (w/v) aquatic Na2CO3 was added. The solution was then allowed to mature for 30 minutes at 30°C before being measured at 765 nm using a UV-Vis spectrophotometer. The results were consistent with a gallic acid calibration curve. All phenols were determined as gallic acid equivalents (mg gallicacid/g extract), and their valves were proposed as a medium for triple assessment (Kähkönen et al. 1999).

Total Anthocyanin
The total anthocyanin concentrations of fruit samples were estimated using spectrophotometer absorbance values at various pH ranges, following the method proposed by Giusti and Wrolstad (2001). To measure the diluted extracts, pH 1.0 (hydrochloric acid-potassium chloride) and pH 4.5 buffer solutions were produced, and absorbance values were taken at 531 and 700 nm. The total anthocyanin content (molar extinction coefficient of 28,000, cyanidin-3-glucoside) and absorbance [(A531-A700) pH 1.0-(A531-A700) pH 4.5] were determined as milligrams per 100 g fresh weight.

DPPH

Determination of DPPH radical scavenging activity was performed by the method of Brand-Williams et al. (1995). The DPPH solution was freshly prepared before analysis. Then, 1 ml of 10-4 M DPPH in a methanol solution was taken and transferred to a glass tube coated with aluminium foil. 3 ml samples of the prepared 0, 3, 1.25, 6.25, 12.5, 25, 50, 100, 200, 400 µg ml-1 antioxidant solutions in methanol were added to the DPPH solution. Instead of the antioxidant solution, 3 ml of pure methanol was added to the control tubes. The samples were kept in the dark and room temperature for 30 minutes and then their absorbance was measured at 517 nm against methanol. Ascorbic acid and Trolox were used as standards (Somparn et al., 2007; Mishra et al., 2012). The percentage of DPPH scavenging activity was calculated using the following equation:

$$\% \text{ DPPH} = [(Ac - As)/Ac] \times 100$$

where Ac was the absorbance of the negative control (containing the extraction solvent instead of the sample) and As was the absorbance of the samples. The results were expressed as EC50 (µg ml-1).

Statistical Analysis

The replicate data on various quality parameters (fruit weight, width, length), color, soluble solids concentration, pH, titratable acidity, and biochemical parameters such as ascorbic acid, total phenolic substances, antioxidant capacity and anthocyanins of blackberry fruits were first summarized in Excel program. Then, figures were created using means and standard deviations, and then ANOVA and Tukey's test were performed to test the differences between cultivars at 5% significance level. Related tests were performed in SPSS 22 package program. Then, the relationship between the quality parameters was subjected to correlation test using the corplot package of the R program. In addition, cluster analysis was performed with the help of FactoMineR package and PCA- Biplot analysis was performed using factoextra package.

Result and Discussion

Fruit weight, fruit width, fruit length and fruit color (L, a, b) are given in Figure 1. The highest fruit weight was obtained in the Jumbo variety. The highest fruit width value was determined in the Chester variety (23.33 mm). The highest value in terms of fruit length was found in the Jumbo variety (34.74 mm).

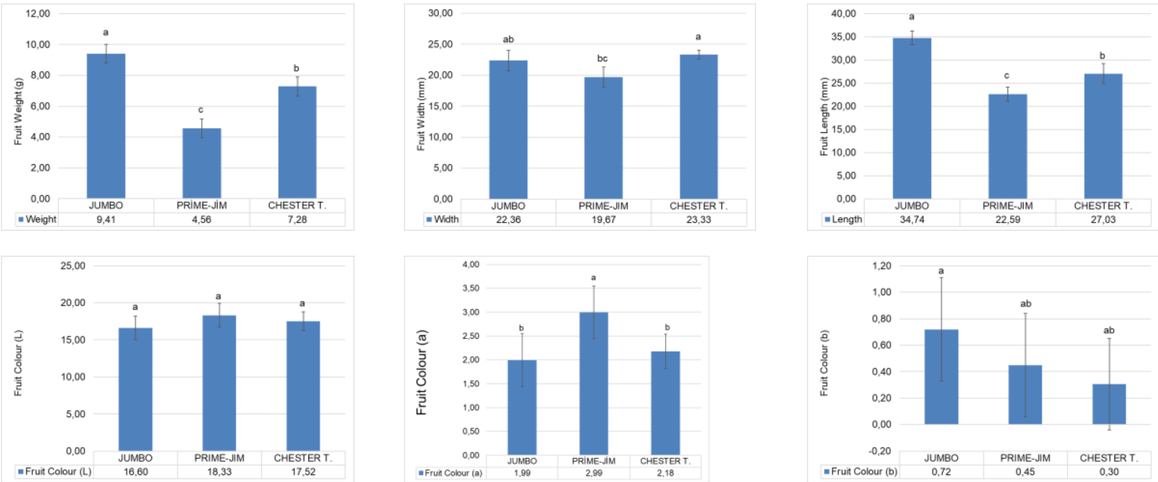

Figure 1. Values of fruit weight, width, length and colours

Values of soluble solids, pH and titratable acidity in fruit juices of blackberry varieties are given in Figure 2. The highest soluble solids value was found in the Prime-Jim variety (16.52 Brix). The highest pH ratio was determined in the Prime-Jim variety (4.77). The highest titratable acidity was observed in the Jumbo variety (2.22%).

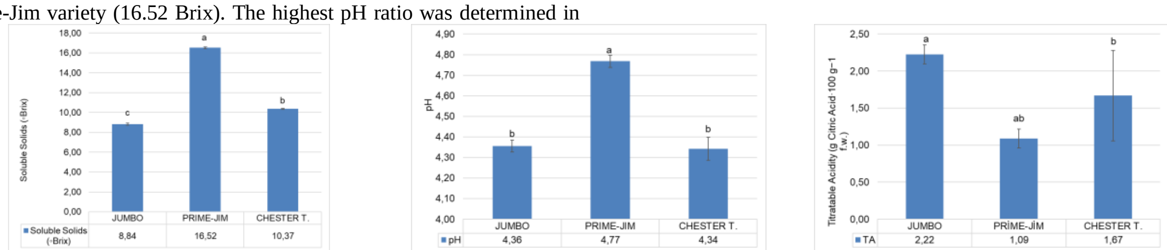

Figure 2. Values of soluble solids, pH and titratable acidity in fruit juices of blackberry varieties

Contents of vitamin C, total phenolics, DPPH and anthocyanin of blackberry varieties are given in Figure 3. The highest vitamin C value was found in the Jumbo variety (57.90 mg/100 mL). The total phenolic content was highest in the Jumbo variety (7875.33 mg GAE/L). Among the varieties, the highest DPPH appeared in the Chester variety (82.29%). The highest anthocyanin value was found in Chester variety (225.36 100 g FW).

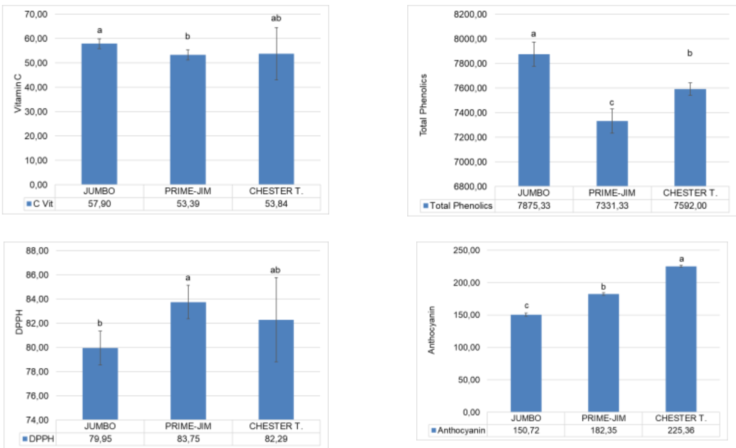

Figure 3. Contents of vitamin C, total phenolics, DPPH and anthocyanin of blackberry varieties

Ağaoğlu et al. (2007) examined the pomological characteristics of certain blackberry cultivars (Arapaho, Black Satin, Bursa 1-2-3, Chester Thornless, Cherokee, Jumbo, Dirksen, Navaho, and Ness) grown for 5 years in Ankara (Ayaş) ecology. They found that the fruit weight of the Chester Thornless variety was 5.40 g, total acidity was 25.56 g/l, and the soluble solid content was 16.66%. Koca et al. (2008) conducted research in the Black Sea Region on the cultivation of some berry species (blackberry, blueberry, and blackcurrant), examining certain physical and chemical properties of these species. In the study, pH, soluble solids content (SSC), titratable acidity (TA), ascorbic acid, ash, color, total sugar, sucrose, and reducing sugar analyses were conducted on fruits of 10 blackberry cultivars and 7 wild genotypes. The study found that in the fruit juices of the Chester variety, the sugar index was 81.60, pH was 2.85, SSC was 12.03%, TA was 1.40%, and the ascorbic acid value was 21.86 mg/100 g. It was determined that the formal number was lower in the blackberry genotypes obtained from cultivated blackberry varieties, and it was found that the strawberry tree fruit, which is not widely recognized in our country, is an important fruit species in terms of vitamin C content, acidity, and color compared to other berry species. Velde et al. (2016) investigated the adaptation of Dirksen, Black Satin, and Jumbo blackberry varieties to Argentine conditions in a study. The phytochemical properties of these varieties were determined using HPLC-TOF-MS. The highest soluble solids content (SSC) ratio was found in the Black Satin variety (7.0±1.0), while the lowest ratio was observed in the Jumbo variety (5.5±1.0). pH levels

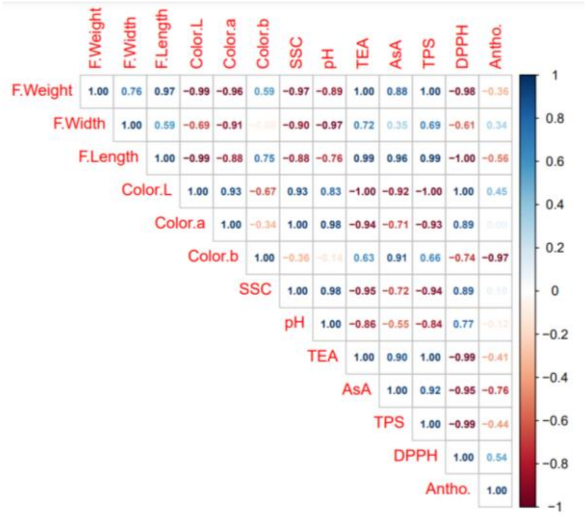

Figure 4. Correlation analysis of the study parameters and cultivars.

PCA-Biplot (Figure 5) results of current study showed the best characteristics of the 3 varieties tested. According to this, CHESTER T variety is superior to the other varieties in terms of anthocyanins. PRIME JIM and JUMBO varieties were found to have opposite characteristics, and accordingly, the characteristic that was good in one cultivar was measured as weak in the other. Accordingly, the most important traits defining the JUMBO variety were fruit weight, titratable acidity, TPS, fruit length and ascorbic acid. On the contrary, DPPH, L-color, SSC, a-color and pH were determined as superior traits for the PRIME JIM variety.

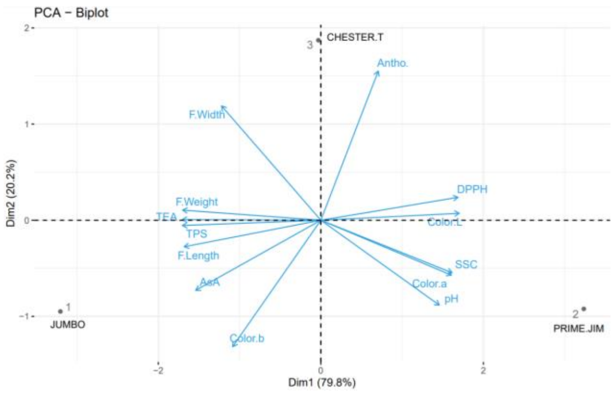

Figure 5. PCA biplot analysis of the study parameters

Conclusions

The Kestel/Bursa region holds significant importance in blackberry production in Turkey. In the study, the physical and chemical properties of three varieties grown in this region, namely Chester, Prime-Jim, and Jumbo, were examined. The examined varieties were found to be significant in both physical and chemical properties. Especially, Jumbo and Chester varieties stood out in terms of fruit size.

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Conflict of Interest

The authors declare that they have no conflict of interest.

Author's Contributions

The authors contributed equally to this manuscript.

were found to be nearly similar in all varieties, averaging around 2.90 across the three varieties. When examining vitamin C values, the highest ratio was found in the Dirksen variety (96±0.3 mg/100 g), while the lowest ratio was observed in the Black Satin variety (7.1±0.6 mg/100 g). Tosun et al. (2008) investigated the physiological and chemical changes in 9 blackberry genotypes at different ripening stages (green, red, black) under Samsun ecological conditions. They found that the total sugar content was on average 45.00 g/kg in the green stage, 97.00 g/kg in the red stage, and 485.00 g/kg in the black stage. In the same genotypes, the total phenolic content was determined to be on average 14,600 mg/kg in the green stage, 11,000 mg/kg in the red stage, and 9,368 mg/kg in the black stage. When looking at total anthocyanin, the average was found to be 1,009 mg/kg in the red stage and 7,927 mg/kg in the black stage for the genotypes.

According to correlation studies (Figure 4), the highest positive correlations were found between fruit weight and F. Lenght, TEA, AsA and TPS. In addition to this, some other parameters also had strong positive relationships, such as SSC and pH, DPPH also between TEA and AsA.

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Determinants of Technical Efficiency and Economies of Scale in Sorghum (*Sorghum bicolor*) Production, Kaduna State, Nigeria: Implication for Sustainable Income

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Abstract
This study examined the determinants of technical efficiency and economies of scale in sorghum (Sorghum bicolor) production, Kaduna State. The result shows that sorghum production was profitable in the study area. The calculated gross margin and net farm income of sorghum production per hectares were 811, 211.27 Naira (853.90 USD) and 728, 947.93 Naira (767.31 USD) respectively. The significant factors influencing technical efficiency of sorghum production include farm size, hired labour, fertilizer input, and seed input. In the technical inefficiency component, the significant socio-economic factors increasing technical efficiency of sorghum production include age, household size, farming experience, educational level, access to credit facilities, farmers' internet usage, media interest and usage. The sorghum farmers' relations with public institutions are not statistically significant in influencing technical efficiency of sorghum production. The return to scale was estimated at 0.8299, this signifies the decreasing return to scale. The average technical efficiency score was 0.6047 leaving a gap of 0.3953 for improvement. The major constraints facing sorghum farmers include lack of credit (1st), high cost of inputs (2nd), and bad road infrastructures (3rd). The policy recommendations include provision of credit facilities to sorghum farmers at low interest rate devoid of cumbersome administrative procedures. The provision of fertilizers, improved seeds, and chemicals to sorghum farmers at affordable prices for increase productivity and efficiency.

Key words
Determinants, Technical Efficiency, Elasticities of Production, Economies of Scale, Sorghum Production, Sustainable Income, Nigeria.

Introduction

Sorghum (*Sorghum bicolor*) is the fourth most important cereal crops in the world after wheat, rice, and maize (Sani and Oladimeji, 2017). It is a staple food crop in Africa, India, and China. Sorghum (*Sorghum bicolor*) is widely cultivated in the northern guinea savannah zone of Nigeria. The production of sorghum in Nigeria for 2022 season was 6,806,370 tonnes, the area harvested was 5,700,000 hectares, and the yield in 100g/ha was 11941 (FAOSTAT, 2023). Nigeria is the leading sorghum producers in Africa at 34%, followed by Sudan at 21%, other countries like Ethiopia, Tanzania, Uganda, Rwanda, and Kenya which accounted for 7,4,2, 0.8, and 0.6% respectively of sorghum produced in Africa (Okeyo et al., 2020). Nigeria is the largest producer of sorghum in West Africa accounting for around 71% of total output in the sub-region (Ogbonna, 2011). India and United States of America are the leading sorghum producers in the world cultivating 16 million and 11 million hectares respectively. Total sorghum production in the world exceeds 50 million tonnes (Sani and Oladimeji, 2017). Sorghum is the largest staple cereal crop accounting for 50% of the total output and occupying about 45% of the total land area devoted to cereal crops production in Nigeria (FAO, 2019). It has been reported that between 70 – 85% of the poor Africans entirely depend on agriculture for livelihood (Byerlee et al., 2005; Ravallion et al., 2007). Sorghum serves as a staple food crop for many sub-Saharan African countries and it's a key ingredient for various industries such as feed, breweries (FAO, 2015). Sorghum plays an important role in providing food security in the face of climate change and as a source of livestock feeds in many developing countries (Mundia et al., 2019). Sorghum is a very valuable industrial crop for brewing non-alcoholic and alcoholic drinks as well as in the confectionary and baking industry in Nigeria (Baiyegunhi and Fraser, 2009). Sorghum grain is fermented for malting and used in preparing local brewing products. Industrially, sorghum is predominantly used by firms producing beverages, confectionaries, breakfast cereals, and a small percentage of the sorghum grain is also used as animal feed. The stalks are used to build fences or shelters and as livestock feed. Sorghum is used as raw materials for the biofuel industries (Yahaya et al., 2022; GAIN, 2020). Sorghum stover and stems are used as animal feed and wall board for house building respectively (Omonona et al., 2019). The small-scale farmers' who constitute the largest percentage of farming populations are threatened with the problems of rural poverty. The farmers cannot afford to purchase necessary farm inputs such as pesticides, fertilizers, improved seeds, which leads to low productivity. The farmers had low income, low savings and investment, and hence low productivity. Sorghum yields in Nigeria and most of sub-Saharan Africa are low (Omonona et al., 2019). Sorghum production in most sub-Saharan Africa is characterized as traditional, subsistence, and small-scale with low yields, whereas in industrialized countries such as the USA, production is mechanized, large scale and high input use (CGIAR, 2015). Technical efficiency measures the ability of a sorghum production unit to obtain the maximum possible output from a combination of production factors. Efficiency can be defined as the ability of the sorghum producers to produce the maximum quantity of sorghum with the minimum production factor. Technical efficiency is a precise and relevant instrument in the analysis of the technical performance of farms, especially those producing cereals. Technical efficiency measures the efficiency of the use of resources and factor of production. Technical efficiency is the allocation of inputs involved in the production process of a given output. The sorghum economic potential has not been fully realized in Nigeria and sub-Saharan African (SSA) countries due to a number of production and productivity constraints. The small-scale sorghum farmers who accounted for 90% of sorghum production for instance still prefer to use their farm-saved seed which is local and unimproved varieties. This local landrace has low yield potentials, long maturity, tall plant height and are non-responsive to improved agronomic management practices (Ajeigbe et al., 2018). A critical analysis of existing literatures shows the current research gap to fill which show no work done on technical efficiency and economies of scale in sorghum production in the study area.

Objectives of the Study

The broad objective is to examine the determinants of technical efficiency and economies of scale of sorghum (*Sorghum bicolor*) production, Kaduna State, Nigeria. The specific objectives are to:

(i) determine the socio-economic, institutional, and farm specific characteristics of sorghum farmers;
(ii) analyze the costs, returns and profitability of sorghum production;
(iii) evaluate the factors influencing the technical efficiency of sorghum production;
(iv) estimate the elasticities of production, and economies of scale in sorghum production;
(v) determine the technical efficiency scores of sorghum farmers; and
(vi) identify the constraints faced by sorghum farmers in the study area.

Methodology

This research study was conducted in Kaduna States. The sample size and sample frame of sorghum farmers in the area was 160 and 267 respectively. Primary sources of data were obtained. A well-designed and a well-structured questionnaire was administered to the respondent using well-trained extension officers. The structured questionnaire was subjected to validity and reliability tests. This research work used the formula advanced by Yamane (1967) in the estimation of the sample size. The formula is stated thus:

$$n = \frac{N}{1+N(e^2)} = 160 \ldots\ldots\ldots\ldots (1)$$

Where, n = Calculated Sample Size, N = Sample Frame (Number), e =Maximum Acceptable Margin of Error as Determined by the Researcher (5%) Data were analyzed using the following statistic and econometric tools:

Farm Budgetary Technique

Gross margin model (GM) and net farm income analysis (NFI) of sorghum production was estimated using the following models:

$$GM = TR - TVC \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$NFI = \sum_{i=1}^{n} P_i Q_i - \left[\sum_{j=1}^{m} P_j X_j + \sum_{k=1}^{k} GK\right] \ldots . (3)$$

Where, P_i = Price of Sorghum ($\frac{N}{Kg}$), Q_i = Quantity of Sorghum (Kg), P_j = Price of Factor Inputs ($\frac{N}{Unit}$), X_j = Quantity of Factor Inputs (Units), TR =Total Revenue obtained from the Sales of Sorghum (N), TVC = Total Variable Cost (N), GK = Cost of all Fixed Inputs (Naira), NFI = Net Farm Income (Naira)

The farm budgetary technique was used to analyze the costs, returns and profitability of sorghum production as stated in specific objective 2 (ii).

Financial Analysis

This study follows the work advanced by of Alabi et al. (2020), who defined gross margin ratio (GMR) as:

$$Gross\ Margin\ Ratio = \frac{Gross\ Margin}{Total\ Revenue} \ldots\ldots (4)$$

This study follows the work advanced by Olukosi and Erhabor (2015), who defined operating ratio (OR) as:

$$Operating\ Ratio = \frac{TVC}{GI} \ldots\ldots\ldots\ldots\ldots (5)$$

Where, TVC = Total Variable Cost (Naira), GI = Gross Income (Naira),

The rate of return per Naira invested (RORI) in sorghum production is stated as follows:

$$RORI = \frac{NFI}{TC} \ldots\ldots\ldots\ldots\ldots (6)$$

Where, NFI = Net Farm Income from Sorghum Production (Naira), TC = Total Cost (Naira)

The financial analysis was used to analyzed the profitability of sorghum production as stated in specific objective 2 (ii).

Stochastic Production Efficiency Frontier Model

This research study follows the model advanced by Alabi *et al*. (2022[a]), who defined the stochastic production efficiency frontier model as:

$$Y_i = f(X_i, \beta_i) e^{v_i - u_i} \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

$$l_nY = \beta_0 + \beta_1 l_nX_1 + \beta_2 l_nX_2 + \beta_3 l_nX_3 + \beta_4 l_nX_4 + \beta_5 l_nX_5 + +V_i - U_i \ . (8)$$

where, Y_i = Output of Sorghum (Kg), X_i = Vectors of Factor Inputs, β_i = Vectors of Parameters, V_i = Random Variations in Sorghum Output, U_i= Error Term due to Technical Inefficiency, X_1 = Farm Size (Ha), X_2 = Hired Labour Input in Mandays, X_3 = Fertilizer Input (Kg), X_4 = Chemical Input (Litre), X_5 = Seed Input (Kg), X_6 = Family Labour (Mandays)

$$U_i = \alpha_0 + \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \alpha_4 Z_4 + \alpha_5 Z_5 + \cdots . \alpha_9 Z_9 \ldots\ldots\ldots . (9)$$

where, Z_1 = Age (Years), Z_2 = Household Size (Number, Z_3 = Gender (1, Male; 0, Otherwise), Z_4 = Farming Experience (Years), Z_5 = Educational Level (Years), Z_6 = Access to Credit Facilities (Naira) Z_7 = Farmers Internet Usage (1, Aware; 0, Not Aware), Z_8 = Media Internet Usage (1, Usage; 0, Not Use), Z_9 = Relations with Public Institutions (1, Receive Support; 0, Do Not Receive Support) α_0 = Constant Term, $\alpha_1 - \alpha_9$ = Parameters to be Estimated, U_i= Error Term due to Technical Inefficiency. This will be used to achieve specific objectives 3 (iii) and 5 (v).

Elasticity of Production Model and Return to Scale

Elasticity of production is a measure of a farm success in producing maximum output from a given set of inputs. The elasticity of production (E_P) and return to scale (RTS) was estimated using the formulae: -

$$E_{P_{X_i}} = \frac{\partial Y}{\partial X_i} \cdot \frac{\overline{X}}{\overline{Y}}, i = 1, 2 \ldots k \quad (10)$$

$$\sum_{i=1}^{K} E_{P_{X_i}} = RTS \quad (11)$$

Where; $\overline{X}$ = Mean of Inputs (Units), $\overline{Y}$ = Mean of Output (Units), $E_{P_{X_i}}$ = Elasticity of Production of Input x_i , $\sum_{i=1}^{K} E_{P_{X_i}}$ = Return to Scale i.e Sum of Elasticity of Production

Sanusi *et al*. (2022) and Alabi and Safugha (2022[b]) suggested that return to scale of the farm operations can either be increasing, decreasing, or constant return to scale base on the value of the estimated coefficients**.** This was used to achieve part of specific objective 4 (iv).

Principal Component Analysis

Constraints faced by sorghum farmers was subjected to principal component analysis or factor analysis. The principal component analysis is stated thus:

$$\alpha_K = (\alpha_{1k}, \alpha_{2k}, \alpha_{3k}, \ldots \alpha_{pk}) \quad (12)$$

$$\alpha_k^T X = \sum_{j=1}^{p} \alpha_{kj} X_j \quad (13)$$

The variance of each of the principal components are:

$$Var[\alpha_k^T X] = \lambda_k \quad (14)$$

$$S = \frac{1}{n-1} \sum_{i=1}^{n} (X_i - \overline{X}_i)(X_i - \overline{X}_i)^{T} \quad (15)$$

Where, X_i= Vector of p Random Variables, α_k = Vector p Components, λ_K = Eigen Value, T = Transpose, S = Covariance Matrix, This was use to achieve part of specific objective 6 (vi).

Results and Discussion

Socio-Economic, Farm Specific and Institutional Characteristics of Sorghum Farmers

Table 1 presented the socio-economic, institutional, and farm specific characteristics of sorghum farmers. The socio-economic characteristics include gender, age, marital status, years in schooling, household size, farming experience, farm size, member of cooperatives, extension contact, and access to credit facilities. In terms of gender, about 75% (120) of sorghum farmers were male, while 25% (40) of sorghum farmers were female. This result is in line with findings of Aduba et al. (2013) and Baiyegunhi and Fraser (2009) who reported that women majorly take part in processing. Also, the male dominance may be due to demand of time and effort required to work in the enterprise. The mean age of sorghum farmers was 43 years with a standard deviation of 8.813. About 71.88% of sorghum farmers were less than 50 years of age, while 18.12% of sorghum farmers were 51 years and above. This implies that the sorghum farmers were young, active, energetic in their productive age. This result is in line with findings of Tugga et al. (2023) who reported in their studies that sorghum farmers are within their active age and can make positive contribution to agricultural production. About 86.87% of sorghum farmers were married, 2.50% were single, 4.38% were divorced, while 6.25% were widowed. This result is in line with findings of Aduba et al. (2013) who reported that 92.90% of sorghum farmers were married. These married farmers engaged in sorghum production in order to cater for the wants and needs of their family. Averagely, sorghum farmers had 6 years (SD = 3.6840) of schooling. Most sorghum farmers (54.39%) attended primary school (1 – 6 years), and 39.37% attended secondary education (7 – 12 years), in comparison, the least proportion (6.25%) was recorded for tertiary education (13 years and above). According to Yahaya et al. (2022) who reported that education is vital for productivity, the improvement of agricultural management and the creation of farmers' rural prosperity. Farmers with formal education can easily make farm decisions and adopt innovations about agricultural production methods. Sorghum farmers with formal education have better understanding and knowledge of farm production technologies. About 45% of sorghum farmers had less than 5 persons as members of the household. Also, 35.63% of sorghum farmers had between 6 to 10 persons as members of the household. Averagely, sorghum farmers had 7 persons as household size. The importance of household size as reported by Amaza (2000), and Oladimeji and Abdulsalam (2013) were based on the availability of labour for farm production. In addition, the total area cultivated, the marketable surplus and the amount of farm produce retained for domestic consumption were all determined by the size of the farm household. The results presented on Table 1 also shows that about 40% of sorghum farmers had less than 10 years of farm experience in sorghum production. In addition, 51% of sorghum farmers had between 11 to 20 years' experience in sorghum production. The mean farm experience in sorghum production was 14 years (SD = 9.3329). According to Sani and Oladimeji (2017) who reported that farming experience of a sorghum farmers determines his ability to adhere to agronomic practices, make effective farm decisions, and also combine inputs or resource allocations. In addition, farming experiences also influence farm production efficiencies because accumulation of skills assists a sorghum farmer to perform better on his farms. Furthermore, about 77.50% of sorghum farmers had farm size that is less than 2 hectares. Also, 26% of sorghum farmers had farm size that ranged between 2.1 to 4 hectares. The average cultivated farm size was 1.59 hectares (SD = 1.59875), this implies that sorghum farmers were small-scale or peasant farmers. The institutional variables under considerations were members of cooperatives organizations, extension contact, and access to credit facilities. About 68.13% of sorghum farmers were members of cooperative associations, while 31.87% of sorghum farmers were not members of cooperative associations respectively. In addition, 58.75% of sorghum farmers had contact with extension officers, while 41.25% of sorghum farmers had no contact with extension officers. The contact with extension officers should enhance the ability of sorghum farmers to utilize the farm resources efficiently through the adoption of improved methods used in sorghum production. About 55.63% of sorghum farmers have access to credit facilities, while 44.37% of sorghum farmers do not have access to credit facilities. According to Ekong (2003) who reported that credit facilities is a strong factor that is needed to develop any farm enterprise, the availability of credit could determine the extent of production capacity.

Table 1: Socio-Economic, Farm Specific and Institutional Characteristics of Sorghum Farmers

Variables	Frequency	Percentage
Gender		
Male	120	75.00
Female	40	25.00
Age (Years)		
≤ 20	02	01.25
21 – 30	10	06.25
31 – 40	37	23.13
41 – 50	82	51.25
51 and above	29	18.12
Mean Value	43.30 (SD = 8.813)	
Marital Status		
Married	139	86.87
Single	04	02.50
Divorced	07	04.38
Widowed	10	06.25
Years in Schooling		
1 – 6	87	54.38
7 – 12	63	39.37
13 and above	10	06.25
Mean Value	6.6125(SD = 3.6840)	
Household Size (Number)		
1 – 5	72	45.00
6 – 10	57	36.63
11 – 15	21	13.12
16 and above	10	06.25
Mean Value	7.03125(SD = 4.4685)	
Farming Experience (Years)		
1 – 10	64	40.00
11 – 20	51	31.87
21 – 30	35	21.88
31 and above	10	06.25
Mean Value	14.937 (SD = 9.3329)	
Farm Size (Hectares)		
≤ 2	124	77.50
2.1 – 4	26	16.25
4.1 – 6	09	05.62
6.1 and above	01	00.63
Mean Value	1.59875 (SD=1.21864)	
Member of Cooperatives (Dummy)		
Yes	109	68.13
No	51	31.87
Extension Contact (Dummy)		
Yes	94	58.75
No	66	41.25
Access to Credit Facilities (Dummy)		
Yes	89	55.63
No	71	44.37
Total	**160**	**100.00**

Source: Field Survey (2023) SD = Standard Deviation

The Costs, Returns and Profitability of Sorghum Production per Hectare

Table 2 presented the costs, returns, and profitability of sorghum production per hectare in the study area. The various costs incurred in sorghum production and the revenue obtained was based on the prevailing market prices as at the time of the field survey. The total costs (TC) involved in sorghum production consists of total variable cost (TVC) and total fixed costs (TFC). The TVC accounted for 84.11% of the total cost (TC) of production, while the TFC accounted for 15.89% of the TC. The TVC include seed input (07.09%), fertilizer input (18.31%), agrochemical input (07.49%), labour input (47.82%), transportation (0.99%), loading and offloading (0.57%), fees and commission (0.47%), and bags or sacks (1.38%). The TFC include depreciation on farm implement (7.64%), land rent (4.77%), taxes (0.73%), and interest paid on capital (2.75%). The total revenue (TR) obtained was 1, 246, 781.43 Naira. The estimated gross margin (GM) and net farm income (NFI) was 811, 211.27 Naira (853.90 USD) and 728, 947.93 Naira (767.31 USD) respectively. This shows that sorghum production was profitable in the study area. The GMR of sorghum production was 0.65, this implies that for every one naira invested in sorghum production about 65 kobo covered taxes, profits, depreciation, and expenses. The operating ratio (OR) of sorghum production was estimated at 0.54, this signifies that 54% of sales revenue from sorghum produce was used to the cover cost of sorghum sold and other operating expenses. The OR is used to measure the profitability and operating efficiency of sorghum production, a low OR is acceptable and it is a signal for positive development. The rate of return on investment (RORI) was calculated at 1.41, this means that for every one Naira invested in sorghum production, a profit of 41 kobo was made. This result is in line with findings of Tugga et al. (2023) who evaluated profitability of sorghum among small-scale farmers in selected local government areas of Gombe State, Nigeria. The results obtained the gross margin of 167, 188.6 Naira per hectare, and return to naira invested of 2.12.

Table 2: The Costs, Returns and Profitability Analysis of Sorghum Production per Hectare

Variables	Units	Value (N)	Percentage (%)
Variable Cost			
Seed Input	Kg	36,698.82	07.09
Fertilizer Input	Kg	94, 810.67	18.31
Agrochemicals	Litre	38, 762.21	07.49
Labour Input	Mandays	247, 621.72	47.82
Transportation	Naira	5,149.47	00.99
Loading and Offloading	Naira	2,957.62	00.57
Fees and Commission	Naira	2,421.41	00.47
Bags/Sacks/Sewing	Naira	7,148.24	01.38
Total Variable Cost (TVC)	Naira	**435,570.16**	**84.11**
Fixed Cost			
Depreciation on Farm	Naira	39, 531.14	07.64
Implement	Naira	24, 721.27	04.77
Land Rent	Naira	3,769.21	00.73
Taxes	Naira	14, 241.72	02.75
Interest Paid on Capital		**82, 263.34**	**15.89**
Total Fixed Cost (TFC)		**517,833.50**	**100.00**
Total Cost (TC)	2,800.12Kg	---------	
Quantity Sold	Naira/Kg	445.26	
Price	Naira	1,246,781.43	
Total Revenue (TR)	Naira	811, 211.27	
Gross Margin (GM)	Naira	728,947.93	
Net Farm Income	Number	0.65	
Gross Margin Ratio (GMR)	Number	0.54	
Operating Ratio (OR)	Number	1.41	
Rate of Return on Investment			

Source: Field Survey (2023) 950 Naira = 1USD

Technical Efficiency Scores of Sorghum Producers in the Study Area

Table 3 shows the summary statistics of technical efficiency scores of sorghum producers. The majority (71.89%) of sorghum producers were between 21 to 80 % efficiency levels. The mean technical efficiency was 60.47 % leaving a gap of 39.53 % for improvement. This means that the sorghum farmers are able to obtain 60.47% of potential output from a given mixture of production inputs. Thus, opportunity still exists for increasing sorghum productivity and income through increased efficiency using available resources and by adopting new technologies and techniques used by the best performing sorghum farmers. In addition, the least technical efficiency score was 6.80 %, while the best performing sorghum farms had the maximum technical efficiency of 98.90%. If the average sorghum farmers were to achieve the level of technical efficiency like most of its efficient counterparts, then the average sorghum producers could make 38.86 % cost savings calculated as $\left[\left[1 - \frac{60.47}{98.90}\right] \times 100\right]$. The calculated value for the most technically inefficient sorghum farmers reveals a cost savings of 93.12 % calculated as $\left[\left[1 - \frac{6.80}{98.90}\right] \times 100\right]$. This is consonance with findings of Sani and Oladimeji (2017) who obtained an average technical efficiency score of 0.83 for sorghum farmers in Gombe State, Nigeria. Also, the result of Alemu and Haji (2016) obtained an average technical efficiency score of 0.74 for sorghum farmers in Eastern Ethiopia.

Table 3: Distribution of Technical Efficiency Scores among Sorghum Farmers

Technical Efficiency Score	Frequency	Percentage
0.00– 0.20	09	05.63
0.21 – 0.40	15	09.38
0.41 – 0.60	59	36.88
0.61 – 0.80	41	25.63
0.81 – 1.00	36	22.50
Mean	0.6047	
Standard Deviation	0.2226	
Minimum	0.0680	
Maximum	0.9890	

Source: Field Survey (2023)

Factors Influencing Technical Efficiency of Sorghum Production

The results of the maximum likelihood estimate of the Stochastic frontier production model for sorghum farmers was presented in Table 4. In the technical efficiency component, the variables included in the model were farm size, hired labour, fertilizer input, chemical input, seed input, and family labour. The estimated coefficients of all the parameters of the production functions were positive. The significant variables influencing technical efficiency of sorghum production include: farm size (P < 0.05), hired labour (P < 0.05), fertilizer input (P < 0.05), and seed input (P < 0.01). The coefficient of farm size (0.1375) was positive and significant at 5% probability level. A 1% increase in farm size will lead to 13.75% increase in output of sorghum farmers. The fertilizer is a major land augmenting input because it improves the quality of land by raising the yields per hectare. A 1% increase in fertilizer input will lead to 12.57% increase in output of sorghum farmers. This result is in agreement with the findings of Oladiebo and Fajuyigbe (2007).

The return to scale is the summation of all elasticities of production. The regression coefficients are the respective elasticities of production. The return to scale is the summation of elasticities (EP) of production from the regression coefficients of the Cobb Douglas production function. The elasticities of production for farm size as an example was estimated at 0.1375. The return to scale (RTS) was calculated at 0.8299, this signifies decreasing to scale. This means that an increase in one factor keeping other factors constant will lead to less than proportionate increase in output of sorghum farmers. This return to scale value describes that smallholder sorghum farmers are exactly operating in rational production stage and that area has a value of 0≤RTS≤1 to reach constant return to scale CRS or RTS=1. This result is in line with the findings of Alabi and Anekwe (2023). The value of gamma (γ) was estimated to be 0.5442 and it was statistically significant at 1% probability level. This is in line with the theory that true gamma (γ) should be greater than zero. This implies that 54.42% of random variations in the yield of the sorghum farmers was due to the farmers' inefficiency in their respective farms and not as a result of random variability. These factors are under the control of sorghum farmers, hence reducing the influence of the effect of gamma (γ) will greatly increase the yield and enhance the technical efficiency of the sorghum farmers.

The value of sigma square (σ^2) was 0.3882 and this was highly significant at 1% level of probability. This signifies a good fit and correctness of the specified distributional assumptions of the composite error terms. This result is in line with Sani and Oladimeji (2017) who examined determinants of technical efficiency among sorghum farmers under agricultural transformation agenda in Gombe State, Nigeria. The results show that the significant factors influencing sorghum production in Gombe State, Nigeria are seed, fertilizer, and labour. The sigma square and gamma values were estimated at 0.6188 and 0.8144 respectively. In addition, Alemu and Haji (2016) who evaluated economic efficiency of sorghum production for smallholder farmers in Eastern Ethiopia reported that the significant factors influencing technical efficiency of sorghum production include age, experience, sex, and farm size.

Socio-Economic Factors Influencing Technical Inefficiency of Sorghum Production

Table 4 also shows the maximum likelihood estimates of socio-economic factors influencing technical inefficiency of sorghum production. The socio-economic variables included in the technical inefficiency model include: age, household size, gender, farming experience, educational level, and access to credit. All the socio-economic factors included in the technical inefficiency component had negative coefficients. All the signs of the socio-economic factors included in the technical inefficiency component were in line with a priori expectations. The significant socio-economic factors negatively influencing technical inefficiency includes: - age (P < 0.10), household size (P < 0.10), farming experience (P < 0.01), educational level (P < 0.01), and access to credit (P < 0.05). The coefficient of educational level is -0.3717, this implies a 1% increase in farm experience among sorghum farmers will lead to a 37.17% decrease in technical inefficiency of sorghum production. This result is in line with earlier findings of Sani and Oladimeji (2017). According to Kalirajan and Shard (2004) who reported that education of farmers sharpens his managerial input and leads to better decision making in farming. Education also widens the scope of farmers' horizon towards the adoption of innovations or new farm technologies, thereby moving the farmers away from traditional practices. The coefficient of farm experience in sorghum production was negative (-0.1640). This means a 1% increase in farming experience among sorghum farmers will lead to 16.40% decrease in technical inefficiency of sorghum production. Farmers' experience could be linked with skills accumulation which could increase productivity and enhance resource allocations hence reduce technical inefficiency among sorghum farmers. This is in line with Sani and Oladimeji (2017) who evaluated technical efficiency of sorghum production in Gombe State, Nigeria using stochastic frontier production model, reported that in the technical inefficiency component the significant socio-economic factors include education, farming experience, membership of cooperatives, and farm size. Farmers internet usage (-0.12076) and media interest and usage (-0.03509) had negative coefficients and are statistically significant in influencing technical efficiency of sorghum farmers at 5% probability level each. This outcome conforms with a priori expectations. A 1% increase in internet usage among sorghum farmers holding all other regressors constant will give rise to 12.07% increase technical efficiency of sorghum production. Also, 1% increase in media interest and usage among sorghum farmers holding all other predictors constant will give rise to 3.05% increase in technical efficiency of sorghum production. In addition, the relations of sorghum farmers with public institutions were not statistically significant in influencing technical efficiency of sorghum production.

Table 4: Results of the Maximum Likelihood Estimates of the Stochastic Frontier Production Model for Sorghum Farmers

Variables	**Coefficients**	**Z-Score**
Farm Size	0.1375**	2.04
Hired Labour	0.1504**	2.67
Fertilizer Input	0.1257**	2.20
Chemical Input	0.0341	0.36
Seed Input	0.3416***	5.24
Family Labour	0.0406	0.67
Constant	2.3714***	4.93
RTS	**0.8299**	
Age	-0.2302***	- 3.47
Household Size	- 0.1234*	- 1.90
Gender	- 0.0427	- 0.35
Farming Experience	- 0.1640***	- 3.41
Educational Level	- 0.3717***	- 8.50
Access to Credit	- 0.1547**	- 2.34
Farmers Internet Usage	-0.12076**	-2.46
Media Interest and Usage	-0.03509**	-2.27
Relations with Public Institutions	-0.01271	1.04
Diagnostic Statistics		
Log-Likelihood	-121.6581	
Sigma Square (Total Variance) (σ^2)	0.3882***	
Gamma (Variance Ratio) (γ)	0.5442***	

*Source: Field Survey (2023) ***-Significant at 1% Probability Level, **-Significant at 5% Probability Level*-Significant at 10% Probability Level*

Constraints Faced by Sorghum Producers

The constraints faced by sorghum farmers were subjected to principal component analysis (Table 5). Six (6) constraints with Eigen-value greater than one (1) were retained by the principal component model. Lack of credit facilities was ranked 1st with an Eigen-value of 4.7183, and this explained 38.14% of all constrained retained by the model. High cost of input was ranked 2nd with an Eigen-value of 3.7922, and this explained 17.62% of all constraints retained by the principal component model. Bad road infrastructure was ranked 3rd with an Eigen-value of 2.7514, and this explained 5.14% of all constraints retained by the model. All constraints retained by the principal component model jointly explained 72.95% of all constraints included in the analysis. The Kaiser-Meyer-Olkin measures of sampling adequacy (KMO) of 0.6915 and Bartlett test of sphericity of 2941.42.01 and were statistically significant at 1 % probability level which demonstrated that the variables were feasible for principal component analysis. This result is in line with the findings of Alabi and Anekwe (2023), Onuk et al. (2020), and Aduba et al. (2013). The work of Aduba et al. (2013) on economic analysis of sorghum production among sorghum farmers in Kwara State, Nigeria enumerated the constraints facing sorghum farmers to include high cost of labour, high cost of transportation, inadequate fund, inadequate access to extension services, inadequate access to improved seeds, lack of market for products, lack of motorable roads, lack of recommended agrochemicals, poor pricing of sorghum products, and problems of pests and diseases.

Table 5: Results of the Principal Components Analysis of the Constraints Faced by Sorghum Farmers

Constraints	Eigen-Value	Difference	Proportion	Cumulative	Ranks
Lack of Credit Facilities	4.7183	0.9261	0.3814	0.3814	1st
Lack of Improved Seeds	3.7922	1.0408	0.1762	0.5576	2nd
Bad Road Infrastructures	2.7514	0.3361	0.0514	0.6090	3rd
Inadequate Extension Services	2.4153	0.2775	0.0412	0.6502	4th
High Cost of Labour	2.1378	0.1117	0.0401	0.6903	5th
High Cost of Fertilizer	2.0261	1.1900	0.0392	0.7295	6th
Bartlett Test of Sphericity					
Chi Square	2941.42				
Rho	1.0000				
KMO	0.6915				

Source: Field Survey (2023)

Conclusion and Recommendations

This research study has established that sorghum production was profitable in the study area. This is in line with reports of Tugga et al. (2023) who reported that sorghum production is profitable among small scale farmers in Gombe State, Nigeria. The sorghum farmers were energetic, active, productive in their youthful age. They are peasant, or small-scale farmers and majority (77.50%) of the producers cultivated less than 2 hectares of sorghum farms. The gross margin and net farm income of sorghum production were estimated at 811,211.27 Naira (853.90 USD) and 728,947.93 Naira (767.31 USD) per hectares respectively. The gross margin and operating ratios were calculated at 0.65 and 0.54 respectively. The significant factors influencing output of sorghum farmers include farm size, hired labor, fertilizer input, and seed input. The significant socio-economic factors reducing technical inefficiency of sorghum production include age, household size, farming experience, educational level, access to credit facilities, farmers' internet usage, media interest and usage. The sorghum farmers' relations with public institutions is not statistically significant in influencing technical efficiency of sorghum production. The average technical efficiency score of sorghum farmers was 60%, leaving a gap of 40% for improvement. The major constraints faced by sorghum farmers include: lack of credit facilities (1st), high cost of inputs (2nd), and bad road infrastructures (3rd). Based on the findings of this research work, the following recommendations were made:

(i) Credit facilities should be made available for sorghum farmers at low interest rate with no collaterals and devoid of cumbersome administrative procedures.
(ii) Farm inputs such as fertilizers, chemicals and improved seeds should be given to sorghum farmers at affordable prices and at appropriate time to increase productivity and efficiency.
(iii) Feeder roads should be constructed and more roads should be rehabilitated to facilitate easy access and movement of agricultural produce to nearby market.
(iv) Extension officers should be employed to disseminate innovations and new research findings to farmers.

New farm technologies and techniques together with labour saving equipments' should be introduced to sorghum farmers to increase productivity and efficiency.

Statement of Conflict of Interest

The author(s) declare no conflict of interest for this study.

Author's Contributions

The contribution of the authors is equal

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Food consumption tendencies of Turkish consumers within COVID-19 process

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Abstract
Some occasions and situations lead significant variation and evolutions in continuity of livelihoods. The impact of COVID-19 pandemic has been visible in many aspects since its first announcement in 2020. Even if the people seemed to turn back to their old routines, the routines had already changed within the process. This paper aimed to look at the changing nutrition preferences and demand for specific products. An online consumer survey was applied in 2020 in Turkey with 499 randomly selected individuals to understand their changing demand for fresh fruits and vegetables and animal products. The rising purchases were estimated against socio-demographic factors with multinominal logistic regression. The outputs indicated the importance of education, level of income and amount of prospective spending on nutrition for maintenance of demand and supplies under pandemic conditions. JEL Codes: D12, D91, I12, H24

Key words
COVID-19, consumption, food, logit, income

Introduction
There have been many changes in lifestyles, socio-economic conditions, preferences, and attitudes of individuals due to emergence and persistence of unexpected COVID-19 pandemic in 2020. The effects of the disease have been harsh on socio-economic situations in many countries. Individuals have been experiencing many challenges in their daily routines since then, due to rising health consciousness and economic consequences of the disease.

Departing from a representative sample of consumers from Turkey, changing food purchases and consumption tendencies of the society within the COVID-19 process were evaluated. The main objective was to differentiate the factors that affect the rising tendency to buy and consume specific products under pandemic conditions. This emphasis was considered as necessary for potential future occasions, and it was aimed to provide some information to the producer and suppliers in a comparative way. Therefore, probability to increase purchases consumption of vegetables, fruits, meat and milk products were estimated due to responses of a random sample of 499 people to understand the factors that affect rising consumption.

Materials and methods
Posterior to the initial shutdowns in Turkey to disable dispersion of COVID-19 after March 2020, an online consumer survey was conducted randomly. Changing lifestyles and purchasing - consumption tendencies of 499 correspondents within the COVID-19 process were assessed. Detection of changing demand for specific food and agricultural product groups and factors affecting those demand shifts are considered as contributory for marketing organisations and management of supplies both for the pandemic conditions and for future occasions. Therefore, COVID-19 related changing tendency to buy and consume more vegetable products, fruits, meat and milk products of the representative sample were estimated with binary logistic regression.

The analyses focused on rising consumption on four product groups and its possible categorical or continuous factorial causes. These sorts of probabilistic analyses are made by binomial or multinomial analyses that infer on the detected probability estimation of a binary/dichotomous or scaled/polychotomous variable (McFadden, 1973). For the concerned multiple dependent variables referring to binary choices and factors related to probability of realisation of these choices can be indicated as following.

Dependent Variables	Independent Variables
If the household started to buy and consume more: • Vegetables – Cv=1 • Fruits – Cf=1 • Meat products – Cmeat=1 • Milk products – Cmilk=1	• Gi: Gender of the individual – Binary (female – 1; male – 0) • Ai: Age of the individual – Discrete • ACi: Age category of individual – scale (below 29: 0; 30-49: 1; above 50: 2 • Ei: Level of education (1: elementary; 2: secondary; 3: BA/BSc; 4: MSc+) • ESi: Sector employed in (public: 1; industry: 2; construction: 3; agriculture: 4; services: 5) • VEi: **Expenditure on FFVs (**Quantitative – Continuous, TL) • VE_Ci: Categorical **Expenditure on FFVs (**below $136,26: 0; $136,26-$272,51: 1; above $272,51: 2)
If the household started to buy and consume less or made no difference in consumption attitudes: 0	• **AEi : Expenditure on Animal Products (**Quantitative – Continuous, TL) • AE_Ci: Categorical **Expenditure on Animal Products (**below $136,26: 0; $136,26-$272,51: 1; above $272,51: 2) • Ui: Unemployment situation in the household (there is unemployed member:1; no one is unemployed within COVID-19 process • **DIi: Downsizing in Household Income (**Quantitative – Continuous, TL) • HIi: Categorical Household Income (below minimum wage -$313,38:1; minimum wage-$313,38: 2; $313,38-$613,14:3; $613,14-$885,64:4; $885,64 above:5)

Checking out the binomial characteristics of dependent variables and multiple independent variables, multivariate logistic regression analyses were conducted. The logistic regression model was initially proposed by Berkson (1944) and developed thereafter for inference on situational or behavioural probabilities. The logit or log of probability function adapted to four product groups can be demonstrated as following. The equity intends to infer on effects of discrete/continuous variables via estimates of β and effects of categorical variables with estimates of α.

$$log[Pr(Y = 1|x)] = \ln\left[\frac{Pr(Y = 1|x)}{1 - \Pr(Y = 1|x)}\right] = \sum \beta_i x_i + \sum \alpha_i D_i + u_i$$

Detected probability ranging between 0 and 1 were estimated against grouped/scaled or discrete/quantitative variables to find out and comment on the probability of odds (Efron, 1988, Cox and Snell, 1989). Parameter estimates are inferred as odds of occurrence for binary/categorical variables over non-occurrence. Odds ratio for the estimate is reached by antilog transformation or taking e^b and the odds lead inference on the relationship between two categorical variables (Bland and Altman, 2010).

Results
In the first instance, it is important to note that variations in consumption behaviours were measured though categorical responses of consumers. The share of 499 individuals that declare a rising tendency for four product groups ranges around 32 %. The rising tendency of the respondents for meat products was lowest with 27 %. On the contrary the declination was highest for fruits

with 9 %, followed by meat (8%), vegetables (7%) and milk products (6%). Prior to measuring and evaluating the effects, it is important to note the varying spending on FFVs and animal products within the process. It was understood that 28 % of the consumers were spending below $136,26 to FFVs, while 38 % were paying more. However, 69 % or participants were spending below $136,26 on milk/meat products, while only 8 % were spending above $272,51 by the date of survey.

Many random respondents were female with 60 % share and the average age was 40. This may be considered as an indication of well-endowment on nutrition information of the households. In addition, education level was high enough with 54 % Bachelor's graduates and 30 % of the surveyed seemed to hold MSc and above degrees. This educational stance can be related with the online survey process. More than half of the participants (55 %) seemed to live alone or with 2 companies at most and 41 % declared that they have children. This social frame signs participation of mostly white-collared workers. While 51 % of the audience were public workers, the share of fully employed people rises to 85 % with private workers.

Keeping these demographic features of the target groups on mind, it is essential to understand and evaluate the changing purchasing and consumption attitudes hereafter.

Probability to buy more vegetables and fruits within the COVID-19 process

Respecting the potential indicators, the probability to buy more vegetables was estimated in the first instance towards all indicators. The antilog of estimators and their individual and joint significance were inspected due to statistical and economical requirements. Odds ratio that is equal or almost equal to 1 has no statistical impact on the dependent variable (Adams and Conway, 2014). The odds with more than 1 may induce rise in the effect, while the impact is reverse for strictly low odds. Checking out odds and Wald test following a Z distribution results, the indicators were reduced. Therefore, the probability to buy and/or consume more vegetables within COVID-19 process seemed to be determined by the amount of expenditure on Fresh Fruits and Vegetables (FFVs), level of education, household income, sector employed and existence of unemployed family member. The results were demonstrated in Table 1.

The statistical strength of the estimates was the following concern. Cox-Snell and Nagelkerke pseudo-R^2 joint significance statistics are produced by SPSS to be used in exchange of Mc Fadden R^2 (Cox and Snell, 1989, Nagelkerke, 1991). Yet, these significance statistics were lower than expected. Therefore, joint significance of the estimation can be viewed by Likelihood Ratio test (Gujarati, 2003) and higher log-likelihood statistic refers to significance of estimates (Crochiere et al., 1980). In addition, Hosmer - Lemeshow (H-L) statistic also provides insights on joint significance as well. The significance of binomial estimators can be confirmed with the probability value of H-L statistic. As the p-value of the statistic gets higher, the estimates can be inferred due to the (Hosmer and Lemeshow, 1989).

The rising expenditure devoted to FFVs in scales indicates 1,4 times more vegetable purchases. An individual paying between $136,26 and $272,51 would buy 1,4 times more vegetables than one paying below $136,26. The raise for above $272,51 budget was almost double (1,96) of the base budget share.

While exp(b) provides the odds ratio and comparison between existence and inexistence of situations, the estimated probability is important for evaluation of the changing individual conditions (Cramer, 2002). Therefore, probability to consume more vegetables was compared depending on the individual characteristics taking household income as a reference. For individuals having moderate household income ($613,14-$885), a moderate spending amount on FFVs ($136,26-$272,51), having no unemployed household member were categorized due to the sector they were employed (public -industry) and education level as (BA/BSc – MSc and above). Occurrence probability of relevant cases was calculated with the following formula and indicated in Table 2.

P=1/(1+e^(-E(Y^))

In comparison to the original set up, it can be said that the probability of public workers to consume more vegetable products was lower than the other employees as can be seen in Table 2. The rising probability was visible concerning the rising education level. It can be concluded that public workers with tertiary and higher degrees and industry sector employees having below master's degrees are expected not to rise their vegetable purchases and consumption in Turkey with probability scores below 0,5. However, it is important to keep in mind that the reference education levels are comparatively high and above 0,5 probability can be understood with this perspective.

Following vegetables, socio-economic impact on probability to purchase more fruits was estimated and initial parameter estimates were indicated in Table 3. The statistical significance of estimation outputs was close to vegetable purchases. An individual is expected to buy 1,4 fold more with rising scale of income as it was the case for vegetables. Specifically log-likelihood and H-L statistics enables further inference. Rather than the inference of odds-ratio, a probability comparison was intended due to employment status of the correspondent or the household. Therefore, the probability estimated for different sectors employed were demonstrated in Table 4 briefly.

As the only variation measure left was the sector employed, the probabilities were estimated and calculated accordingly. All estimates were below 0,5 and there was no significant evidence of rising fruits purchases during the COVID-19 process for the concerned households. In contrast to vegetable purchases and consumption, tendency to increase fruits consumption seemed to be lower. This finding seemed to be contradictory with findings of some similar research. A probit analysis conducted via telephone interviews with 1.023 individuals indicated rising focus on fruits as well as other fresh products (Guney and Sarigun, 2021). A comparative analysis between Turkey and Portuguese inferred rising tendency to buy and consume more organic fruits and vegetables in both countries (Guiné et al., 2022). These varying findings call the need to analyse the impact of price and income alterations as well for sample of Turkey. Prior to further discussions, the decisions regarding meat and milk products were analysed as well.

Probability to buy more meat and milk products within the COVID-19 process

The determinants for variation in demand for meat products were appeared as education level of the correspondent, the sector that the individual is employed, and the amount of budget devoted for animal products. The parameter estimates were indicated in Table 5.

The statistical significances of the parameters and the equation estimated were similar. All parameters seemed to lead rising meat demand. The expected value of estimated parameters indicated the scaled rise for ranges of variables. High school graduates seemed to demand 1,27 folds more meat than primary school graduates. Yet, ones that hold college degree purchased 1,62 and that hold MA and above degrees 2,06 times more meat than primary school graduates. The budgetary allotment provides a similar upscaling in demand and purchases. The ones that spend between 136,26 and 272,51 Dollars to animal products seemed to buy 1,256 times more meat, the highest class spending more than 272,51 Dollars were buying 1,57 times more meat within the pandemic process. The scenario was renewed for meat products taking the sectors as a reference again.

The exact intention to buy more meat products is only visible for services sector workers holding at least MSc degree with the probability estimate above 0,5 which also means positive likelihood of meat consumption. The remaining estimates were demonstrated in Table 6. Besides, the share of the participants that declared wiring intention to buy more meat products was lowest within four groups and households dedicating more than $272,51 was very low with 8 % and many participants seemed prefer paying more to FFVs rather than animal products. Yet, even if the measured probability scores were lower for the rest scales, it is still visible that the tendency rises with rising education level.

Milk consumption variations were estimated to seek the impact of the pandemic as follows. The determinants of the intention to buy and consume more milk products were the same as meat products and the alternative aggregate significance statistics enable inference. It can be said from probability estimates Taking place in Table 7 that the scaled rise for education, sector employed, and budget devoted for animal products is more than 100 %. In other words, university graduates were demanding 1,42, those with higher education were demanding 1,69 times more than elementary school graduates. The ones devoting highest share of their budget declared that they demand 1,48 times more than the lowest share as below 136,26 Dollars. Finally, the probabilities of rising milk products demand were compared depending on the sectoral focus. The comparison due to the changing preference towards milk-based product preference based on employment situation and income and education levels was demonstrated in Table 8.

It was understood that the tendency to purchase and consume more milk products as raw milk, yoghurt, butter or cream had risen relatively within the COVID-19 process in 2020. Due to the feedback from 499 individuals, leaving public officials aside, the people with higher education seemed to declare their pure intention to buy more milk products, with detected probability above 0,5. The figure provided the same inference for college graduates that were employed in construction, agriculture, and services sectors. However, it is still important to remember that the variation for milk products were much lower than the other product groups.

Discussion

Statistical analyses of four product groups provided compatible and comparable outcomes. A significant finding is the rising probability in response to rising education level. In comparison of the odds, the average household income and the amount of income devoted to FFVs or animal products were taken as fixed. Yet, the rising impact of the expenditure level is visible from positive parameter estimates in all cases. So, even if it was not signified quantitatively, rising consumable income and the amount devoted for products affect the tendency positively.

Although there has been much primary research focused on rising consumption within the pandemic process, the changing patterns were mostly attributed to psycho-social factors. Health and nutrition related findings strictly emphasized rising food intake of Turkish consumers during the pandemic and continuous stockpiling activities (Bolek, 2021, Ozenoglu et al., 2021). Yet, our current research provided a different and complementary view for supply management and pricing of products. Especially positive impact of tertiary education on rising demand and the change related with occupational status of correspondents refer to the rising potential of online order and delivery systems for the audience.

Previously, in the research prepared from the same sample, the impact of rising income was recognised in purchases from all venues including online systems (Ceylan et al., 2021). In other words, rising tendency of online shopping with rising education can be confirmed with the current findings as well. In addition, another survey study completed in Tokat province of Turkey with 277 consumers inferred impact of rising education and income on the purchasing decisions. Serbian consumers declared positive valuation of online shopping and rising interest through rising education (Ivanović and Antonijević, 2021). Even though the major focus was online shopping in these examples, impact of education and income was visible as well.

An aggregate evaluation may focus on price and income alterations. A nationwide survey with more than 1.000 people in Turkey indicated that changing purchasing and consumption attitudes were related with changing prices. This was correlated with changing economic conditions as well (Guney and Sarigun, 2021). Their relevance to our research is related with the declining tendency effect of unemployment situation for fruits and vegetables. The meat consumption tendency was surveyed within different settings. For different meat kinds, 1.000 consumers declared no change or slight increases in demand. Yet, the survey that was conducted at the early days of COVID-19, considerable declination in demand was observed for fish products with 31 %, while the rate was around 11 % for red and white meat. Medium-term economic views and prices seemed to affect the audience especially in meat product (Haskaraca et al., 2021).

There have been alternative ways of looking at the variations. A factor analysis was undertaken in three countries focused on rising product preferences in 2020 demonstrated that Portuguese consumers increased consumption of sea-food, bread and butter. It was found out that Chinese maintained their traditional preference as rice and meat and Turkish consumers declared raised consumption of meat and eggs. However, the FFVs focus seemed to rise more in the Mediterranean Portugal and Turkey (Kartari et al., 2021). This is relevant to our findings as well. In addition to focus on online shopping tendency, rising interest on grocery or meat purchases was confirmed for Morocco through an online survey (El Bilali et al., 2021). Therefore, panic buying and stockpiling had been effective at the onset of the process and is still preferred by educated ones and individuals receiving above-moderate income.

Conclusions

As an unexpected incidence, the COVID-19 pandemic led to many changes in perceptions and preferences of consumers. Demand for different product groups mainly varied with education, income and employment status related factors. Besides, sectoral orientation of employment signed importance of reaching products that public officials or workers in industry seemed to get affected from variations on education or income related factors on a lower extent. In other words, rising education or income seemed to direct workers in agriculture and services sectors to buy and consume more food products, considering the odds ratio indications in almost all product groups. As the survey was conducted at the early days of the pandemic in Turkey, the views and perceptions of households may have evolved then. However, regardless of the impact's size, the effective factors seem to be comparable with relevant field-based research findings. Therefore, price and income alterations and supply management seemed to be important for these kinds of situations and policy makers should keep socio-economic effects in mind.

Tables

Table 1. Probability estimates for vegetables

Variable	**Estimate (b)**	**Wald (p)**	**Exp (b)**
VE_Ci	0,337	5,625 (0,018)	1,401
Ei	0,080	0,30 (0,584)	1,083
HIi	-0,238	4,976 (0,026)	,788
ESi	0,087	0,741 (0,389)	1,091
Ui	-0,554	3,268 (0,071)	,575
Constant	-,502	0,612 (0,434)	,605
LR:	-2 LL: 612,497	**Cox & Snell R2:** 0,024 **Nagelkerke R2:** 0,034	H-L: 8.28 (0,36)

Table 2. Comparative probability for vegetables based on education and sector employed

	Public	**Industry**	**Construction**	**Agriculture**	**Services**
FFVs Expenditure: 136,26-$272,51 Household Income: $613,14-$885,64 Education: BA/BSc	0,45	0,48	0,54	0,59	0,64
FFVs Expenditure: 136,26-$272,51 Household Income: $613,14-$885,64 Education: MSc+	0,49	0,54	0,59	0,64	0,70

Table 3. Probability estimates for fruits

Variable	**Estimate (b)**	**Wald (p)**	**Exp (b)**
VE_Ci	0,338	5,606 (0,018)	1,402
HIi	-0,199	3,561 (0,059)	,819
ESi	-0,947	8,317 (0,04)	,388
Ui	0,139	1,952 (0,162)	1,150
Constant	-0,477	,861 (0,353)	,620
LR:	-2 LL: 604,429	Cox & Snell R2: 0,34 Nagelkerke R2: 0,047	H-L: 10,17 (0,18)

Table 4. Comparative probability for fruits based on sector employed

	Public	**Industry**	**Construction**	**Agriculture**	**Services**
FFVs Expenditure: 136,26-$272,51 Household Income: $613,14-$885,64	0,152	0,059	0,023	0,009	0,003

Table 5. Probability estimates for meat products

Variable	**Estimate (b)**	**Wald**	**Exp (b)**
Ei	,241	2,507 (0,113)	1,273
ESi	,045	0,192 (0,661)	1,046
AE_Ci	,228	2,802 (0,094)	1,256
Constant	-2,091	12,987 (0,00)	,124
LR:	-2 LL: 575,437	Cox & Snell R2: 0,014 Nagelkerke R2: 0,021	H-L: 5,58 (0,58)

Table 6. Comparative probability for meat products based on education and sector employed

	Public	**Industry**	**Construction**	**Agriculture**	**Services**
Animal product Expenditure: 136,26-$272,51 Education: BA/BSc	0,34	0,35	0,37	0,38	0,40
Animal product Expenditure: 136,26-$272,51 Education: MSc+	0,43	0,45	0,47	0,49	0,51

Table 7. Probability estimates for milk products

Variable	Estimate (b)	Wald (p)	Exp (b)
Ei	,175	1,523 (0,217)	1,192
ESi	,115	1,443 (0,230)	1,121
AE_Ci	,198	2,358 (0,125)	1,219
Constant	-1,738	10,413 (0,00)	,176
LR:	-2 LL: 619,573	Cox & Snell R 2: 0,010 Nagelkerke R 2: 0,014	H-L: 6,09 (0,53)

Table 8. Comparative probability for milk products based on education and sector employed

	Public	Industry	Construction	Agriculture	Services
Animal product Expenditure: 136,26-$272,51 Education: BA/BSc	0,407	0,456	0,512	0,574	0,644
Animal product Expenditure: 136,26-$272,51 Education: MSc+	0,484	0,543	0,610	0,684	0,767

Statement of Conflict of Interest

The author(s) declare no conflict of interest for this study.

Author's Contributions

The contribution of the authors is equal

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Can sorghum Sudanense be an alternative for maize forage in the frame of sustainable water management?

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Abstract
Maize forage is an important feed crop for animal breeding, and it needs a significant amount of water during cultivation. Sorghum Sudanense (Sudan grass) has appeared as an alternative to maize forage with its similar feeding qualities but lower water demand. This study intended to understand the potential effect of de-coupled price supports on production of sorghum and maize. Therefore, production amount of maize and sorghum were estimated for the USA, as a major forage crop producer, with supply response modelling for 1991 and 2021 to understand the effect of price on supplies.
The findings inferred that price affects maize and sorghum supplies in the USA by 20 % on average with an annual lag, with almost no difference. The USA example emphasized the importance of informing producers and sellers of feed products, and animal breeders regarding the low water demand and lower irrigation costs of Sudan grass. This may contribute to lower water use in feed production for animal breeding and to water sustainability accordingly. Besides, it was understood that price incentives may be used to encourage users of sorghum Sudanense rather than sorghum farmers to promote the product in the forage crop market in an indirect way. JEL Codes: Q11, Q18, Q31

Key words
Forage crops, water, sustainability, price, USA

Introduction
Rising population and consumption exert pressure on water, food, energy, and other natural resources. Sustainable and proper utilization of natural resources is very important in meeting the needs of the rising population. Management of resources to proceed in environmental sustainability was emphasized by the United Nations' World Commission on Environment and Development (or the Brundtland Commission after 1983) (Smardon, 2015). Production of goods and services needs to be planned and maintained considering environmental and economic sustainability. This view includes the maintenance of agricultural activities and food production through managing their environmental effects. Due to rising population, demand for vegetable and animal products has been rising. Demand for forage crops that are used as feed in livestock breeding rises as well. However, the amount of water used, especially in roughage production, is quite high. This is an important problem in terms of the sustainability of water supplies.
Water has received more attention recently as an agricultural input as most of the water is concentrated in specific regions (Pimentel et al.,1999; Qadir et al., 2003). In addition to human use for drinking and sanitation, the amount of water used in forage crops is quite high (Huang et al., 2020). The quantity and quality of forage produced are now thought to be important for the efficient use of land. The ability to produce a high dry matter yield of good-quality forage using corn has a stimulating effect on its extensive cultivation, mainly in temperate areas (Wedin, 1970; Silva, 1981).
Forage maize, which is a C4 plant, is important in feeding livestock and it has a significant irrigation water demand. Maize is the least resistant cereal to abiotic stresses such as drought, salinity, and elevated temperatures (Dragičević et al., 2016). Rain-fed maize cultivation is still the most widespread cropping practice. Therefore, water management is very important in forage maize (*Zea mays L.*) production in two sustainability directions. Assuring water supply security and sustainability in cattle breeding is related to the production and use of forage maize. Finding alternatives for forage maize may also contribute to water sustainability.
Sorghum Sudanense, is a high yielding hybrid of sorghum that grows fast and can be adapted to warm conditions as it is drought tolerant (Ha, 1995). Sorghum Sudan grass farming provides a year-round supply of nutritious forage for livestock consumption (Nazli et al., 2014; Chaudhuri et al., 1986). It is widely used in livestock breeding as both green fodder and silage due to its nutrient content and low water requirements (Moray and Istanbulluoglu, 2022). Sorghum has been recognized as a viable option in Europe for addressing these challenges (Ramos et al., 2012). Therefore, it can be considered an alternative to forage maize.
With this research it was aimed to compare these two specific forage crops, forage maize and sorghum Sudan grass. The probability of offering sorghum as an alternative feed was evaluated with a complementary perspective. The price impact on maize and sorghum supplies in the USA was estimated using a time series approach. The selection of the USA was related to its supremacy as a major supplier of both crops.

Materials and methods
The supply response to specific factors, especially price, was estimated for the USA's maize and sorghum production to understand the substitution potential of these two forage crops. The USA was selected as the example for analysis due to the country's experience with both products. Annual change in the USA was demonstrated and evaluated between 1961 and 2021. Following this process, maize and sorghum supplies were estimated for 30 years between 1991 and 2021 using time series supply response analysis (Nerlove and Addison, 1958; Granger 1981). The data was withdrawn from the FAOSTAT databases (Anonymous, 2023).
The main objective of the analysis was to measure the effects of price and non-price factors on the quantity supplied of any product. An important significance of modelling agricultural production is the need to consider time lags, especially for the impact of price. As there is a time gap between the planting and harvest of vegetable products, all factors affect supplies with time differences in the time series analysis frame (Engle and Granger, 1987; Dickey and Fuller, 1981). This process is related to the production characteristics of agricultural products. The exemplary products focused on are annual and accordingly, the supply relationship is expected to involve at least one year of lag, and the statistical equations to be estimated are set as follows:

$$Q_t = f(Q_{t-1}, P_{t-1}, Z_{t-1})$$

Here the quantity produced at time t (Q_t) is estimated against price (P_t) and non-price (Z_t) factors. The main non-price factor was the area in which either maize or sorghum was harvested. Supply of two products were estimated against price and land devoted for cultivation in the USA for 1991–2021 using E-views. The findings were demonstrated in the following section.

Findings
Changing sorghum and maize production in the world and in the USA (1961–2021)
The aggregate lands devoted to maize forage were 105 million hectares in 1961 and had risen to 205 million hectares with 95% coverage in 2021 FAO (Anonymous, 2023). The changing amount produced globally is more significant. The rise was almost five times larger, from 205 million metric tons in 1961 to 1,2 billion metric tons in 2021. For sorghum production, the inference needs further explanation. The amount of land utilized has declined in the past 60 years with 46 million hectares in 1961 reducing to 41 million hectares. However, the global sorghum production was 41 million metric tons in 1961 and rose to 61 million metric tons in 2021. Therefore, a yield appreciation might be considered for sorghum.
The important sorghum producer countries were the USA and Mexico,

followed by Nigeria, Sudan, India, and Ethiopia. The highest amount of production was in 1985, with 77.5 million metric tons. As the crop is annual, the fluctuations are related to weather conditions and the record-keeping of the relevant countries.

Following this global assessment, it was intended to maintain a continental comparison for forage crops. The cultivation land and production amount of two crops were compared between and among two continents: Africa and the Americas for 1961 and 2021. The irrigation characteristics of destinations are the main reason for continental limitations.

The amount of land used for maize production had risen by 175% in 60 years in Africa. Yet, the amount cultivated had risen by almost five times and reached almost 100 million metric tons. The same figures indicated in Table 1 correspond to 113% for land and 146% for the amount produced for sorghum. The yield per hectare more than doubled for maize in the selected years. However, the average yield seemed to be steady for sorghum. This may be attributed to increasing irrigation opportunities in Africa when the rise in maize is considered.

The figures were visited for America as a continent. The change in figures signified rising land and harvested amounts for both crops within 60 years as demonstrated in Table 2. However, there was a fluctuating tendency for sorghum in contrast to maize. The land used for maize forage rose by 75%, the amount cultivated quadrupled and the yield per hectare increased from 2,68 to 7,81 metric tons in 60 years. Despite declining area from 2000 to 2021, there was no reduction in the sorghum production. Due to declining lands and increasing production, the yield seemed to rise during this period. This is also related to irrigation opportunities.

Following the aggregate evaluation, the data for the USA was investigated and evaluated. The land devoted to maize production in the USA rose by 48% from 23 to 34 million hectares in 60 years. The corresponding change in the amount was more than three times higher, from 91 million to 384 million metric tons. A fluctuation in maize yield was observed thereafter. However, the tendency was toward appreciating figures. The highest yield of 11,74 metric tons per hectare was observed in 2016. There was a sharp decline in 2012 to 7,73 metric tons per hectare, which can be related to lower record keeping due to the global crisis and climatic fluctuations.

There were similar fluctuations in sorghum production. The steady rise is being maintained. Yet, the lowest observation in the recent 20 years was in 2012, like for maize. The same reasoning is relevant here as for economic and climatic shifts. In the last 20 years, the yield has seemed to rise by around 30%. The yield change was from 2,74 tons in 1961 to 4,33 tons per hectare in 2021.

These figures signify the need to analyze, especially, the price impact on production of these two alternatives. The analysis was based on a time-series approach, and price was considered the main determinant of supplies. After descriptive and integrative tests, the relationship between two products was reduced to quantity and price.

Sorghum supplies in the USA (1991 – 2021)

The normality of variables was assured via logarithmic transformation, and cointegration processes were confirmed via ADF test procedures (Johansen, 1988). The estimation outputs were demonstrated in Table 3 after confirmation of cointegrating relationships, as all variables were found as I(1) after normalization (Benoit, 2011). Considering the annual characteristics of crops, this has also been an expected situation.

The relationship between sorghum supplies, previous supplies and prices adopted by farmers was estimated. The one-year-lag in supply determinants seemed to explain 32% of the variation in sorghum supplies. This might be considered low, but above 20% significance can be inferred, especially when the joint significance is confirmed with the F-statistic (Table 3). The variation explained by the model is 61%.

It was noted that the parameter estimates in the log-log model indicate percentage changes in the dependent variable (Benoit, 2011; Dickey and Fuller, 1981). So, with a 100% rise in the previous year's sorghum supplies, contemporary supplies rose by 59%. The price impact was lower than the quantity impact. The price dependency seemed to be 4%.

Yet, for proper interpretation, the time effect was checked and demonstrated in Table 4. With the implication of the same procedure, it was understood that the factorial explanation declined slightly to 55%. Yet, the effect of time was negative with 2%, while the previous price level seemed to lead to 22% appreciation.

As the estimation findings are more concise and inferable, the almost negligible time effect could be accepted. This effect can be related to the low acceptance of sorghum by producers or the ease of shifting to other products. Maize supplies were estimated afterwards.

Maize supplies in the USA (1991 – 2021)

The relationship for maize supplies was compared with previous supplies and prices adopted by farmers. The variation explained by the previous production and maize prices appeared to be 61%, and estimates were significant jointly and individually as demonstrated in Table 5.

It was understood that with a 100% rise in the previous year's announced purchasing prices, current maize supplies are expected to rise by 21%. The follow-up effect of the quantity supplied was 54%.

Specifically, the price impact for both forage crops seems to be similar at 20%. Yet, the ease of leaving sorghum production and additional suggestions should be considered with respect to water management in forage crop production.

Results and Discussion

It is essential to look at the water demand of the two crops during irrigation and cultivation. There are many studies that focus on the comparison of forage crops and conclude the superiority of sorghum Sudan grass as an alternative. Some of the relevant studies were summarized below.

Meeske and Basson (1995) studied maize (*Senkuil*) and a forage sorghum hybrid (*DeKalb FS2*) as silage crops under drought conditions. Sorghum yielded more digestible organic matter per hectare than maize, even though their preservation under aerobic conditions was similar.

Huang et al. (2020) studied yields and soil water consumption characteristics of sweet sorghum (*Sorghum dochna*), Sudan grass (*Sorghum Sudanense*), and forage maize (*Zea mays L.*) for two consecutive years under natural rainfall conditions. Forage sorghum presented the highest yield, seemed to consume less soil water than forage maize, in addition to having similar nutritional quality for breeding. Sorghum appeared as an advisable option for forage production in the soil-water-limited semi-arid regions.

Getachew et al. (2016) indicated the adaptation potential of sorghum to a variety of agronomic and environmental conditions, particularly in areas with low rainfall or limited access to irrigation water. Forage sorghum produces a comparable yield to corn, suggesting that there is a potential for sorghum to replace corn in areas where water supply is limited. But there is a lack of information on the feeding value of sorghum silage for high-producing dairy cows.

Uzun et al. (2017) studied changes in irrigation water use efficiency (IWUE) and some agronomic and nutritional characteristics of forage maize and sorghum cultivars (CVs) irrigated in shallow soil. Two maize and seven sorghum cultivars were evaluated in rain-fed (NIR) and irrigated (IR) field conditions for a 3-years period. There was an advantage for sorghum CVs over maize CVs. The superiority of sorghum cultivars was related to agronomic and nutritional traits in shallow soil, irrespective of irrigation.

Schittenhelm and Schroetter (2013) compared the drought tolerance of maize, sweet sorghum, and sorghum Sudan grass hybrids. Sweet sorghum and sorghum Sudan grass hybrids were considered worthy alternatives to maize for biogas production under drought conditions as well.

Piccinni et al. (2009) reported crop water use for maize and sorghum for 3 years. Accumulated seasonal crop water use ranged between 441 and 641 mm for maize and between 491 and 533 mm for sorghum, signing lower average for sorghum.

Gelley et al. (2020) found out that it is essential to prepare agricultural producers for volatile weather changes, specifically drought. This preparation requires a better understanding of forage water use efficiency. Sorghum Sudan grass had appeared as a forage alternative with its drought mitigation and resilience properties.

The relevant previous research can also be related to water preservation potential via cultivating and using sorghum forage. Therefore, the suggestions regarding forage crop preferences should be related to the findings of current research.

Conclusion and Suggestions

Departing from these examples, it was considered beneficial to return the estimation findings for the USA. Sorghum Sudan grass, and maize forage have similar price impacts based on data from 1991 and 2021. The previous year's price affects current supplies of both products by around 20%. Doubling the market price or price incentives may induce a 20% rise in supplies on average. Departing from the USA's example, this can be generalized to countries with similar endowments. However, we need to keep in mind that producers may prefer or focus on either product, but forage maize production is widespread around the world. Yet, introducing or promoting cultivation of the alternative sorghum varieties may contribute to better management of water resources. In this respect, other features of sorghum production should be considered.

Annual preference towards sorghum cultivation seemed to be negative via the estimate of the trend parameter, even if it is very low. This is related to the easy shift to other products, as mentioned before. However, keeping similar price effects aside, the producers may leave sorghum production due to low market awareness or limited demand from cattle breeders, forage sellers, and exporters. If this has been the case for the US market, it is also valid for the rest of the world.

Extensive information of feed farmers and sellers and cattle breeders may increase attention to sorghum farming. Especially if feed farmers are acknowledged about the lower water demand of sorghum farming which leads to lower irrigation costs, they may be willing to shift to sorghum. Consequently, less water use in sorghum farming would contribute to water sustainability or even water security. But to keep farmers in the market, demand from the market needs to be induced. Informing livestock breeders about lower water demand and potential lower costs may lead to change in traditional breeding practices. Direct promotion and information of actors that may use sorghum as feed can contribute to acceptance of sorghum, especially in Asian, American, and African countries, where the costs of animal breeding to the environment and climate have been rising.

These shifts can be achieved via price support or well-calculated subsidies that can be provided by the central or regional authorities. Departing from the US example, it is more achievable and efficient to provide decoupled support where rising yields have not been directly related to the field of production. However, for producers in African countries, where maize production has been declining already due to irrigation causes, cost-price promotions can be considered as more attached to lands or production amounts. Even though the effect of price seems similar with maize, cost efficiency and water savings may lead to changes in the market. Besides, extension activities need to be incorporated into the promotion of the alternative regardless of the existing choice of production. These information efforts should include animal breeders also. Looking at the limited price effect, demand-driven supports may also lead pragmatic changes in favor of producers and environmental sustainability. Even though the effect of price seems similar with maize, cost efficiency and water savings may lead to changes in the market.6.

Tables

Table 1. Land and production amounts of maize and sorghum in Africa

Africa	Maize (corn)			Sorghum		
	area - ha	**tons**	**yield**	**area - ha**	**tons**	**yield**
1961	15.461.095	16.147.243	1,04	13.214.290	10.691.514	0,81
2000	24.248.256	43.798.254	1,81	21.195.363	18.365.958	0,87
2021	42.456.666	96.637.314	2,28	28.134.341	26.280.475	0,93

Table 2. Land and production amounts of maize and sorghum in America

America	Maize (corn)			Sorghum		
	area - ha	**tons**	**yield**	**area - ha**	**tons**	**yield**
1961	43.418.705	116.312.914	2,68	5.799.547	14.390.682	2,48
2000	57.303.735	335.431.253	5,85	7.086.810	23.257.680	3,28
2021	75.860.140	592.356.330	7,81	6.324.741	23.598.501	3,73

Table 3. Sorghum Supply Response

Variable	Estimate	t-statistic (p-value)
Constant	6,36	1,36 (0,18)
Log(Qt-1)	0,59	2,78 (0,01)
Log(Pt-1)	0,04	0,22 (0,82)
R2: 32 %	**Mean Dependent Variable:** 16,23	
F (p-value): 6,26 (0,01)		

Table 4. Sorghum Supply Response with Trend

Variable	Estimate	t-statistic (p-value)
Constant	7,33	1,68 (0,10)
Log(Qt-1)	0,44	2,13 (0,03)
Log(Pt-1)	0,22	1,94 (0,18)
Trend	-0,02	-2,25 (0,03)
R2: 43 %	**Mean Dependent Variable:** 16,23	
F (p-value): 6,50 (0,00)		

Table 5. Maize Supply Response

Variable	Estimate	t-statistic (p-value)
Constant	8,05	3,26 (0,00)
Log(Qt-1)	0,54	3,93 (0,00)
Log(Pt-1)	0,21	2,24 (0,02)
R2: 61 %	**Mean Dependent Variable:** 19,47	
F (p-value): 21,22 (0,00)		

Statement of Conflict of Interest

The author(s) declare no conflict of interest for this study.

Author's Contributions

The contribution of the authors is equal

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Determination of Karyological Characteristics of Two Different Chickpea (*Cicer arietinum* L.) Varieties

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Abstract
In this study, the karyological characteristics of two registered chickpea varieties belonging to the Cicer arietinum species Aras and Katran were investigated. This study was carried out to determine the karyological differences in these varieties, which differ in terms of seed structure and color. Karyological observations were made by hydrolyzing and staining the fixed root tips. The chromosome number of both varieties was determined as 2n=2x=16. Both varieties were found to have the same karyotype formula (4m + 4sm). It was observed that the chromosome length of the Aras variety varied between 1.43 and 4.11 mm. When haploid chromosomes of this variety were examined, it was observed that three chromosomes had satellites on both arms of the first chromosome, the short arm of the second chromosome and the long arm of the fourth chromosome. Chromosome length varied between 1.81 and 3.89 mm in the tar variety. When the haploid chromosome set was examined, it was observed that both arms of the first chromosome and the short arms of the second, third, and sixth chromosomes had satellites. The metaphase chromosomes of the cultivars were photographed under a microscope, measured and ideograms were prepared. It was observed that there were differences between the examined varieties in terms of seed color and size, as well as some karyological differences. However, since these varieties are registered from the same species in terms of breeding, it has been observed that they are very close to each other karyologically.

Key words
Cicer, chickpea, chromosome number, karyotype

Introduction
Cicer reticulatum, defined as the wild ancestor of chickpea, has spread to large areas after being cultivated in Southeastern Anatolia and ranks second after beans among the world's legume cultivation areas. Today, it is cultivated in South Asia, West Asia, North Africa, Southern Europe, North America, South America and Australia, covering 33 countries all over the world, excluding the Antarctic continent. In South, West and East Asia, where cereal consumption is predominant, and for vegetarians who do not consume meat, chickpeas meet the need for high-quality protein (Öztürk, 2011). Chickpeas, whose homeland is the Mediterranean, contains plenty of beneficial proteins, minerals and vitamins. It is recommended that these legumes, which have high nutritional values, be consumed abundantly to increase body resistance in cold weather. Chickpeas also have properties such as cleaning the blood circulating in our body, increasing appetite, relaxing the digestive system and relieving vascular occlusion. This food, which is recommended to be consumed especially during the puerperium period because it increases breast milk, has also been reported to balance the estrogen hormone in the body (Sarıoğlan, 2022). The genus *Cicer* L. (Leguminosae) is represented in the temperate zone of the Northern Hemisphere with approximately 45 herbaceous or semi-shrub annual or perennial forms. Of these, 9 are annual and 35 are perennial taxa, of which the center of distribution is Southwest Asia and two endemic species are reported to be distributed in Morocco and Canary Islands (Van der Maesen et al., 2007). The total number of taxa, 22 of which are endemic, is 45 and the endemism rate is 48.9%. In the Flora of Turkey, the genus *Cicer* was represented by 10 species (Davis et al., 1988, Öztürk, 2011). Of these species, 4 are endemic, namely *Cicer echinospermum* P.H.Davis, *C. floribundum* Fenzl, *C. isauricum* P.H.Davis and *C. reticulatum* Ladizinsky (Davis, 1970; Davis et al., 1988). *Cicer heterophyllum* Contandr., Pamukç. & Quezel species and *C. uludereensis* Dönmez species, which are endemic to Turkey, the total number of species increased to 12 and the number of endemic species to 6, increasing the endemism rate to 50% (Öztürk, 2011). As reported by Venora et al. (1995), Dombrowsky-Sludsky (1927) was the first to report the number of chromosomes in chickpea (2n=14) and in the following years, researchers reported either 2n=14 or 2n=16 chromosomes (Rao, 1929; Dixit, 1932; Frahm-Leliveld, 1957). As a result of cytogenetic studies, this controversy has now been resolved and the chromosome number in chickpea is accepted as 2n=16. Ahmad and Hymowitz (1993) reported that the longest first chromosome of *C. arietinum*, *C. reticulatum* and *C. echinospermum* had satellites and the second chromosome of *C. reticulatum* also had satellites. Unlike the somatic karyotype analysis, detailed pachytene chromosome analysis of *C. arietinum* reported that satellites were also found on the third chromosome of this species. In this study, chromosome number and karyomorphological characteristics of two chickpea cultivars of different colors belonging to the same species (*C. arietinum*) were investigated.

Material
The seeds of the chickpea varieties used were obtained from Olgunlar agricultural company in Adıyaman province. Considering the general characteristics of chickpea varieties used in the study;
Aras (Winter Chickpeas)
Plant height 38-66 cm, upright growing, suitable for mechanized cultivation, light beige seed color, koçbaşı seed shape. Leaves are lighter colored than other varieties. The first pod height is 13-35 cm. The grains are light beige in color and it is a large grain variety. 100-grain weight is between 38.8-53.0 g.
Katran (Black Chickpea)
Plant height 33-65 cm, upright growing, suitable for machine cultivation, black seed color and dark leaves. The first pod height is 17-36 cm. It is black in color and has koçbaşı seed shape. The weight of 100 seeds is between 21.0-30.9 g.

Methods
The seeds obtained for the determination of the karyomorphological characteristics of these two cultivars were germinated on moist filter paper in petri dishes at 24℃. When the germinated seeds reached a length of 1-2 cm (Fig.1), they were pretreated in 0.05% aqueous colchicine solution for 2 hours at room temperature and pretreated in a saturated solution of 1,4 Dichlorobenzene for 4 hours at room temperature. The root tips were then removed from the pretreatment solution and fixed in acetic alcohol (1 glacial acetic acid; 3 ethanol) solution for 24 hours at +4 ℃ in the refrigerator. Root tips were stored in 70% alcohol in the refrigerator for later use (Acar et al., 2022; Tasar et al., 2023). For dyeing, the root tips were hydrolyzed in 1 N HCl acid for 20 minutes in an oven at 60℃. At the end of the hydrolysis process, the root tips were stained in Feulgen dye in the dark for 1 hour at room temperature (Hayta et al., 2014; Elci, 1982). When the staining time was over, the root tips were washed and left in water. In the preparations, it was observed that 0.05% aqueous colchicine solution was not effective. For this reason, the roots first treated with 1,4 Dichlorobenzene were used and gave positive results. Preparations were made to visualize the metaphase chromosomes and photographs of the appropriate metaphase chromosomes in these preparations were taken with a Nikon E200 research microscope at 100X magnification and a Nikon Digital Sight DS Fi2 microscope camera. The centromere status of chromosomes was determined according to Levan et al. (1964). Karyotype asymmetry was determined according to Huziwara (1962) (TF%), Arano (1963) (AsK%), Syi and Rec indices according to Greilhuber and Speta (1976), A index according to Watanabe et al. (1999) and A1 and A2 indices according to Romero (1986).

Figure 1. Germinated seeds used for mitotic examination; A: Aras variety, B: Katran variety

Results and Discussion

This study was carried out to determine the karyomorphological characteristics of two different colored chickpea varieties belonging to *Cicer arietinum* species. From the preparations examined, pictures of the cells suitable for karyological measurements were taken and the values of the long arm, short arm, and length of each chromosome, total length, relative length, arm ratio and centromere indices and chromosome asymmetry indices are given below.

Aras variety

In this study, the diploid chromosome number of the Aras chickpea variety was determined as 2n=16. As a result of the measurements and calculations, it was observed that the haploid chromosomes had 4 median (m) and 4 submedian (sm) structures according to the centromere status. The total length of the chromosomes varied between 1.43-4.11 mm and the total chromosome length was 18.72 mm. Arm ratios varied between 1.16 and 2.19. Relative length ranged between 8.22 and 21.96 and centromere index ranged from 31.32 to 46.22. Three pairs of chromosomes were determined in the chromosomes of the Aras variety (Table 1, Fig. 2,3).

Table 1. Karyomorphological data of Aras variety

Number	Chromosome length (µm)	Long arm	Short arm	Arm ratio	Relative length (%)	Centromeric indices (CI)	Karyotype formula
1	4.11	2.00+0.71*	0.80+0.60*	1.93	21.96	34.08	sm
2	2.63	1.41	0.77+0.45*	1.16	14.05	46.22	m
3	2.66	1.74	0.92	1.88	14.21	34.68	sm
4	2.29	0.70+0.55*	1.04	1.20	12.26	45.39	m
5	2.09	1.27	0.82	1.56	11.14	39.09	m
6	1.97	1.35	0.62	2.19	10.53	31.32	sm
7	1.54	0.93	0.61	1.52	8.22	39.63	m
8	1.43	0.94	0.49	1.92	7.64	34.20	sm

*****The length of the chromosome arm where the satellite is located

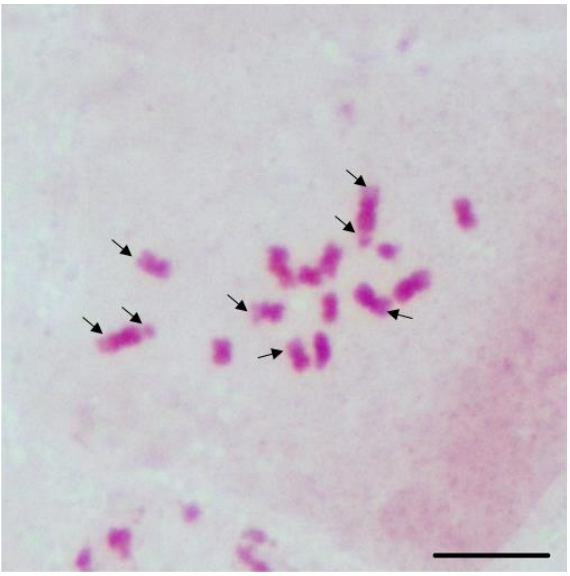

Figure 2. Metaphase chromosomes of the Aras variety (2n=16), Scala bar 10 µm.

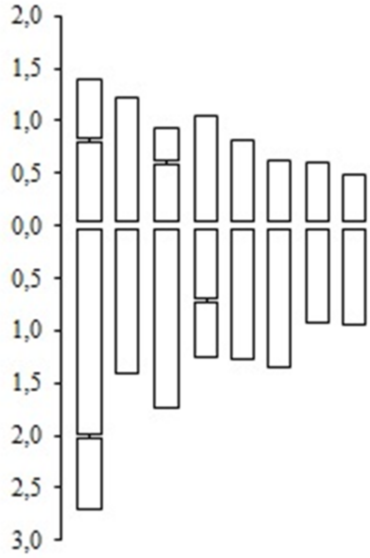

Figure 3. Ideogram of haploid metaphase chromosomes of the Aras variety

Katran variety

As a result of the karyological observations, the chromosome number of the Katran chickpea variety was determined as 2n=16. When the karyotype formula of the Katran variety is examined, it is seen that it has chromosomes with 4 media region (m) and 4 submedian (sm) centromeres. Chromosome lengths ranged between 1.81 and 3.89 mm and total chromosome length was determined as 19.45 mm. The arm ratio of the chromosomes reduced to haploid varies between 1.08 and 2.21. Relative length varied between 9.33 and 19.97 mm, while centromere index varied from 31.15 to 48.00. In addition, 4 pairs of satellites were observed in the chromosomes of the Katran variety (Table 3, Fig. 4,5).

Table 2. Karyomorphological data of Katran variety

Number	Chromosome length (µm)	Long arm	Short arm	Arm ratio	Relative length(%)	Centromeric indices (CI)	Karyotype formula
1	3.89	1.97+0.71*	0.71+0.50*	2.21	19.97	31.15	sm
2	2.89	1.50	0.78+0.61*	1.08	14.84	48.00	m
3	2.61	1.44	0.67+0.51*	1.22	13.43	44.97	m
4	2.39	1.44	0.95	1.52	12.31	39.67	m
5	2.05	1.32	0.74	1.79	10.56	35.79	sm
6	1.98	1.32	0.16+0.50*	2.02	10.18	33.08	sm
7	1.82	1.16	0.66	1.75	9.37	36.34	sm
8	1.81	1.18	0.63	1.88	9.33	34.75	sm

*****The length of the chromosome arm where the satellite is located

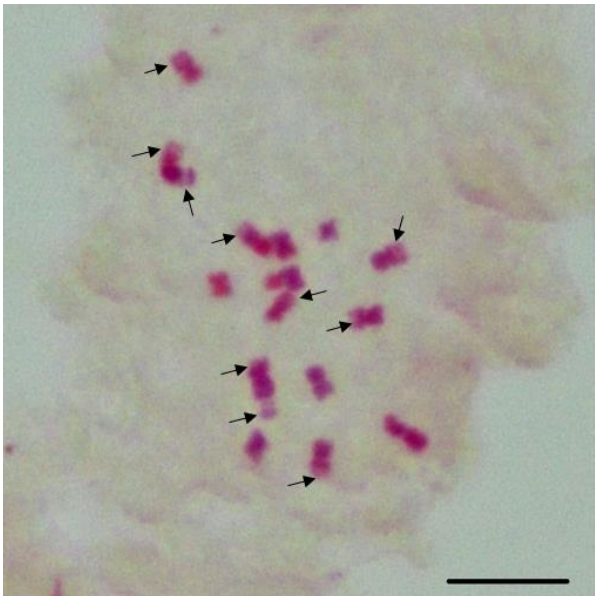

Figure 4. Metaphase chromosomes of the Katran variety (2n=16), Scala bar 10 mm.

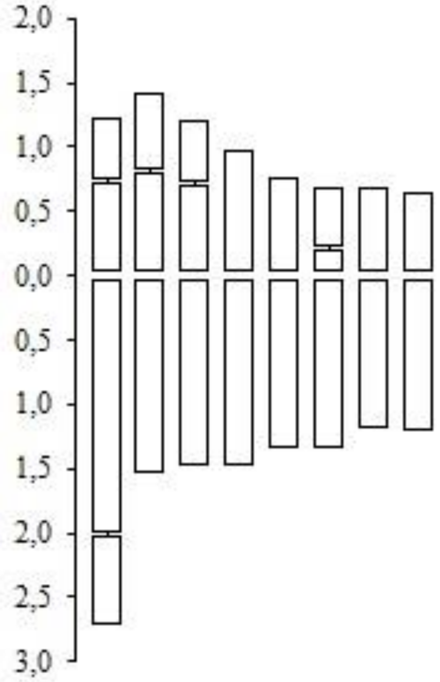

Figure 5. Ideogram of haploid metaphase chromosomes of the Katran variety

Table 3. Polyploid level, chromosome length range, total chromosome length and asymmetry index values (Rec, TF %, As K %, Syi, A, A1, A2) of different chickpea varieties (Aras and Katran).

Variety	2n	Ploidy level	Chromosome length Range	Total Chromosome Length	Rec	TF %	As K%	Syi	A	A1	A2
Aras	16	2x	1.43-4.11	18.72	56.94	37.98	62.01	61.26	0.23	0.37	0.29
Katran	16	2x	1.81-3.89	19.45	62.50	38.06	61.94	61.45	0.24	0.37	0.29

Chromosome morphologies and asymmetry indices of two different colored chickpea varieties are given in Table 3. The chromosome numbers of the varieties were determined as 2n=2x=16. Although the chromosome numbers and karyotype formulas of the varieties were the same, the Katran variety had higher values than the Aras variety in terms of both chromosome length and total chromosome length. Regarding the asymmetry indices, Rec index, TF% (total percent form) and Syi index values were higher in the Katran variety, while As K% (karyotype asymmetry index) index was higher in the Aras variety. While the A1 (intra-chromosome asymmetry) index and A2 (inter-chromosome asymmetry) index had the same value in both varieties, A (degree of karyotype asymmetry) index had a higher value in the Katran variety (Table 3). When the literature studies related to the subject studied are examined; Öner (1988) reported the chromosome number as 2n=16 in his karyological study on *Cicer arietinum* species. He also reported that chromosome lengths varied between 1.52 and 3.72 mm and a pair of satellites were determined on the largest chromosome. In this study, 4 pairs of chromosomes with satellites were observed in the Katran variety and 3 pairs of chromosomes with satellites were observed in the Aras variety. Venora et al. (1995) determined the chromosome number of *C. arietinum* species as 2n=16 and reported that the chromosome length varied between 1.03 and 3.45 mm. The karyotype formula of 3 of the 4 genotypes studied was reported as 3m + 5sm and one genotype was reported as 4m + 4sm. In this study, similar to the study of Venora et al. (1995), the karyotype formula of the cultivars in this study was determined as 4m + 4sm, which is similar to the previous studies. Öztürk (2011) reported the chromosome number as 2n=16 in his study on *C. arietinum* species.

Conclusion

In this study, the karyological characteristics of two registered chickpea cultivars belonging to *Cicer arietinum* species were determined. One of the varieties has a light beige seed color while the other one has black color. Despite the different seed structures of these varieties, the chromosome number was determined as 2n=2x=16 in both varieties. As a result of the study, since these two varieties were bred from the same species, although some differences were observed in terms of karyological characteristics (chromosome length, total chromosome length and asymmetric index), it was observed that they had close values in general. This study is similar to the results of previous studies and the satellites of the chromosomes were seen.

Statement of Conflict of Interest

The author(s) declare no conflict of interest for this study.

Author's Contributions

O.G. karyological analysis and article writing, C.Y. material supply and article writing

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The Effects of Cutting Time on Herbage Production and Quality of Buckwheat (*Fagopyrum esculentum* Meonch.) Cultivated in Kahramanmaras Conditions

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Abstract
This research was carried out in the trial area of Kahramanmaras Sutcu Imam University, Faculty of Agriculture, Field Crops Department in the summer production period of 2021 to determine the appropriate cutting time of buckwheat varieties to be grown as animal feed in the ecological conditions of Kahramanmaras province. In the study, Aktas and Gunes buckwheat varieties were cut at five different times. The field experiment was conducted in randomized complete block design in a split plot with three replications. The research results showed that dry herbage yield, dry matter ratio, crude protein ratio, raw ash ratio, neutral detergent ratio, acid detergent fiber ratio, digestible dry matter value and digestible dry matter yield were statistically significantly affected. It was determined that green herbage yield was between 657.6-995.1 kg/da, dry herbage yield 136.8-298.5 kg/da, crude protein ratio 7.51-15.02 %, crude protein yield 17.14-29.72 kg/da, crude ash ratio 9.93-12.97 %, NDF ratio 53.95-66.46 %, ADF ratio 37.26-50.52 %, RFV 70.60-103.25 and the digestible dry matter yield 72.76-150.17 kg/da were between. It can be said that the most suitable cutting time for forage quality of buckwheat to be used in animal feeding in Kahramanmaraş conditions is the beginning of flowering.

Key words
Buckwheat, NDF and ADF ratio, herbage yield and herbage quality, animal feeds, protein ratio

Introduction
One of the greatest fears of humankind today and in the near future is the problem of food insufficiency, our basic need. This concern drives us to find fast and effective alternative sources of food. In order to increase production and quality, resources need to be derived in addition to existing products. The main way to meet the need for food is through agricultural production. Agricultural production is the sum of crop and animal production. In order for people to lead a healthy life, it is a necessity for them to include both plant-based and animal-based foods in their nutrition programs. Plant protein sources are more preferred than animal protein because they are cheaper and more easily accessible. The increase in meat prices also limits people's access to animal protein (Aiking, 2011). One of the most important criteria in determining the level of development of countries is the amount of animal products consumed per capita (Gunes, 2013). In order to meet the increasing consumption of animal products, it is necessary to increase the effective use of production areas, increase the yield of products obtained and increase the number of animals and the yield obtained from animals (Balcı, 2022). Accessibility to cheap and high-quality roughage resources is one of the main problems in animal nutrition. In an enterprise where feed costs constitute 70% of total expenses, 78% of feed expenses are roughage and 22% are concentrate feed (Harmansah, 2018). Increasing the production of roughage and making this production by the enterprises themselves will reduce the cost to a great extent. The increase in subsidies to be made by the state will also positively affect production. Roughages are indispensable feed resources in animal husbandry and it is a fact that there is a serious deficit of quality roughage in animal husbandry in our country. In order to meet the feed needs of our animals, it should be aimed to close the quality roughage deficit. In order to achieve this goal, the possibilities of using alternative roughage resources that we can increase the production and quality should be investigated (Gemalmaz and Bilal, 2016). It has been reported in different studies conducted by various researchers that buckwheat, which is rich in leaf number, can be used as roughage (Surmen and Kara, 2017), its short vegetation period, rapid growth and high herbage yield (Kara and Yuksel, 2014), and its adaptability to different soil conditions (Karafaki, 2017). Buckwheat (Debnath et al., 2008), which is annual and has no kinship ties with cereals, is a plant characterized as pseudocereal and has common areas of use with cereals (Yavuz et al., 2016). It is a plant with a height between 60-150 cm, a large number of branches and flower colours such as white, pink, light green, red (Valenzuela and Smith, 2002). Buckwheat is a plant that can reach higher yields in cool weather and is quickly affected by frosts. In regions with high temperatures, plant height is short and yield is low. It is a suitable plant for short summer months in cold ecologies. Although it can be cultivated in every region of our country, the region with the most favourable climatic conditions for buckwheat is Central Anatolia (Balci, 2022). The need for alternative forage crops with high yield and quality and high adaptability is very high both in our country and worldwide. There are very few studies in which buckwheat plant, which has high potential under suitable ecological conditions, is evaluated as feed. Our study and similar studies are of great importance directly in animal nutrition and indirectly in human nutrition. Harvest time is very important for grain and herbage yield (Tan, 2018). This study, which aimed to determine the most suitable harvest time for herbage yield and quality in buckwheat, was conducted in 2021 under Kahramanmaras ecological conditions.

Material and Methods
In the summer season of 2021, the experiment was carried out in the experimental field of Kahramanmaras Sutcu Imam University, Faculty of Agriculture, Department of Field Crops. The experimental field located in Kahramanmaras Onikisubat district of the Mediterranean region is located between 37°35'40.86' north latitude and 36°48'47.51' east longitude degrees. The altitude is 487 m and the slope is 3-5%. The temperature, rainfall and relative humidity in 2021, when the experiment was established, are given in Table 1.

Table 1. Climate Data for 2021 and Long Years Measured at Kahramanmaras Meteorological Station

Months	Total Rainfall (mm)		Average Temperature (°C)		Relative Humidity (%)	
	2021	Long Years	2021	Long Years	2021	Long Years
April	16.2	73.0	16.3	15.6	45.3	57.59
May	12.0	38.8	23.2	20.6	47.8	54.95
June	0.0	8.6	26.0	25.7	48.1	49.67
Tot./Avr.	28.2	120.4	21.8	20.6	47.1	54.07

Based on Table 1, when the data of the research period are analysed, the long-term average of total rainfall is 120.4 mm (Anonymous, 2021a). Considering the dates of the experiment, this value was 28.2 mm and 92.2 mm less precipitation than the long-years average. In the season in which the research was conducted, the long-years average temperature was 20.6 °C. In the dates corresponding to the trial season, the average temperature was 21.8 °C. When this value is compared with the long-years average, it is seen that it is higher. When the relative humidity values are considered, the long-years average is 54.07% and 47.1% during the growing period. When the whole table is analysed, it can be said that the experimental year was hotter and drier.

Table 2. Physical and Chemical Properties of Soil from the Experimental Area

Parameters Analysed							
Depth (cm)	Water Saturation	pH	Lime (%)	Organic Matter (%)	Salinity (%)	P_2O_5 (kg/da)	K_2O (kg/da)
0-30	69.96	7.71	6.09	1.58	0.05	2.84	55.51

Before the experiment was established, samples were taken from 0-30 cm depth and analysed to determine the physical and chemical properties of the soil. The results of the analyses performed at USKIM are given in Table 2. According to the results of the analysis; water saturation was 69.96% (clay loam), pH value was 7.71 (slightly alkaline), lime content was 6.09% (medium calcareous), organic matter content was 1.58% (low), salinity was 0.05% (saline), phosphorus (P_2O_5) content was 2.84 kg/da (very low) and potassium (K2O) content was 55.51 kg/da (high) (Anonymous, 2021b).

Aktas and Gunes buckwheat varieties obtained from Bahri Dagdas International Agricultural Research Institute were used as the main material in this study. Aktas is a buckwheat variety with white flower colour, grain yield 80-160 kg/da, protein rate 11-14%, thousand grain weight 20-29 g, height range 80-95 cm and hectolitre weight 58-65 kg. It can be grown in every region of our country. Gunes is a variety with white flower colour, grain yield 100-180 kg/da, protein ratio between 11-14%, thousand grain weight 22-30 g, plant height 85-100 cm and hectolitre weight 60-68 kg. As in Aktas variety, it can be cultivated in every region of our country.

The research was established according to the split plots experimental design with 3 replicates. The experimental area was ploughed with plough. Then it was made suitable for sowing by using cultivator and tappet. Sowing was done manually in 6 rows in plots with 20 cm row spacing and 3 m length. The plot size was 1.2 m x 3 m = 3.6 m^2. For both varieties, 350 plants per m^2 was taken as a basis and 1260 plants per 3.6 m^2 were calculated. The thousand grain weight was found to be 25.52 g for Aktas buckwheat variety and 24.99 g for Gunes buckwheat variety. Based on the thousand grain weights, the amount of seeds per 3.6 m^2 was calculated as 32.16 g/parcel for Aktas variety and 31.48 g/parcel for Gunes variety. To determine the green herbage yield, the green herbage harvested from each plot was weighed. Then, based on the value determined for the plot, green herbage yield per decare was calculated. To calculate dry herbage yield, 700 g samples were taken from the mown green herbs and dried at 70 °C in the drying cabinet until the weight was constant. The dried samples were weighed and the dry herbage yield per plot was determined and converted to buckwheat dry herbage yield per decare. For crude ash content, samples of 3 grams each were taken from the plant samples dried at 105 °C and then cooled in a desiccator, placed in porcelain crucibles and burnt at 550 °C for 3 hours. Then crude ash content (%) was calculated by using the formula (Crude ash content (%) = (c-a)/(b-a) x 100 (a: Crucible tare b: Crucible tare + sample c: Crucible tare + ash)). In order to calculate the crude protein ratio, nitrogen analysis was performed on the dried samples by Kjeldahl method and the determined nitrogen values were multiplied by a coefficient of 6.25. In order to determine the crude protein yield, the crude protein ratios determined for each plot were multiplied by the dry herbage yield of each plot and crude protein yield was found. Then, crude protein yield per decare was calculated by making the necessary conversions. NDF and ADF ratios were determined by using Kutlu (2008). In order to determine the relative feed value, NDF and ADF values were calculated using the formulae described by Sheaffer et al. (1995).

Digestible Dry Matter (DDM) (%) = 88.9 - (0.779 x % ADF)

Dry Matter Intake (DMI) (%) = 120 / % NDF (in dry matter)

Relative Feed Value (RFV) = (DDM x DMI) / 1.29

The following formula was used to calculate the digestible dry matter yield (Tassever, 2019).

Digestible Dry Matter Yield (DDMY) (kg/da) = Dry Matter Yield (DMY) (kg/da) x Digestible Dry Matter (%) (DDM)

Based on the results of soil analysis, fertiliser application was made with 20.20.0 compound fertiliser as 6 kg/da N and 6 kg/da pure P. Weed control was carried out manually during the period from germination to harvest. During the vegetation period, drip irrigation was applied 9 times (22 April, 27 April, 5 May, 15 May, 23 May, 27 May, 4 June, 10 June and 14 June). In five different periods (beginning of flowering-22 May 2021, 50% flowering-27 May 2021, 75% flowering-1 June 2021, 100% flowering-7 June 2021, seed ripening-20 June 2021), mowing was done with the help of a sickle from the closest place to the soil.

Results and Discussion

Analysis of variance results of the analysed traits of buckwheat harvested at different times are given in Table 3.

Table 3. Analysis of Variance Results for the Analysed Traits of Buckwheat Harvested at Different Times

	GHY	DH Y	DMR	CPR	CPY	CAR	NDF	ADF	DDM	DMI	RFV	DDMY
	P Value*											
V	0.04	0.02	0.00	0.49	0.35	8.95	0.32	9.98	9.94	0.28	2.90	0.07
CT	0.62	5.53*	88.58*	43.48*	1.81	4.16*	78.26*	18.97*	18.88*	90.49*	71.57*	3.66*
V x CT	1.95	1.62	1.84	2.09	2.09	1.16	7.18*	7.59*	7.60*	6.76*	9.54*	1.89

*Significant at P≤0.05, V: Variety, CT: Cutting Time, GHY: Green Herbage Yield, DHY: Dry Herbage Yield, DMR: Dry Matter Ratio, CPR: Crude Protein Ratio, CPY: Crude Protein Yield, CAR: Crude Ash Ratio, NDF: Neutral Detergent Fiber, ADF: Acid Detergent Fiber, DDM: Digestible Dry Matter, DMI: Dry Matter Intake, RFV: Relative Feed Value, DDMY: Digestible Dry Matter Yield.

Green Herbage Yield (kg/da)

Table 4. Average Green Herbage Yield (kg/da) of Buckwheat Varieties Harvested at Different Maturity Periods and Groups Formed

	Varieties		
Cutting Time	Aktas	Gunes	Average
Beginning of flowering	866.7	657.6	762.1
50% Flowering period	942.3	816.8	879.5
75% Flowering period	893.1	810.1	851.6
100% Flowering period	828.1	944.1	886.1
Seed ripening period	759.4	995.1	877.3
Average	857.9	844.7	851.3

Green herbage yield (kg/da) obtained from buckwheat varieties harvested at different maturity periods was not statistically significant. When Table 4 is analysed, the highest green herbage yield average was 857.9 kg/da for Aktas variety and the lowest green herbage yield average was 844.7 kg/da for Gunes variety. According to the mean values of green herbage yield for harvesting times, the highest green herbage yield was obtained as 886.1 kg/da in 100% flowering period. When Aktas cultivar was evaluated in terms of cultivar x harvest time interaction, it was determined that green herbage yield was between 759.4-942.3 kg/da. In Gunes variety, it was determined that the green herbage yield was between 657.6-995.1 kg/da in terms of variety x harvest time interaction. The highest green herbage yield was 995.1 kg/da in Gunes variety at seed ripening period and the lowest green herbage yield was 657.6 kg/da in Gunes variety at the beginning of flowering. When the results obtained were compared with the results of the researchers who previously studied on the same subject; our findings were higher than the findings obtained by Alkay (2019) in Bingol (269.75-410.00 kg/da), similar to the findings obtained by Polat and Kan (2021) in Konya (114.60- 1520.30 kg/da) and lower than the findings obtained by Acar et al. (2011) in Konya (1783.80 kg/da). It is thought that the difference between our data on green herbage and the values obtained by the researchers is due to climate factor, variety, soil structure and different harvesting times.

Dry Herbage Yield (kg/da)

It was determined that the dry herbage yield (kg/da) obtained from buckwheat varieties harvested at different maturity periods was statistically significant in terms of harvest time.

Table 5. Averages and Groups of Dry Herbage Yield (kg/ha) of Buckwheat Varieties Harvested at Different Maturity Periods

	Varieties		
Cutting Time	Aktas	Gunes	Average
Beginning of flowering	163.3	136.8	150.0 C[1]
50% Flowering period	219.6	183.9	201.7 BC
75% Flowering period	205.4	184.4	194.9 BC
100% Flowering period	214.4	235.6	225.0 AB
Seed ripening period	226.6	298.5	262.6 A
Average	205.9	207.8	206.9

[1]) Averages with similar letters in the same column are statistically indistinguishable from each other within P≤0.01 error limits according to LSD test.

When Table 5 is analysed, the highest average dry herbage yield was obtained in Gunes variety (207.8 kg/da) and the lowest average dry herbage yield was obtained in Aktas variety (205.9 kg/da. According to the mean values of dry herbage yield for harvest times, the highest dry herbage yield was determined as 262.6 kg/da at seed ripening period. In terms of cultivar x harvest time interaction, it was determined that the dry herbage yield of Aktas cultivar was in the range of 163.3-226.6 kg/da and the dry herbage yield of Gunes cultivar was in the range of 136.8-298.5 kg/da. The highest dry herbage yield of Gunes variety was 298.5 kg/da at the seed ripening period and the lowest yield of Gunes variety was 136.8 kg/da at the beginning of flowering. When the results obtained are compared with the results of the previous researchers on the same subject; our findings are higher than the results obtained by Omidbaigi and De Mastro (2004) in Tehran (10.7-25.2 kg/da) and Alkay (2019) in Bingöl (100. 2-142.3 kg/da), similar to the results obtained by Polat and Kan (2021) in Konya (29.5- 413.9 kg/da) and lower than the results obtained by Kara (2014) in Isparta (120.0-853.7 kg/da).

Dry Matter Ratio (%)

Table 6. Averages and Groups of Dry Matter Ratio (%) of Buckwheat Varieties Harvested at Different Ripening Periods

	Varieties		
Cutting Time	Aktas	Gunes	Average
Beginning of flowering	19.0	20.8	19.9 D[1]
50% Flowering period	23.5	22.6	23.0 C
75% Flowering period	23.1	22.9	23.0 C
100% Flowering period	26.1	25.2	25.6 B
Seed ripening period	30.1	30.1	30.1 A
Average	24.3	24.3	24.3

[1]) Averages with similar letters in the same column are statistically indistinguishable from each other within P≤0.01 error limits according to LSD test.

It was determined that the dry matter ratio of buckwheat varieties harvested at different ripening periods was statistically significant in terms of cutting time. Table 6 shows that the average dry matter ratio was 24.3% for Aktas and Gunes varieties. According to the mean values of dry matter ratio of cuttings, the highest dry matter ratio was obtained at the seed ripening period as 30.1% and the lowest dry matter ratio was obtained at the beginning of flowering as 19.9%. When evaluated in terms of cultivar x cutting time interactions, it was determined that the dry matter ratio of Aktas cultivar was between 19.0-30.1% and that of Gunes cultivar was between 20.8-30.1%. The highest dry matter ratio was observed in the seed ripening period (30.1%) for both varieties. The lowest dry matter ratio was reached at the beginning of flowering in Aktas variety with 19%. The findings obtained are higher than the findings of Yavuz and Kara (2018) in Isparta (11.1-21.25%).

Crude Protein Ratio (%)

It has been determined that the crude protein ratio obtained from buckwheat varieties harvested at different ripening periods is statistically significant in terms of mowing time.

Table 7. Crude Protein Ratio (%) Averages of Buckwheat Varieties Harvested at Different Ripening Periods and Groups Formed

	Varieties			Feed Quality
Cutting Time	Aktas	Gunes	Average	
Beginning of flowering	15.02	12.68	13.85 A[1]	2nd grade
50% Flowering period	13.24	12.61	12.93 A	3rd grade
75% Flowering period	11.48	10.98	11.23 B	3rd grade
100% Flowering period	8.50	9.18	8.84 C	4th grade
Seed ripening period	7.51	7.75	7.63 D	5th grade
Average	11.15	10.64	10.89	

[1]) Averages with similar letters in the same column are statistically indistinguishable from each other within P≤0.05 error limits according to LSD test.

Rohweder et al. (1978) prepared a table to be used in classifying feed quality according to crude protein ratio. According to this table, if the crude protein ratio is higher than 19%, it is considered as "top quality feed", between 17-19% as "1st class feed", between 14-16% as "2nd class feed", between 11-13% as "3rd class feed", between 8-10% as "4th class feed" and less than 8% as "5th class feed". Feed quality classification is given in Table 7. When Table 7 is analysed, the highest crude protein ratio average was 11.15% in Aktas variety and the lowest crude protein ratio was 10.64% in Gunes variety. According to the average values of crude protein ratio for cutting times, the highest crude protein ratio was determined as 13.85% at the beginning of flowering. In the evaluation made in terms of variety x cutting time interaction, it was determined that the crude protein ratio was between 7.51-15.02% in Aktas variety and between 7.75-12.68% in Gunes variety. The highest crude protein ratio was 15.02% in Aktas variety at the beginning of flowering and the lowest crude protein ratio was 7.51% in Aktas variety at seed ripening period. The crude protein ratio of the plant in the vegetative development period is higher than the plants that have matured and completed their growth. As the plant matures, the ratio of leaves to stems decreases and crude protein ratio decreases with ripening (Buxton, 1996). The results are higher than those obtained by Alkay (2019) in Bingol (8.76-9.88%), similar to those obtained by Köksal (2017) in Yozgat (10.97-15.81%), and lower than those obtained by Arslan (2021) in Bursa (10.57-21.88%).

Crude Protein Yield (kg/da)

Table 8. Averages and Groups of Crude Protein Yield (kg/da) of Buckwheat Varieties Harvested at Different Maturation Periods

	Varieties		
Cutting Time	Aktas	Gunes	Average
Beginning of flowering	24.59	17.27	20.94
50% Flowering period	29.72	23.02	26.37
75% Flowering period	23.31	19.91	21.61
100% Flowering period	18.00	21.37	19.68
Seed ripening period	17.14	22.66	19.90
Average	22.55	20.85	21.70

Crude protein yield obtained from buckwheat varieties harvested at different ripening periods was not statistically significant. When Table 8 is analyzed, it is seen that the highest crude protein yield average was 22.85 kg/da for Gunes variety and the lowest protein yield average was 20.55 kg/da for Aktas variety. According to the average values of crude protein yield for cutting times, the highest crude protein yield was found to be 26.37 kg/da at 50% flowering. According to the evaluation made in terms of variety x cutting time interaction, crude protein yield of Aktas variety was between 17.15-29.72 kg/da and crude protein yield of Gunes variety was between 17.27-23.02 kg/da. The highest crude protein yield of Aktas variety was 29.72 kg/da at 50% flowering period and the lowest crude protein yield of Aktas variety was 17.14 kg/da at seed ripening period. The results were higher than those obtained by Alkay (2019) in Bingol (8.9-12.7 kg/da) and lower than those obtained by Arslan (2021) in Bursa (27.26-62.49 kg/da). It is thought that the difference between our data and the values obtained by the researchers is due to climate factor, variety, soil structure and different harvesting times.

Crude Ash Ratio (%)

It was determined that the crude ash content of buckwheat varieties harvested at different ripening periods was statistically significant in terms of cutting time

Table 9. Crude Ash Ratio (%) Averages of Buckwheat Varieties Harvested at Different Ripening Periods and Groups Formed

	Varieties		
Cutting Time	Aktas	Gunes	Average
Beginning of flowering	12.97	11.39	12.18 A
50% Flowering period	11.10	10.61	10.86 B
75% Flowering period	11.68	10.66	11.17 AB
100% Flowering period	9.99	10.00	9.99 B
Seed ripening period	9.93	10.67	10.30 B
Average	11.13	10.67	10.90

[1]) Averages with similar letters in the same column are statistically indistinguishable from each other within P≤0.05 error limits according to LSD test.

When Table 9 is examined, it is seen that the average crude ash content was 11.13% in Aktas variety and 10.67% in Güneş variety. According to the average values of the crude ash content of the cutting times, the highest crude ash content was 12.18% at the beginning of flowering and the lowest crude ash content was 9.99% at 100% flowering. According to the evaluation made in terms of variety and cutting time interactions, it was determined that the crude ash rate of Aktas variety was between 9.93-12.97% and the crude ash rate of Güneş variety was between 10.00-11.39%. The highest crude ash rate was obtained in Aktas variety (12.97%) at the beginning of flowering and the lowest crude ash rate was obtained in Aktas variety (9.93%) at seed ripening period. The findings were higher than the results obtained by Alkay (2019) in Bingol (2.29-2.60%) and close to the values obtained by Yavuz and Kara (2018) in Isparta (8.19-16.05%). It is thought that the difference between our data and the values obtained by the researchers is due to climate factor, variety, soil structure and different harvesting times.

Neutral Detergent Fiber (NDF) (%)

It was determined that the NDF ratio (%) obtained from buckwheat varieties harvested at different ripening periods was statistically significant in terms of cutting time and variety x cutting time interaction.

Table 10. Averages and Groups of NDF Ratio (%) of Buckwheat Varieties Harvested at Different Ripening Periods

	Varieties			Feed Quality
Cutting Time	Aktas	Gunes	Average	
Beginning of flowering	53.95 e*	54.26 e	54.10 E[1]	3rd grade
50% Flowering period	55.49 de	56.95 cd	56.22 D	3rd grade
75% Flowering period	57.96 cd	57.90 cd	57.93 C	3rd grade
100% Flowering period	61.94 b	59.01 c	60.47 B	3rd grade
Seed ripening period	62.66 b	66.46 a	64.56 A	4th grade
Average	58.39	58.91	58.66	

[1]) Averages with similar letters in the same column are statistically indistinguishable from each other within P≤0.01 error limits according to LSD test. *Averages of cultivar-mowing time interactions indicated with the same letter are statistically indistinguishable from each other within P≤0.01 error limits.

Rohweder et al. (1978) prepared a ruler to be used in classifying feed quality according to NDF values. According to this table, if the NDF value is less than 40%, it is considered as "best quality feed", 40-46% as "1st class feed", 47-53% as "2nd class feed", 54-60% as "3rd class feed", 61-65% as "4th class feed" and more than 65% as "5th class feed". Feed quality classification is given in Table 10. When Table 10 is analyzed, the highest NDF ratio mean value was found in Gunes variety with 58.91% and the lowest NDF ratio mean value was found in Aktas variety with 58.39%. According to the mean values of NDF ratio for cutting times, the highest NDF ratio was 64.56% at seed ripening and the lowest NDF ratio was 54.10% at the beginning of flowering. According to the evaluation made in terms of variety x cutting time interactions, it was determined that the NDF ratio of Aktas variety was between 53.95-62.66% and the NDF ratio of Gunes variety was between 54.26-66.46%. The highest NDF ratio of Gunes variety was 66.46% at the seed ripening period and the lowest NDF ratio of Aktas variety was 53.95% at the beginning of flowering. The results obtained were higher than the values determined by Surmen and Kara (2017) in Aydın (31.83-40.66%), Yavuz and Kara (2018) in Isparta (31.61 41.63%), and relatively close to the results determined by Köksal (2017) in Yozgat (42.20-52.03%).

Acid Detergent Fiber (ADF) Ratio (%)

It was determined that the ADF ratio (%) obtained from buckwheat varieties harvested at different ripening periods was statistically significant in terms of cutting time and variety x cutting time interaction.

Table 11. Averages of ADF Rate (%) of Buckwheat Varieties Harvested at Different Maturation Periods and Formed Groups

	Varieties			Feed
Cutting Time	Aktas	Gunes	Average	Quality
Beginning of flowering	37.26*c	45.84 b	41.55 D[1]	3rd grade
50% Flowering period	46.28 b	47.52 ab	46.90 BC	5th grade
75% Flowering period	45.50 b	45.78 b	45.64 C	5th grade
100% Flowering period	50.52 a	48.56 ab	49.54 A	5th grade
Seed ripening period	47.81 ab	49.36 ab	48.58 AB	5th grade
Average	45.47	47.41	46.44	

[1]) Averages with similar letters in the same column are statistically indistinguishable from each other within P≤0.01 error limits according to LSD test. *Averages of cultivar-mowing time interactions indicated with the same letter are statistically indistinguishable from each other within P≤0.01 error limits.

Rohweder et al. (1978) prepared a ruler to be used in classifying feed quality according to ADF values. According to this table, if the ADF value is less than 31%, it is considered as "best quality feed", between 31-35% as "1st class feed", between 36-40% as "2nd class feed", between 41-42% as "3rd class feed", between 43-45% as "4th class feed" and more than 45% as "5th class feed". Feed quality classification is given in Table 11. When Table 11 is analyzed, the highest average ADF rate was found in Gunes variety (47.41%) and the lowest in Aktas variety (45.47%). According to the mean values of ADF ratio for cutting times, the highest ADF ratio was found to be 49.54% at 100% flowering. When Table 11 was analyzed in terms of variety x cutting time, it was found that the ADF ratio of Aktaş variety was in the range of 37.26-50.52% and the ADF ratio of Gunes variety was in the range of 45.78-49.36%. The highest ADF content of Aktas variety was 50.52% at 100% flowering and the lowest ADF content of Aktas variety was 37.26% at the beginning of flowering. The findings were higher than the values obtained by Koksal (2017) in Yozgat (29.94-35.82%) and close to the results of Alkay (2019) in Bingöl (40.19-42.04%). It is thought that the difference between our data and the values obtained by the researchers is due to climate factor, variety, soil structure and different harvesting times.

Digestible Dry Matter (%)

Table 12. Averages and Groups of Digestible Dry Matter Value of Buckwheat Varieties Harvested at Different Ripening Periods

	Varieties		
Cutting Time	Aktas	Gunes	Average
Beginning of flowering	59.88*a	53.19 b	56.54 A[1]
50% Flowering period	52.85 b	51.89 bc	52.37 BC
75% Flowering period	53.46 b	53.24 b	53.35 B
100% Flowering period	49.55 c	51.08 bc	50.32 D
Seed ripening period	51.66 bc	50.45 bc	51.06 CD
Average	53.48	51.97	52.72

[1]) Averages with similar letters in the same column are statistically indistinguishable from each other within P≤0.01 error limits according to LSD test. *Averages of cultivar-mowing time interactions indicated with the same letter are statistically indistinguishable from each other within P≤0.01 error limits.

It was determined that the digestible dry matter value obtained from buckwheat varieties harvested at different ripening periods was statistically significant in terms of cutting time and variety x cutting time interaction. When Table 12 is examined, the highest average digestible dry matter value was obtained as 53.48% in Aktas variety and the lowest value was obtained as 51.97% in Gunes variety. When the mean values of digestible dry matter value of cutting times were analyzed, the highest value of 56.54% was obtained at the beginning of flowering. According to the evaluation made in terms of variety x cutting time interaction, it was determined that the digestible dry matter value of Aktas variety was between 49.55-59.88% and the digestible dry matter value of Gunes variety was between 50.45-53.24%. The highest digestible dry matter value was 59.88% in Aktaş variety at the beginning of flowering and the lowest value was 49.55% in Aktaş variety at 100% flowering. The values determined as a result of the research were similar to the values obtained by Alkay (2019) in Bingol (56.15-57.59%) and lower than the values obtained by Surmen and Kara (2017) in Aydin (60.99-67.05%).

Dry Matter Intake (%)

It was found that the digestible dry matter intake value obtained from buckwheat varieties harvested at different ripening periods was statistically significant in terms of harvest time and variety x harvest time interaction.

Table 13. Averages and Groups of Dry Matter Intake Value of Buckwheat Varieties Harvested at Different Ripening Periods

	Varieties		
Cutting Time	Aktas	Gunes	Average
Beginning of flowering	2.22*a	2.21 a	2.22 A[1]
50% Flowering period	2.16 ab	2.11 bc	2.13 B
75% Flowering period	2.07 cd	2.07 cd	2.07 C
100% Flowering period	1.94 e	2.03 d	1.99 D
Seed ripening period	1.92 e	1.81 f	1.87 E
Average	2.06	2.05	2.06

[1]) Averages with similar letters in the same column are statistically indistinguishable from each other within P≤0.01 error limits according to LSD test. *Averages of cultivar-mowing time interactions indicated with the same letter are statistically indistinguishable from each other within P≤0.01 error limits.

Table 13 shows that the average dry matter uptake value (%) was 2.06% for Aktas variety and 2.05% for Gunes variety. The highest value was 2.22% at the beginning of flowering and the lowest value was 1.87% at seed ripening. When the values in terms of variety x cutting time were analyzed, it was found that the dry matter uptake value of Aktas variety was in the range of 1.92-2.22% and Gunes variety was in the range of 1.81-2.21%. The highest dry matter uptake value was 2.22% for Aktas variety at the beginning of flowering and the lowest dry matter uptake value was 1.81% for Gunes variety at the seed ripening period. The values obtained were lower than the values obtained by Alkay (2019) in Bingol (2.61-2.92%).

Relative Feed Value

It was found the relative forage value obtained from buckwheat varieties harvested at different maturity periods was statistically significant in terms of harvest time and variety x harvest time interaction.

Table 14. Relative Feed Value Averages and Groups of Buckwheat Varieties Harvested at Different Ripening Periods

	Varieties			Feed
Cutting Time	Aktaş	Gunes	Average	Quality
Beginning of flowering	103.25*a	91.21 b	97.23 A[1]	3rd grade
%50 Flowering period	88.62 bc	84.80 cd	86.71 B	3rd grade
%75 Flowering period	85.86 bcd	85.56 bcd	85.71 B	4th grade
%100 Flowering period	74.68 ef	80.52 de	77.60 C	4th grade
Seed ripening period	76.75 e	70.60 f	73.68 D	5th grade
Average	85.83	82.54	84.19	

[1])Averages with similar letters in the same column are statistically indistinguishable from each other within P≤0.01 error limits according to LSD test. *The Averages of variety-cropping time interaction indicated with the same letter are statistically indistinguishable from each other within P≤0.01 error limits.

A table showing feed quality standards was prepared by Rivera and Parish to be used in classifying relative feed values. According to this table, if the relative feed value is greater than 151, it is considered as “the best quality feed”, 151-125 as “1st class feed”, 124-103 as “2nd class feed”, 102-87 as “3rd class feed”, 86-75 as “4th class feed” and less than 75 as “5th class feed”. Forage quality grades are given in Table 14. When Table 14 is analysed, the highest mean relative feed value was 85.83 in Aktas variety and the lowest mean relative feed value was 82.54 in Gunes variety. According to the mean values of the relative feed value of the harvesting times, the highest value was obtained as 97.23 at the beginning of flowering. The relative feed value of Aktas variety was found to be in the range of 74.68-103,25 and Gunes variety was found to be in the range of 70.60-91.21 in terms of variety x harvest time interaction. The highest relative feed value was found 103.25 in Aktas variety at the beginning of flowering an the lowest was found 70.60 in Gunes variety at seed ripening period. Our findings were lower than those obtained by Yavuz an Kara (2018) in Isparta (145.69-213.53), Sürmen and Kara (2017) in Aydin (139.75-196.22) and Alkay (2019) in Bingol (118.84-123.12). It is thought that the difference between our data and the values obtained by the researchers is due to climate factor, variety, soil structure and different harvesting times.

Digestible Dry Matter Yield (kg/da)

İt was determined that the digestible dry matter yield values obtained from buckwheat varieties harvested at different ripening periods were statistically significant in terms of harvest time and variety x harvest time interaction.

Table 15. Averages and Groups of Digestible Dry Matter Yield of Buckwheat Varieties Harvested at Different Maturity Periods

	Varieties		
Cutting Time	Aktas	Gunes	Average
Beginning of flowering	97.64	72.76	85.20 C[1]
%50 Flowering period	116.30	95.03	105.67 BC
%75 Flowering period	110.33	98.20	104.27 BC
%100 Flowering period	106.87	120.40	113.64 AB
Seed ripening period	116.92	150.17	133.54 A
Average	109.6	107.3	108.46

1-) Averages with similar letters in the same column are statistically indistinguishable from each other within P≤0.01 error limits according to LSD test

When Table 15 is analysed, it is seen that the highest average digestible dry matter yield was 109.6 kg/da in Aktas variety and the lowest was 107.3 kg/da in Gunes variety. The highest digestible dry matter yield was 133.54 kg/da at seed ripening and the lowest was 85.20 kg/da at the beginning of flowering. The digestible dry matter yield of Aktas variety was 97.64-116.92 kg/da and that of Gunes variety was 72.76-150.17 kg/da. The highest digestible dry matter yield was 150.17 kg/da at seed ripening period in Gunes variety and the lowest digestible dry matter yield was 72.76 kg/da at the beginning of flowering in Gunes variety. The findings of the study were lower than the values determined by Arslan (2021) in Bursa (145.96-431.97 kg/da).

Conclusion

In this study, green herbage yield, dry herbage yield, dry matter rate, crude protein rate, crude ash rate, NFD, ADF, digestible dry matter value, dry matter intake value, relative feed value and digestible dry matter yield were investigated in buckwheat plant under the ecological conditions of Kahramanmaras. In general, it has been reported that feeds containing less than 8% crude protein enough ammonia for rumen microorganisms to maintain their normal activities (Norton, 2003). El-Shatnawi and Mohawesh (2000) reported the protein requirement of lactating ewes as 7-9% crude protein for survival and 10-12% crude protein for lactation period. Therefore, when the crude protein values of buckwheat hay to be used as an alternative feed source for feeding purposes are examined, it can be said that grasses containing less than 8% protein and mown during the seed ripening period will not be sufficient for the activity of rumen microorganisms in the animal. Therefore, when low protein buckwheat hay is used by animal breeders, a protein source must be added to the feed. In summary, buckwheat hay with a protein content above 8% is suitable for direct use in animal feeding, while buckwheat hay with a lower protein content is suitable for use as an additive in compound feeds. It can be said that the most suitable harvesting time in terms of dry herbage yield of buckwheat for animal feeding in Kahramanmaras conditions is 100% flowering or seed setting period, and the most suitable harvesting time in terms of forage quality (crude protein ratio, ash ratio, NDF, ADF and NYD) is the beginning of flowering.

Statement of Conflict of Interest

The authors declared that for this research article, they have no actual, potential or perceived conflict of interest.

Author's contribution

The contribution of the authors to the present study is equal. All the authors read and approved the final manuscript. All the authors verify that the Text, Figures, and Tables are original and that they have not been published before results.

Description

This research article is summarised from the first author's master's thesis.

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