IDENTIFICATION OF EGYPTIAN FABA BEANS (VICIA FABA L.) CULTIVARS FROM GRAIN ORPHOLOGICAL FEATURES USING DISCRIMINANT ANALYSIS

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ABSTRACT

The objective of this study was to develop a statistical classifier to identify Egyptian faba beans cultivars using grain morphological features if they are in mixed case. Five Egyptian faba beans cultivars were tested namely: Giza3, Giza461, Misr1, Nobarya1 and Sakha1. The tested faba beans cultivars were grown during agricultural season 2005 and the moisture content ranged from 5.2 % to 6.3 % (w.b). The results showed that the average length of Giza3, Giza461, Misr1, Nobarya1 and Sakha1 was 16.71, 16.12,15.61, 18.87, and 16.25 mm, respectively. In spit of this converge in length values among cultivars, the efficiency of the develop classifier had reasonable accuracy. The best prediction accuracies was 67.9% when using testing data set with quadratic discriminant function. The corresponding category wise prediction accuracies were 45.5, 62.5, 87.5, 80.0 and 68.8% for Giza3, Giza461, Misr1, Nobarya1 and Sakha1, respectively with test data set using quadratic discriminant function. The development discriminant analysis showed low accuracy with its performance. So, it is recommended to improve the discrimination performance by adding another features to the grain morphological features like features extracted form texture and/or color of faba beans cultivars images obtained by machine vision technique. Whereas, the development discriminant analysis is conceptually simpler, easier to code into computer applications for faba beans (Vicia Faba L.) discrimination purposes in Egyptian grading, packing and cleaning seeds stations.

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INTRODUCTION

In Egypt, cultivated faba beans (Vicia Faba L.) is used as human food and as animal feed. It can be used as a vegetable, either green or dried, fresh or canned. It is a common breakfast food. The most popular dishes of faba beans are Medamis (stewed beans), Falafel (deep fried cotyledon paste with some vegetables and spices), Bissara (cotyledon paste poured onto plates) and Nabet soup (boiled germinated beans) (***Jambunathan et al., 1994***). The production of faba beans in Egypt was 336840 ton during season 2003 (***Arab Organization for Agricultural Development, 2004***). In Egypt there are different faba beans cultivars adapted to local conditions, with high yielding capacity and grains suitable for different uses. These cultivars usually plant during one season and harvest in the same period and may be mixed in the storages for different purposes. Meanwhile, cooking time and other industrial processing may be affected by faba beans cultivars. However, ***Yossef et al. (1982)*** mentioned that the cooking time required to reach the optimum eating quality for Medamis varies among cultivars. So, it is prefer to provide a faster and effortless objective evaluation method to discriminant among faba beans cultivars when they are in mixed case. Also, faba beans grain size is an important factor during handling, mechanical planting and cooking. ***Panigrahi et al. (1998)*** indicated that different quality parameters of the beans are used to select their appropriateness to be used as fresh or canned food products. Quality attributes such as color, surface cracks, diseased beans, and foreign materials (i.e.; such as stones, soil clods, and broken beans) play a very critical role in their marketability in the domestic as well as in international markets.

The purpose of discriminant analysis can be directed to find one or more of the following: (1) a mathematical rule, or discriminant function, for guessing to which class an observation belongs, based on knowledge of the quantitative variables only (2) a set of linear combinations of the quantitative variables that best reveals the differences among the classes (3) a subset of the quantitative variables that best reveals the differences among the classes (***SAS, 1986***). Classificatory discriminant analysis according to ***SAS (1986)*** is used to classify observations into two or more known groups on the basis of one or more quantitative variables. Classification can be done by either a parametric method or a nonparametric method in the DISCRIM procedure. A parametric method is appropriate only for approximately normal within-class distributions. The method generates either a linear discriminant function (the within-class covariance matrices are assumed to be equal) or a quadratic discriminant function (the within-class covariance matrices are assumed to be unequal). When the distribution within each group is not assumed to have any specific distribution or is assumed to have a distribution different from the multivariate normal distribution, nonparametric methods can be used to derive classification criteria. These methods include the kernel method and nearest-neighbor methods. The kernel method uses uniform, normal, epanechnikov, biweight, or triweight kernels in estimating the group-specific density at each observation. The within-group covariance matrices or the pooled covariance matrix can be used to scale the data.

Research papers explain many different types of classifiers. To determine which classifier works best for a particular application usually involves some degree of experimentation. Although, for a given problem most of the classifiers give comparable results, the difference might lie in their time complexity, storage requirements, and precise degree of accuracy (***Jayas et al., 2000***). Also, input features are the most important factors in determining the final outcome of any classifier (***Shahin et al., 2002***). Determining the potential of grain morphological features to classify different grain species, classes, varieties, damaged grains and impurities using a statistical pattern recognition technique has been the main focus of the published research (e.g. ***Paliwal et al., 1999*** and ***Majumdar and Jayas, 2000***).

Suso et al. (1993) reported that to determine the importance of both geographic and botanical variation among the Spanish faba beans cultivars, discriminant analysis was applied. According to their analyses, plant height, height of the lowest pod-bearing node, pod length and 100-grain weight were important traits discriminating among different geographic regions. The main character discriminating among botanical groups was the 100-grain weight. This analysis could help plant breeders in choosing the most favorable accessions in plant breeding. ***Mudzana et al. (1995)*** built variety discrimination in faba beans (Vicia Faba L.) by measuring morphological features of faba beans leaves. ***Thottam et al. (2001)*** conducted linear discriminant analysis on the measured data from both the manual and machine vision system to predict date samples of five varieties into corresponding categories using the features major length and diameter and projected area from the date samples. With features measured manually, the maximum average prediction accuracy was 88.3% when all features were combined. ***Altuntaş and Yildiz (2005)*** showed that the most physical properties of faba beans grains were length, width, thickness, geometric mean diameter, unit mass of grain, sphericity, thousand grain mass and angle of repose. ***Aboukarima and Mourad (2005)*** applied four discrimination analysis namely: linear discriminant analysis, quadratic discriminant function, non-parametric analysis using K-nearest neighbors and normal density-kernels methods to classify Egyptian apples (Anna variety) into three grades. The results showed that the overall classification accuracy ranged from 80 to 93 % based on classification algorithm with features from color image measurements.

Most of the available classification algorithms use the grain size for classification purposes. Use of size can result in significant misclassifications because the variations in grain size depend on maturity and growing conditions. Because the grain at a grain-handling facility is a mixture of grain coming from different farm locations, size variability can give erroneous results (***Visen et al., 2004***). The classification criterion is usually derived from the observation of the known classes, called the training data set (calibration data set). The derived classification criterion can then be applied to classify new observations, called the test data set. A classification criterion partitions an observation or feature hyper-space Ω into hyper-regions Ω_i, i=1,2,…, N, where N is the number of classes. An object is classified as coming from class ω_i if its corresponding feature vector or observation m, a point in the hyper-space Ω, belongs to the region Ω_i (***Jayas et al., 2000***).

The objective of this research was to develop a method to identify Egyptian faba beans (Vicia Faba L.) cultivars from grain morphological features using discriminant analysis if they are in mixed case. The grain morphological features were obtained by manual measurements of single grains

MATERIALS AND METHODS

Site and samples:

The experimental work and measurements were carried out in the Farm Tractors and Machinery Research & Test Station at Alexandria Governorate. Faba beans cultivars used in this study were freshly harvested from the field during the cropping season of 2005. The cultivars used were: Giza3, Giza461, Misr1, Nobarya1 and Sakha1 obtained from Zarzoora Experimental Station at El Beheira Governorate. Then beans were cleaned manually to remove all foreign materials and broken beans. The initial moisture content of the five Egyptian faba beans cultivars was determined by the oven method (***ASAE, 1998***). The average moisture content of the beans was found to be ranged from 5.2 % to 6.3% (w.b).

Features extraction:

A digital caliper was used to measure three axial dimensions of the beans grains. The length (L) and width (W) of a grain were measured as depicted in Fig. (1). Thickness (T) was defined as the measured distance between the two-grain faces. Fifty grains of each beans sample were measured. Measurements of the three axial dimensions of the grain were carried out with a digital caliper to an accuracy of 0.01 mm.

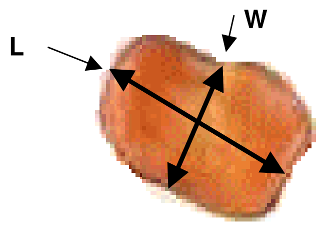

Fig. (1): Length (L) and width (W) of the faba beans grain.

The geometric mean diameter (*Dg, mm*) of the grain is calculated by using the following relationship (***Mohsenin, 1986***):

$$Dg = (L \times W \times T)^{1/3} \qquad (1)$$

The arithmetic mean diameter of the grain (*D*a, *mm*) is calculated using the following formula (***Rich and Teixeira, 2005***):

$$Da = \frac{(L + W + T)}{3} \tag{2}$$

The flat surface area (*Af, mm^2)* is calculated using the following formula (***El Raie et al., 1996***):

$$Af = \frac{\pi}{4} \times L \times W \tag{3}$$

The thickness surface area (*At, mm^2)* is calculated using the following formula (***El Raie et al., 1996***):

$$At = \frac{\pi}{4} \times W \times T \tag{4}$$

The surrounded surface area (*As, mm^2)* is calculated using the following formula (***El Raie et al., 1996***):

$$As = \frac{\pi}{2} \times (L + Dg) \times \frac{\pi}{2} \times Dg \tag{5}$$

The grain volume (*V, mm^3)* is calculated using the following formula (***Deshpande et al., 1993***):

$$V = \frac{\pi}{6} \times Dg^3 \tag{6}$$

The sphericity percent (Φ,%) of grain is calculated using the following formula (***Mohsenin, 1986***):

$$\Phi = \frac{(L \times W \times T)^{1/3}}{L} \times 100 \tag{7}$$

Three aspect ratios (*A1, A2* and *A3, dimensionless*) based on axial dimensions are developed to use in this research as follows:

$$A1 = \frac{L}{W} \tag{8}$$

$$A2 = \frac{L}{T} \tag{9}$$

$$A3 = \frac{W}{T} \tag{10}$$

Shape index (*SI, dimensionless*) is calculated according to ***Abd Alla et al. (1995)*** as follows:

$$SI = \frac{L}{\sqrt{W \times T}} \tag{11}$$

The coefficient of contact surface (*CC,%*) is calculated according to ***Abd Alla et al. (1995)*** as follows:

$$CC = \frac{(Af - At)}{Af} \times 100 \tag{12}$$

Elongation of grain (*E, dimensionless*) is the measurement of how long and narrow an object was. It is calculated according to ***Tian et al. (2000)*** as follows:

$$E = \frac{(L-T)}{(L+T)} \qquad (13)$$

The logarithm of the ratio of length to width (*LHW, dimensionless*) gives a symmetric measure of the aspect ratio of the object. It is calculated according to ***Tian et al. (2000)*** as follows:

$$LWH = \log_{10}\left(\frac{L}{W}\right) \qquad (14)$$

The surface area (*Sa*, *mm*^{2}) is calculated as mentioned in ***Deshpande et al. (1993)*** as follows:

$$Sa = \pi \times Dg^2 \qquad (15)$$

Data analysis and discriminant analysis:

The morphological feature set is 18 features including: *L, W, T, Dg, Da, Af, At, A1, A2, A3, CC, SI, As,* Φ*, V, Sa, E* and *LWH*. All these features will be used in the developed classifiers. Table (1) shows average values of fifteen morphological features adapted from grain axial dimensions for five Egyptian faba beans cultivars.

The discriminant analysis is based on using different combinations of grain morphological features to show the maximum discrimination power as shown in Table (2). The methods used to select features were: (1) using only features represent different dimensions of faba beans grain (model I), (2) using only features represent percentage and dimensionless features of faba beans grain (model II), (3) summing different area features and volume feature of faba beans grain (model III), (4) applying stepwise discriminant analysis method STEPDISC (***SAS, 1986***) to select features with significant discriminant power (model IV) and (4) summing 18 features together (model V).

The selected features and corresponding cultivars were partitioned randomly into two data sets: a calibration data set and a test data set. The calibration data set was used to develop the classifiers model, while the test data set was used to evaluate performance of the classifiers. The calibration data set consisted of 197 patterns (39 Giza3, 42 Giza461, 42 Misr1, 40 Nobarya1and 34 Sakha1) and the test data set consisted of 53 patterns (11 Giza3, 8 Giza461, 8 Misr1, 10 Nobarya1 and 16 Sakha1). The SAS discriminant analysis procedure DISCRIM (***SAS, 1986***) was conducted on the grain morphological features as described using different combinations of grain morphological features to classify faba beans samples of each variety into five cultivars. The analysis was carried out using the quadratic and linear discriminant functions.

Table (1): Average values* of fifteen morphological features obtained from grain axial dimensions for five Egyptian faba beans cultivars.

Morphological features	Cultivars				
	Giza3	Giza461	Misr1	Nobarya1	Sakha1
Arithmetic mean diameter of the grain, *Da (mm)*	11.92	11.67	11.49	13.19	11.79
Geometric mean diameter of the grain, *Dg (mm)*	11.12	10.90	10.88	11.98	11.03
Sphericity percent of the grain, Φ *(%)*	66.86	67.97	69.90	63.95	68.01
Flat surface area of the grain, *Af* (mm^2)	161.51	157.03	146.35	212.27	159.28
Thickness surface area of the grain, *At* (mm^2)	88.81	83.62	85.44	95.67	85.10
Grain volume, *V* (mm^3)	729.66	693.73	680.82	912.18	710.18
Coefficient of contact surface of the grain, *CC (%)*	44.40	46.08	41.17	54.09	46.50
Shape index of the grain, *SI (---)*	1.84	1.80	1.72	1.98	1.79
Ratio of length to width of the grain, *A1 (---)*	1.37	1.31	1.31	1.33	1.31
Ratio of length to thickness of the grain, *A2 (---)*	2.49	2.47	2.26	2.98	2.47
Ratio of width to thickness of the grain, *A3 (---)*	1.83	1.88	1.72	2.24	1.89
Elongation of the grain, *E (---)*	0.4228	0.4948	0.3869	0.4124	0.3869
Logarithm of the ratio of length to width of the grain, *LWH (---)*	0.1341	0.1079	0.0896	0.1151	0.0863
Surface area of the grain, *Sa* (mm^2)	390.23	424.78	414.23	430.80	416.33
Surrounded surface area of the grain, *As* (mm^2)	766.47	732.32	713.03	915.83	744.20

*** Number of observations are 50 for each variety.**

Table (2): Different models used in the discriminant analysis representing different combinations of grain morphological features.

Model	Selected features
I	*L, W, T, Dg* and *Da.*
II	*A1, A2, A3, E, SI, LWH, CC* and Φ .
III	*Af, At, As, Sa* and *V.*
IV	Applying stepwise discriminant analysis method STEPDISC (***SAS, 1986***) to select features with significant discriminant power. The obtained features were *Af, Da, T, Sa, Dg* and *As.*
V	*L,W,T,Dg,Da,Af,At, A1, A2, A3, CC, SI, As,* Φ *,V,E,Sa* and *LWH.*

Classifier performance:

The performance of classifiers was evaluated using 53 independent patterns. These patterns were not used during the two classifiers model development. The performance of the two classifiers was judged on the basis of percentage of correct responses. The following formulas were used:

$$PCC = \frac{N1}{N2} \times 100 \qquad (16)$$

$$OCC = \left[\frac{T1 - T2}{T1}\right] \times 100 \qquad (17)$$

Where *PCC* (%) is the percent correct classified for any variety, *N1* is the observations of the predicted grains for specific variety, *N2* is the actual observations of the same grains inside specific variety, *OCC* (%) is overall correct classification, *T1* is the total observations of samples (for calibration data set they were 197 observations and for testing data set there were 53 observations) and *T2* is the total observations of samples which misclassified and they are changeable.

RESULTS AND DISCUSSION

The descriptive statistical of axial dimensions features for Egyptian faba beans grains sample into five cultivars is shown in Table (3). It is clear from Table (3) that the average values of length, width and thickness of Giza3 variety are 16.71, 12.28 and 6.76 mm, respectively. Meanwhile, these values for Misr1 variety are15.61, 11.90 and 6.97 mm, respectively. These values for Nobarya1 variety are 18.87, 14.23 and 6.48 mm, respectively and for Giza461 variety they are 16.12, 12.29 and 6.59 mm, respectively. Meanwhile, these values for Sakha1 variety are 16.25, 12.45 and 6.66 mm, respectively. These results indicated that the variety Nobarya1 only had different axial dimensions compared to other cultivars. When using discriminant analysis based on the grain length only as a criterion to identify cultivars, low accuracy will be occurred because of overlapping and convergence in grain length as shown in Fig. (2). To overcome this problem, discriminant analysis was conducted on a set of features describing the morphological grain.

Table (4) indicates overall correct classification values of the five cultivars of Egyptian's faba beans based on different models as suggested in Table (2). It is clear that quadratic discriminant function gave best results compared to linear discriminant function for models (I, III, IV and V) using testing data set. The preliminary tests suggested that the selection of model V statistics provided the best classification accuracy of all models. Whereas, the model V performed at 67.9% and 54.7% classification accuracy when testing the quadratic and linear discriminant functions, respectively with 18 features, Table (4).

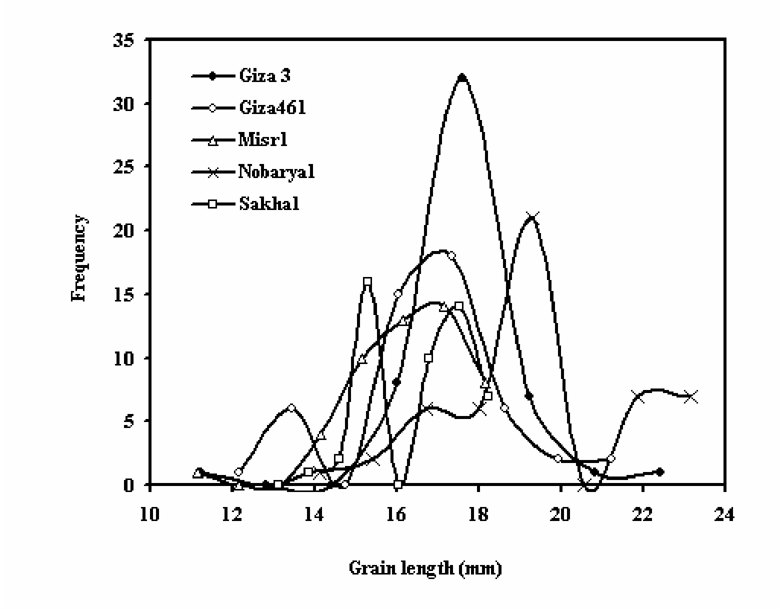

Fig. (2):

Distribution of grain length of five faba beans cultivars.

Table (3): Descriptive statistical of axial dimensions features for Egyptian faba beans grains sample into five cultivars.

Cultivars	Grain axial dimensions	Statistical items			
		Minimum	Maximum	Average	Standard deviation
Giza3	Length, mm	11.21	22.41	16.71	1.56
	Width, mm	7.14	15.23	12.28	1.18
	Thickness, mm	5.12	8.14	6.76	0.65
Giza461	Length, mm	12.15	21.24	16.12	1.90
	Width, mm	10.12	15.14	12.29	1.23
	Thickness, mm	5.12	8.15	6.59	0.74
Misr1	Length, mm	11.13	18.13	15.61	1.29
	Width, mm	9.24	13.24	11.90	0.90
	Thickness, mm	6.12	8.23	6.97	0.60
Nobarya 1	Length, mm	14.12	23.15	18.87	2.27
	Width, mm	11.14	16.23	14.23	1.20
	Thickness, mm	5.13	9.15	6.48	0.91
Sakha1	Length, mm	13.12	18.23	16.25	1.23
	Width, mm	11.13	14.14	12.45	0.77
	Thickness, mm	5.13	8.16	6.66	0.74

Table (4): Developed classifiers classification accuracy model selection.

Model	Overall correct classification, *OCC* (%)			
	Quadratic discriminant function		Linear discriminant function	
	Calibration data set	Testing data set	Calibration data set	Testing data set
I	45.2	45.3	42.4	41.5
II	42.6	37.7	43.7	47.2
III	42.1	37.9	44.2	37.7
IV	43.1	45.3	43.7	42.6
V	76.1	67.9	53.3	54.7

Tables (5 and 6) present the number of observations and percent correct classified of Egyptian faba beans samples into five cultivars with 18 features (model V) with calibration and testing data sets using quadratic and linear discriminant functions, respectively. Generally, the quadratic discriminant function is the best classifier based on overall correct classification. The quadratic discriminant function correctly classified 20 out of 39 Giza3 samples in the calibration data set, Table (5). Hence, the percent correct classified of 51.3% was achieved on the calibration data set (45.5% on the test data set), Table (5). Grade-by grade accuracy of 51.3, 59.5, 90.5, 85.0 and 97.1% was observed for Giza3, Giza461, Misr1, Nobarya1 and Sakha1 cultivars, respectively with calibration data set using quadratic discriminant function, Table (5). Meanwhile, grade-by grade accuracies were 45.5, 62.5, 87.5, 80.0 and 68.8% for Giza3, Giza461, Misr1, Nobarya1 and Sakha1 cultivars, respectively with testing data set, Table (5). The grade-by grade accuracy of Misr1, Nobarya1 and Sakha1 cultivars was higher compared to accuracy values of Giza3 and Giza461 cultivars because they had different axial dimensions.

The linear discriminant function correctly classified 20 out of 39 Giza3 samples in the calibration data set, Table (6). Hence, the percent correct classified of 51.3% was achieved on the calibration data set (36.4% on the test data set), Table (6). Grade-by grade accuracy of 51.3, 33.3, 52.4, 75.0 and 55.9% was observed for Giza3, Giza461, Misr1, Nobarya1 and Sakha1 cultivars, respectively with calibration data set, Table (6). Meanwhile, grade-by grade accuracies were 36.4, 37.5, 75.0, 90.0 and 43.8% for Giza3, Giza461, Misr1, Nobarya1 and Sakha1 cultivars, respectively with testing data set, Table (6). A closer look at the classification results in Tables (5 and 6) revealed that the main reason for poor performance of the selected classifiers was due to higher misclassification for Giza3 and Giza461 cultivars for both calibration and testing data sets. For example, when using quadratic discriminant function, the 20 out of 39 for Giza3 and 25 out of 42 for Giza461 in calibration data set were obtained, Table (5). On the other hand, losses were limited in calibration data set to Misr1, Sakha1 and Nobarya1 cultivars. Whereas 38 out of 42 for Misr1, 34 out of 40 for Nobarya1 and 33 out of 34 for Sakha1 were obtained as shown in Table (5). However, ***Utku (2000)*** mentioned that in grain classification, the best results are achievable when distinct varieties are tested. Meanwhile, in cases where there is a high degree of overlap among groups to be discriminated, classical pattern recognition fails to yield satisfactory results.

Table (5): Number of observations and percent correct classified* of Egyptian faba beans samples into five cultivars with 18 features (model V) using quadratic discriminant function with calibration and testing data sets.

Actual cultivars	Predicted cultivars					Total
	Giza3	Giza461	Misr1	Nobarya1	Sakha1	
	Calibration data set					
Giza3	20	0	8	2	9	39
	(51.3)	(0)	(20.5)	(5.1)	(23.1)	(100)
Giza461	2	25	8	3	4	42
	(4.8)	(59.5)	(19)	(7.1)	(9.5)	(100)
Misr1	0	1	38	0	3	42
	(0)	(2.4)	(90.5)	(0)	(7.1)	(100)
Nobarya1	3	2	0	34	1	40
	(7.5)	(5)	(0)	(85)	(2.5)	(100)
Sakha1	0	0	1	0	33	34
	(0)	(0)	(2.9)	(0)	(97.1)	(100)
Total	25	28	55	39	50	197
	(12.7)	(14.2)	(27.9)	(19.8)	(25.4)	(100)
Overall correct classification (%)						76.1
Testing data set						
Giza3	5	1	2	0	3	11
	(45.5)	(9.1)	(18.2)	(0)	(27.3)	(100)
Giza461	0	5	1	0	2	8
	(0)	(62.5)	(12.5)	(0)	(25)	(100)
Misr1	0	1	7	0	0	8
	(0)	(12.5)	(87.5)	(0)	(0)	(100)
Nobarya1	1	0	0	8	1	10
	(10)	(0)	(0)	(80)	(10)	(100)
Sakha1	0	1	2	2	11	16
	(0)	(6.3)	(12.5)	(12.5)	(68.8)	(100)
Total	6	8	12	10	17	53
	(11.3)	(15.1)	(22.6)	(18.9)	(32.1)	(100)
Overall correct classification (%)						67.9

*** Values in parenthesis indicate the percent correct classified (*PCC, %*).**

Table (6): Number of observations and percent correct classified* of Egyptian faba beans samples into five cultivars with 18 features (model V) using linear discriminant function with calibration and testing data sets.

Actual cultivars	Predicted cultivars					Total
	Giza3	Giza461	Misr1	Nobarya1	Sakha1	
	Calibration data set					
Giza3	20	5	6	3	5	39
	(51.3)	(12.8)	(15.4)	(7.7)	(12.8)	(100)
Giza461	5	14	11	6	6	42
	(11.9)	(33.3)	(26.2)	(14.3)	(14.3)	(100)
Misr1	4	8	22	0	8	42
	(9.5)	(19)	(52.4)	(0)	(19)	(100)
Nobarya1	3	2	1	30	4	40
	(7.5)	(5)	(2.5)	(75)	(10)	(100)
Sakha1	5	3	7	0	19	34
	(14.7)	(8.8)	(20.6)	(0)	(55.9)	(100)
Total	37	32	47	39	42	197
	(18.8)	(16.2)	(23.9)	(19.8)	(21.3)	(100)
Overall correct classification (%)						53.3
Testing data set						
Giza3	4	1	2	1	3	11
	(36.4)	(9.1)	(18.2)	(9.1)	(27.3)	(100)
Giza461	1	3	2	0	2	8
	(12.5)	(37.5)	(25)	(0)	(25)	(100)
Misr1	1	0	6	0	1	8
	(12.5)	(0)	(75)	(0)	(12.5)	(100)
Nobarya1	0	0	1	9	0	10
	(0)	(0)	(10)	(90)	(0)	(100)
Sakha1	1	1	7	0	7	16
	(6.3)	(6.3)	(43.8)	(0)	(43.8)	(100)
Total	7	5	18	10	13	53
	(13.2)	(9.4)	(34)	(18.9)	(24.5)	(100)
Overall correct classification (%)						54.7

*** Values in parenthesis indicate the percent correct classified (*PCC,%*).**

Fig. (3) shows comparison of classification results of faba beans cultivars using linear and quadratic discriminant functions based on calibration and testing data sets with 18 features (model V). It is seen that the quadratic discriminant function was the best classifier for discrimination among Giza3, Giza461, Misr1, and Sakha1 cultivars in testing data set. For Nobarya1 variety, the linear discriminant function was the best classifier compared to quadratic discriminant function in testing data set. This bias in the results may be due to Nobarya1 variety completely differs in its axial dimensions compared to other varieties. The percent correct classified values were equal (51.3%) in the two classifiers for Giza3 variety in calibration data set. Meanwhile, for other cultivars, the percent correct classified values were lower in calibration data set when using linear discriminant function compared to quadratic discriminant function.

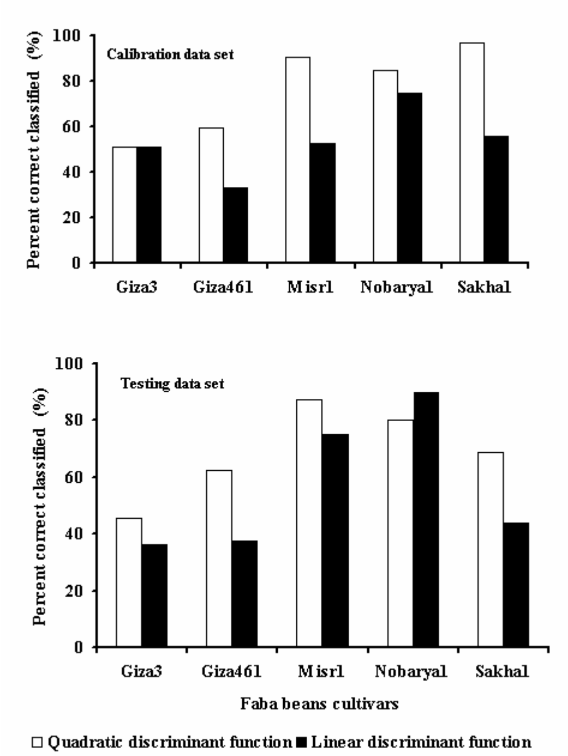

Fig. (3): Comparison of classification results of faba beans cultivars using linear and quadratic discriminant functions based on calibration and testing data sets with 18 features (model V).

CONCLUSION

This study has demonstrated that features from morphological based on axial dimensions for Egyptian faba beans grains samples can be used for classifying them into five cultivars using discriminant analysis. The cultivars used in this study were Giza3, Giza461, Misr1, Nobarya1 and Sakha1. An overall correct classification of 67.9 % using quadratic discriminant function was achieved using 18 features. The obtained results showed a less potential for predicting five faba beans cultivars using the features of morphological measured manually. So, it is recommended to improve discrimination performance by adding another features to grain morphological features like features extracted form texture and/or color of faba beans cultivars images obtained by machine vision technique. On the other hand, the development discriminant analysis is conceptually simpler, easier to code into computer applications for faba beans discrimination purposes in Egyptian grading, packing and cleaning seeds stations.

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الملخص العربي

التعرف على أصناف الفول البلدي المصري من سمات الحبة الشكلية مستخدما تحليل التمايز

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يعتبر محصول الفول البلدي من أهم البقوليات المنزرعة والمستهلكة في مصر على نطاق واسع، حيث يتناول بطرق شتى منها القرون الخضراء والحبوب الطازجة إلى جانب استهلاك الحبوب الجافة على مدار الموسم. وأوضحت الدراسات السابقة أن زمن طهي الفول يختلف باختلاف الأصناف، وحيث أنه لأي سبب من الأسباب يمكن أن تختلط الأصناف ببعضها كالغش التجاري مثلاً، فيجب أن تكون هناك أداة سهلة وسريعة ومميكنة للتعرف على أصناف الفول المختلفة. لذا يهدف هذا البحث إلى تطوير طريقة سهلة وبسيطة وسريعة يمكن برمجتها بالحاسب الآلي للتعرف على أصناف الفول المصري على أساس سمات الحبة الشكلية مستخدما تحليل التمايز. تم قياس طول وعرض وسمك حبة الفول يدويًا ومنهم تم إيجاد وحساب ١٨ سمة. استخدمت في التجارب ٥ أصناف من الفول البلدي المصري ، كانت الحبوب جافة عند إجراء القياسات وتراوح المحتوى الرطوبي لها ما بين ٥,٢ – ٦,٣ % على أساس رطب. وأوضحت النتائج أن متوسط طول الحبة كان ١٦,٧١، ١٦,١٢، ١٥,٦١، ١٨,٨٧، ١٦,٢٥ مم لأصناف جيزة ٣ وجيزة٤٦١ ومصر ١ ونوبارية١ وسخا١ على الترتيب. وعلى الرغم من هذا التقارب في طول الحبة بين الأصناف، إلا أنه أمكن للسمات المختارة أن تفرق بين هذه الأصناف بدقة مقبولة ، حيث كانت أفضل دقة تمايز عند دمج الـ ١٨ سمة مع بعض هي ٦٧,٩% أثناء استخدام بيانات الاختبار مع دالة التمايز التربيعية. ولزيادة دقة التمايز يوصى باستخراج سمات أخرى مثل سمات النسيج وإضافتها إلى سمات الحبة الشكلية. ومن النتائج يمكن التوصية باستخدام طريقة تحليل التمايز (دالة التمايز التربيعية) بعد برمجتها بالحاسب الآلي وقياس الأبعاد بتقنية الرؤية الآلية واستخراج السمات حسابيًا للتعرف على وتصنيف أصناف الفول البلدي المصرية وذلك يفيد في تحسين عمليات التعبئة، والغربلة، والتنظيف بالمحطات المختصة بالبذور.

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