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The Effect of Some Grading Factors on Marketing Prices in Durum Wheat (*T. durum* Desf.)

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Abstract: This study aimed to investigate the effects of some grading factors on marketing prices in durum wheat. The study was carried out in S.Urfa commodity market during the summer of 2004. A randomized complete block design with three factors and four replications (grain buyers) was employed. Factor A', three widely grown durum wheat varieties (Urfa-2005, Firat-93 and Aydin-93) , Factor B, the five various grading factors [yellow berry (YB), red bread wheat content (RBW), dark red bread wheat content (DRBW), sunn pest damaged kernel content (SP) and combinations of all above factors (combined effect)] and Factor C, content ratios (2.5, 5.0, 7.5 and 10%) were utilized. The results, obtained from variance analysis, indicated that all sources of variation turned out to be statistically significant. The grain buyers had different purchasing criteria depending on their needs. Some durum wheat varieties were offered higher prices due to good semolina or bulgur color reputation in macaroni and bulgur industry. Grading factors under study had different effects on marketing price of durum wheat. Marketing price reduced as content ratios of all grading factors in durum wheat increased. It was found that combined effect could reduce the marketing price as much as \$ 41 ton^{-1}, SP damage; \$ 36 ton^{-1}, DRBW; \$ 23 ton^{-1}, RBW; \$ 13 ton^{-1} and YB; \$ 9 ton^{-1}. The regressions between marketing prices vs. all grading factors were found to be statistically significant and the regression equations with high coefficients of determination (R^2%) described the variations in marketing price and can be used for marketing price estimations adequately. It was concluded that durum wheat purchasing criteria in the South East of Anatolia was somewhat different from those of Turkish Grain Board and some international markets. Some of down grading factors such as sunn pest damage and the presence of dark red or red bread wheat kernels must be added into national standards of Turkey and similar Middle East countries. Growing of bread wheat varieties with dark red or red kernels should be limited to avoid marketing price reductions in Middle East countries in which bulgur is common food.

Key words: Durum wheat, grading factors, marketing price, regression

INTRODUCTION

Durum wheat (*T. turgidum* L. var. *Durum)* comprises approximately 8-10% of word wide wheat production (Ozberk *et al*., 2005a; Oztahtac, 2000; Sardana, 2000; Nachit, 1998; Abaye *et al*., 1997). The annual World durum wheat production was estimated to be 21.2-30 million tones from a harvested area of 14-16 million hectares (Anonymous, 2000). More than 85% of the World durum production area is located in the Mediterranean basin. It occupies approximately 11 millions hectares in the Mediterranean basin. Manufacturing and marketing of durum products are also concentrated in the region (Nachit, 1998).

The major use of durum wheat is for pasta products, particularly in the European and North American countries, whereas, in the areas such as Mediterranean basin, it is used as bulgur, couscous and various types of breads (Oner, 2002; Troccoli *et al*., 2000; Nachit, 1998). Turkey, with a production of 978 000 tones of bulgur, 475 000 tones of pasta products, is a leading durum wheat products producer in the region (Anonymous, 2003a). Turkey is also leading durum wheat producer in the West Asia and North Africa (WANA) region with 4-6 millions tones from 2-3 millions ha (Ozberk *et al*., 2005b).

In the context of durum wheat quality, there are various criteria, used by those involved in different parts of supply chain (Ozberk *et al*., 2005a). The main

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parameters for grain dealers are the moisture content of grain, homogeneity of lots and cleaning. But, the grain dealers are in key position, holding the supply chain ranged from farmers to the macaroni and bulgur industry in the South-East of Turkey. They are very much aware of the quality demands of such industry and they offer higher marketing price for some varieties which have good reputation in industry. They also have some influence on the farmers encouraging them to plant market recognized cultivars by providing seeds of some cultivars.

South-East of Anatolia is known as durum wheat belt of the country (Ozberk *et al*., 2005b). Twenty five percent of macaroni production capacity is located in this region (Oztahtac, 2000). S.Urfa commodity market is in third place in importance after Polatli and Konya with over 500 000 tones of summer season marketing capacity (Ozberk *et al*., 2005a).

Canada and the USA are known to be major durum wheat exporters in the World (Lee *et al*., 2000). Durum wheat must fulfill certain quality requirement of protein content, sedimentation value, yellow berry percentage, β carotene content, test weight etc. (Troccoli *et al*., 2000; Sardana, 2000). Durum wheat class in the USA is divided into the following three classes; (i) hard amber durum wheat, (ii) amber durum wheat and (iii) durum wheat. There are five grades in each class and subclasses. Test weight should be over 51 lbs bu^{-1} in fifth grade, 54 lbs bu^{-1} in fourth, 56 lbs bu^{-1} in third, 58 lbs bu^{-1} in second and 60 lbs bu^{-1} for the first grade. Defects should not exceed 3% in first class, 5% in second and 10% in the rest of classes. These ratios are the same for wheat of other classes in the lot. Other material should not exceed 4% for all grades. Insect damaged kernels should not be over 31 out of 100 g of sample (Herman and Reed, 2000).

There are similar subclasses in durum wheat in Canada. The current Canadian grading system has five grade structure for durum wheat, in which No.1 grade is of higher quality than No. 2, both in terms of higher test weight and protein levels (Lee *et al*., 2000). In durum wheat, predominant grading factors include mildew, low vitreous % kernels, sprouting, green kernels and smudge, according to the Canadian Grain Commission (Anonymous, 2003b).

Turkish Grain Board (TGB) classifies durum wheat in varietals base as Anatolian durum and other durum wheat in Turkey. TGB pays extra premium for Anatolian durum wheat. There are 3 grades for each class. They are; AD1, AD2, AD3 and DD1, DD2 and DD3. Minimum test weight must be over 78 kg hlt^{-1} and kernel vitreous ness, 75% in AD1. Presence of bread wheat and other cereals grains, inert material, bund contaminated grains, insect damaged grains, grains with black points and weed grains are not allowed in AD1 and DD1 classes. AD2- DD2 and AD3-DD3 classes are down grading classes and offered lower marketing prices depending on the presence of down grading factors. Lowest limits of down grading factors for AD3-DD3 classes are as follows; 74 kg hlt^{-1}, 50% kernel vitreous ness, 8 g, 100 g^{-1} other cereals, 10 bread wheat kernels 100^{-1}, 5 g, 100 g^{-1} inert material, 100 kernels with bund kg^{-1}, 5 g, 100 g^{-1} insect damaged grains, 10 g, 100 g^{-1} kernels with black point and 100 kg^{-1} weed seeds (Anonymous, 2002).

Although, there are many other quality requirements for durum wheat in the international marketing, some physical characteristics such as high test weight influence strongly the buyer decision rather than protein and amylase activity or the choice between No.1 and No.2 grades in USA (Lee *et al*., 2000). Similar attitude is valid for S.Urfa commodity market. Some physical attributes of lots determine the marketing price. Moreover, if the grain lot belongs to a highly reputed variety, regarding the industrial quality, it is offered even higher price.

Bulgur and pasta are important products, dominating market prices in Turkey and a bright yellow color is the most important characteristic for higher marketing price (Ozberk *et al*., 2005a). Especially in bulgur industry, yellow and bright color has become an important marketing factor in the region in the last decade. Although, the nutritional value of bulgur decrease during the yellowing process, but, the customer demands for yellow color bulgur enforce the industry to produce such type of product (Oner, 2002). The macaroni production capacity of Turkey is 900 000 tones $year^{-1}$. Domestic consumption is 340 000 tones $year^{-1}$ (Turhan and Cetin, 2002). There are 500 bulgur production plants in various scales in Turkey. Bulgur production is over 1000 000 tones, excluding home made production in 2001 (Oner, 2002).

The presence of red bread wheat kernels in durum wheat are not desired by macaroni and bulgur plants in the region. This results in some stains in spaghetti and a non uniform color in bulgur and the reduction in international marketing price of bulgur. Durum grains, damaged by sunn pest, can not be separated by the sieves of flour mill. Gluten in the grain is degraded by proteolytic enzymes while other characteristics such as elasticity are lost. Therefore, sunn pest damaged kernels results in a substantial reduction in baking quality (Ozberk *et al*., 2005a; Koksel *et al*., 2002; Atlı *et al*., 1988). Wheat stem sawfly (*Cephus pygmaeus* L.) damaged durum wheat kernels are also offered less marketing price (Ozberk *et al*., 2005c).

In case of bread wheat, some of varieties offered for high marketing prices visually were found to be processing high sedimentation value. White grains receive higher marketing price offers than that of reds. Millers and bakery industry in the region prefer white flour color. Millers claim that high flour extraction rate and low bran content are achieved from white grains. Same trend was observed in Kansas. Many of plant breeders are now trying to develop hard white winter bread wheat varieties for their superior milling and baking characteristics (Lin and Vocke, 1998, 2004).

This study aimed to assess the effects of some mostly referred visual grading factors such as sunn pest damage, yellow berry and the presence of dark red or red bread wheat kernels on to durum wheat marketing prices and to draw the attention of all grain industry on to the necessity for change in grain purchasing criteria of TGB and the specific end use quality.

MATERIALS AND METHODS

Durum wheat cultivars of Urfa-2005, Firat-93 and Aydin-93 are relatively new and widely grown and market recognized cultivars in the region. They are all spring growing habit cultivars. Urfa-2005 was developed by the Harran University whilst, Aydin-93 and Firat-93 were developed by Southeastern Anatolia Agricultural Research Institute in Diyarbakır.

This study was carried out in Sanlıurfa commodity market during the autumn months of 2004. A split plot experimental design with 3 factors (A, B, C below) and 4 replications was used for statistical analysis. Factor A, three recently released cultivars and Factor B the 5 different grading characteristics (yellow berry, red and dark red bread wheat kernels in durum wheat, sunn pest damaged kernel and the combined effects of all above) were used. Factor C the 5 ratios, starting from 0, 2.5, 5, 7.5 and 10% were utilized. Data, obtained from study were subjected to the variance analysis using TARIST (Acikgoz *et al*., 1994) statistical software.

Pure seed samples of each cultivar were added by yellow berry, brown bread wheat kernels, red bread wheat kernels and sunn pest damaged kernels with the ratios of 2.5, 5, 7.5 and 10%. Finally, same seed samples were further contaminated by all above grading characteristics jointly with same ratios mentioned above. All seed samples were presented to the randomly selected grain buyers in the commodity market for price estimation.

The relationship between average marketing price and all physical properties under study of grain samples were further investigated through regression analysis (Finlay and Wilkinson, 1963; Eberhart and Russell, 1966) using same statistical software.

RESULTS

Marketing price estimations, obtained from study were subjected to variance analysis. It was understood that all sources of variation and interactions turned out to be significant statistically, giving, F= 20.08** for replications (grain buyers), F = 26.16** for Factor A, F = 194.04** for Factor B, F = 203.66** for Factor C (Table 1). Significant A×B, A×C and B×C interactions also indicated the presence of some interactions which may affect on marketing prices jointly. Table 2 revealed that the grain buyers had special preference for some varieties. Large grain sized durum wheat variety of Urfa-2005 was offered the highest marketing price (0.234 \$ kg^{-1}). Aydın-93 with good kernel color took place in second range (0.229 \$ kg^{-1}). Large but dark brown grain colored Fırat-93 was in the third rank giving a 0.229 \$ kg^{-1} marketing price. It was also revealed that the down grading characteristics of combined effect, sunn pest damage, dark red bread wheat kernels, red bread wheat kernels and yellow berry reduced the marketing price giving 0.218, 0.224, 0.233, 0.238 and 0.240 \$ kg^{-1}, respectively. The effect of content ratios of each grading characteristics on to marketing price was further investigated by orthogonal comparisons and the means were grouped by LSD test

Table 1: Analysis of variance of varieties (A), grading factors (B) and content ratios(C) and their interactions

Source of variation	df	Mean square	F	F (5%)	F (1%)
Replications	3	1512.92	20.08**	4.76	9.78
Factor A	2	1971.04	26.16**	5.14	10.92
Error 1	6	75.33			
Factor B	4	10689.18	194.04**	2.45	3.48
A*B	8	179.16	3.25**	2.02	2.66
Factor C	4	11219.51	203.66**	2.45	3.48
A*C	8	118.03	2.14*	2.02	2.66
B*C	16	887.55	16.11**	1.83	2.06
A*B*C	32	73.21	1.32^{ns}	1.60	1.74
Error	216	55.08			
Total	299	424.78			

**: Significant at p≤0.01, * :significant at p≤0.05, ns: Non significant

Table 2: Means and grouping of varieties (A) and grading factors (B)

Varieties	Means ($ kg^{-1})	Groups	Grading factors	Means ($ kg^{-1})	Groups
Urfa-2005	0.234	a	Yellow berry	0.240	a
Aydin-93	0.229	b	Red BW	0.238	b
Firat-93	0.229	c	Dark red BW	0.233	c
			Sunn pest	0.224	d
			Combined effect	0.218	e
LSD: 0.00204,			LSD:0.00182		

Table 3: Means ($ kg^{-1}) and grouping of content ratios and the significance of orthogonal comparisons

Content %	Means/Groups combined	Means/Groups sunn pest	Means/Groups dark red BW	Means/Groups red BW	Means/Groups yellow berry%
Control	0.243a	0.243a	0.245a	0.245a	0.243a
2.5%	0.225b	0.228b	0.237b	0.241b	0.243a
5%	0.214c	0.226b	0.233b	0.237b	0.240a
7.5%	0.208d	0.215c	0.225c	0.233c	0.238b
10%	0.203e	0.208d	0.223c	0.232c	0.234c
Orthogonal comparison					
F(linear)	452.75**	331.35**	154.31**	40.90**	22.89**
F(quadratic)	32.68**	ns	ns	ns	ns

**: Significant at p≤0.01, ns: Non significant

Table 4: Regression equations, significance of regression and coefficients of determination

Combined effect	Sun pest	Dark red BW	Red BW	Yellow berry
Y = 0.38**-0.04x**	y = 0.241**-0.03x**	y = 0.244**-0.02x**	y = 0.244**-0.01x**	y = 0.244**--0.01x**
F = 39.04**	F = 71.02**	F = 98.0**	F = 96.33**	F = 36.90**
R^2% = 92.9	95.9	97	96.3	92.5

**: Significant at p≤0.01

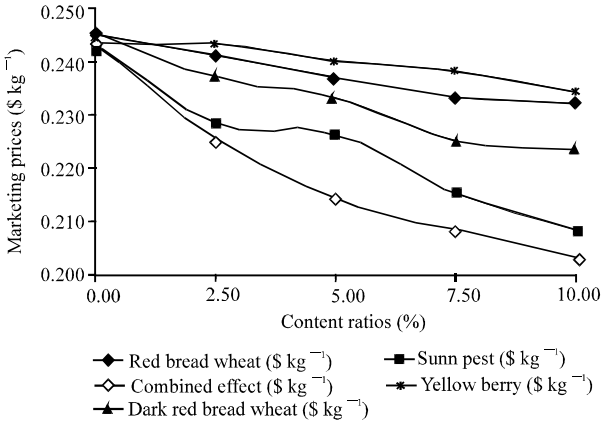

Fig. 1: The relationship between marketing prices and all grading factors

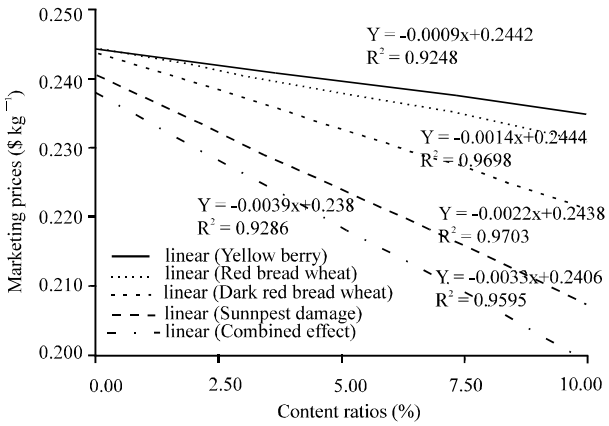

Fig. 2: Linear regression lines of all grading factors

(Table 3). Figure 1 also shows the relationship between marketing price and content ratios of all grading characteristics. Result, obtained from orthogonal comparisons showed that there were statistically significant linear effects between marketing prices and content ratios in the ranges between 0 and 10% for all grading factors. As the content ratio increased, marketing price decreased. This seemed to be consistent for the increasing ranges of all down grading factors. In addition to the linear effect, a quadratic effect was also found to be significant statistically for the combined effect. A hyperbolic relation indicated that reduction in marketing price slowed down as content ratio increased. Research results indicated that the combined effect of all grading factors was the most effective factor, reducing the marketing price ($ 41 ton^{-1}). Sunn pest damaged kernels, dark red bread wheat kernels, red bread wheat kernels were in second, third and forth ranges, giving $ 36 ton^{-1}, $ 23 ton^{-1} and $ 13 ton^{-1} marketing price reductions, respectively. Yellow berry was the least effective factor on to marketing price giving, $ 9 ton^{-1} marketing price reduction.

The relationship between marketing price and the content ratios of all grading factors between 0 and 10% ranges was further investigated through regression analysis. The regression equations, obtained from analysis and the regression lines were given in Table 4

and Fig. 2, respectively. The result of regression analysis indicated that all regressions were found to be significant statistically giving, F = 39.04** for combined effect, F = 71.02** for sunn pest damage, F = 98.0** for dark red bread wheat kernels, F = 96.33** for red bread wheat kernels and F = 36.90** for yellow berry and the coefficients of determination (R^2 %) were 92.9, 95.9, 97, 97 and 92.5, respectively.

DISCUSSION

The most important down grading factors of Turkish Grain Board were further investigated in this study. Except for yellow berry, the ratios employed in the study covered all downgrading ratios of TGB. Yellow berry ratios of the study matched with the premium ranges of TGB. There were some contradictions between the purchasing criteria of TGB and Şanlıurfa commodity market. Although it was not too sharp, the increasing amount of yellow berry (from 0 to 10%) reduced marketing price slightly in Şanlıurfa commodity market. Whist, these ratios receive extra premium from TGB. Yellow berry ratio in bulgur production is not as important as in macaroni production. Yellow berry reduces semolina yield in macaroni production. But, this does not affect bulgur production and quality. Therefore increasing yellow berry ratios can be tolerated in the area. Sunn pest damage over 5% is not purchased by TGB. But, the samples with even 10% sunn pest damage were offered a marketing price in this region. The presence of dark red and red bread wheat kernels in the grain lots were the second and third most effective down grading factors reducing marketing price, respectively. Bulgur production and consumption are over the national average in the South East of Anatolia. The presence of dark red bread wheat kernels in durum wheat leads the occurrence of some dark spots in bulgur. This reduces the marketing value sharply. TGB tolerates the presence of bread wheat kernels in durum wheat with a small amount of marketing price penalty. Joint effects of all down grading factors result in very sharp marketing price reductions obviously. The effect of sunn pest damage, starchy grains and other class of cereals on to marketing price was shown by Ozberk *et al.* (2005a). In which, there were negative correlations between marketing price vs. sunn pest damaged kernels% (r = -0.608**), dark red bread wheat kernels% (r = -0.456**), other cereals% (r = -0.487**), starchy kernels% (r = -0.472**). There was statistically positive correlation between marketing price and vitreous ness% (r = 0.313*). The presence of varietals preference of grain buyers was also confirmed by the research findings of Ozberk *et al.* (2005a). In which, Zenith was given the highest price and Firat-93 was in second range. The grain purchasers in Şanlıurfa commodity market tend to pay more marketing price for some industrially recognized varieties even with poor visual characteristics. In TGB purchasing criteria, definition of insect damaged kernel also include the kernels with sunn pest damage. Sunn pest damaged kernels must be separated from this down grading factor in South East of Anatolia. Dark red and/or red bread wheat grains are summed under the grade of bread wheat and contrasting class of wheat in both Turkey (Anonymous, 2002) and the USA (Bequette and Herman, 1994), respectively. This is a confusing grade, because white bread wheat grains in durum wheat do not reduce marketing price as did the dark red or red bread wheat kernels. Therefore, red or dark red kernels must be described in another column in all national and international markets.

Regression equations, showing the relations between marketing prices and some of down grading factors seem to be used for marketing price estimations safely with high coefficients of determination in the region.

Practical results from markets to wheat breeding for specific end product quality are an important issue. Some purchasing criteria such as kernel vitreous ness, grain and bulgur color are genetically based. Color is highly heritable and evaluated quickly by a color analyzer. Kernel vitreous ness is a heritable trait but it can be strongly affected by abnormal weather conditions such as excessive rainfall during the grain filling period (Bushuk, 1998). Breeding for sunn pest resistance has long been an attractive target for in Turkey. To date, it has been assumed that sunn pest preferred soft white bread wheat varieties followed by soft reds, hard whites and hard reds in the central Anatolia (Kinaci *et al.*, 1998). Taking quality into account, pest resistance studies need to be encouraged and early maturing types of durum wheat need to be focused on (Ozkan *et al.*, 1999). Moreover many problems, resulting in reductions in quality and marketing price can be avoided by using certified seed for crop production (Ozberk *et al.*, 2005a). Wheat breeding techniques can be used for alleviation of many quality problems occurred in durum wheat. But, can these efforts persuade the farmers to plant the cultivars with high quality employing good agricultural practices? A study carried out in bread wheat can answer this question securely. In which, there was a narrow marketing price range exist between cultivars with the highest and the lowest quality ($ ton^{-1}10.94) in Şanlıurfa commodity market. There fore none of farmer intended to plant high quality varieties. Taking into account high cost for production inputs, they mostly prefer high yielding varieties. Durum wheat consumption habits of South east of Anatolia are similar to those of neighboring countries

such as Syria, Iraq and Iran. Bulgur rather than macaroni is more common in these countries. Amber bulgur color is required for high marketing price.

Syria and Iraq markets are not quality conscious. Test weight is only attributing consistently to influence the price of wheat in Iran (Lee *et al*., 2000; Fradoun and Stanmore, 1997). Purchasing criteria are more or less same in local commodity markets in these countries. Research findings must be enlarged expanding such studies in those countries.

It was concluded that purchasing criteria of TGB were somewhat similar to those of Şanlıurfa commodity market. Comparing to the purchasing criteria of TGB, there are more yellow berry tolerance and less dark red and red bread wheat tolerance in Şanliurfa commodity market. Sunn pest damage reduce marketing price significantly in both TGB and Şanlıurfa commodity market purchasing criteria. Grain buyers in Şanlıurfa commodity market are quality conscious purchasers and they are expert to identify the seed lots visually according to the content% of sunn pest damage, the presence of dark red and red bread wheat kernels% and the yellow berry%. Increasing ratios of combined effect of all grading factors under study reduced the marketing price sharply ($ 41 ton^{-1}) and the increasing ratios of sunn pest damaged kernels, the presence of dark red and red bread wheat kernels and yellow berry took place in 3th, 4th and 5th ranks with $36, $23, $13 and $9 ton^{-1}, respectively. Regression equations with high coefficients of determination (R^2%) can be used for marketing price estimations for various down grading factors in the region. Narrow marketing price range between the highest quality variety and the lowest may lead to the farmers to plant high yielding varieties rather than high quality ones for specific end use quality. Negligible premium given to high test weight and kernel vitreous ness by TGB do not encourage the farmers to plant some cultivars with high quality characteristics.

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