CP- 84

A Market-Derived Selection Index for Consumer Preferences of Evident and Cryptic Quality Characteristics of Sorghum

1761

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Summary

A methodology has been developed for identifying relevant quality characteristics that determine consumer preferences for sorghum The estimation results show that a complex mix of evident as well as cryptic quality characters are jointly affecting consumer preferences, as reflected in daily market prices Two data sets (a) from one market over 4 years and (b) from four markets in 1 year were analyzed The estimated coefficients of relevant qualities can be used as weights for predicting an index of consumer preferences for sorghum (SPI) for which the relevant quality characters are known It is shown how 25 new sorghum samples are being ranked by SPI based on the two data sets

The rankings from both data sets are highly correlated, indicating that for predictive purposes the SPI performs consistently, regardless of whether it is derived from time series data or from cross-sectional data

The SPI is applicable for large-scale screening, although a few minor issues need to be resolved for increasing confidence and efficiency in its application

A methodology to predict consumer preferences of newly bred sorghum varieties on analysis of market prices as a function of relevant grain characteristics is the central objective of the ongoing work at the Economics Program, ICRISAT During more than 5 years of research, a number of issues have been resolved and the usefulness of market prices for deriving consumer preferences could be established The results permit a rapid screening procedure of sorghum for consumer acceptance in India However, further improvements in the methodology presented may be possible Further work to extend this methodology for other countries is required

Concept

The methodology proposed is based on the observation, in Indian wholesale markets, that on any market day the price for sorghum differs across different lots transacted and that these price differences are due to differences in quality If it is possible to identify those characteristics which determine quality in a given country or region and to measure the contribution of these characteristics in the determination of price, then it is possible to analyze any new variety for the same quality characteristics and to predict its market value Implicit in this approach is the assumption that price and income elasticities of demand for quality are constant across all income groups taken together and over time, so that the inferences drawn from past observations will hold for the future This assumption may be debatable, but it can be shown that the price differentiation between good and poor quality will continue even if the proportion of good quality has considerably increased as long as total supply is met by an equivalent demand for human consumption (von Oppen 1978b) Once supplies exceed that demand and sorghum is used for other purposes, e g , as animal food, things may perhaps change However, before this stage can be achieved in most parts of the semi-arid tropics (SAT) the production of sorghum has to increase, which requires the adoption of high-yielding varieties for human consumption, and therefore requires

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screening of improved varieties for consumer acceptance.

Methodology

A multiple regression equation was calculated to estimate the relationship between market price and various quality characteristics. The advantage of the multiple regression equation is that it enables the effect of several independent factors to be estimated and in a complex system where several factors are expected to jointly affect the dependent variable, this approach is appropriate.

The relationship between consumer preferences and relevant quality characteristics is certainly such a complex system. As we shall see later, even though the linear correlation matrix shows hardly any direct association between variables, (Tables 1 and 2), the multiple regression equation explains 64% of the variation of the dependent variable. The methodology to arrive at these estimates involves various steps:

1. Collection of market samples.
2. Laboratory analysis for relevant qualities.
3. Statistical analysis.
4. Interpretation and verification of the results.

While developing this methodology, most of the above steps were tried in several different ways to find the most efficient one to arrive at reliable results. The method described below is the result of about 5 years of continuous efforts in refining the methodology (von Oppen 1976, 1978a, 1978b).

1. Sample Collection

In India, market samples of sorghum are best collected from large urban wholesale markets. Smaller primary markets, where the arrivals from the particular region surrounding the market often show little variability in quality, are less suitable for sample collection; also, at the other end of the market channel, retail traders were found to be a less reliable source for sorghum samples than wholesalers; e.g., the same original lot from a wholesale market may be offered by different retailers at different prices; furthermore, retailers often have only two different qualities to offer, while in the case of wholesale traders they normally have more than three different lots at a time. The fact that wholesalers are operating in the same market place not only facilitates the collection but it also assures that the prices quoted on a particular market day are in fact comparable.

On any market day normally about 15 to 20 different lots are available. However, our experience shows that for the statistical analysis to yield satisfactory results, a set of around 80

Table 1. Correlation matrix of transformed[a] variables in data set (A) Hyderabad, 1977/1980, combined.

Variables[a]	Log price	Yellow grain	Red grain	Slight mold	Severe mold	Glumes	Log dry volume	Log swelling incapacity	Log 100-seed weight	Log protein
Log price	1	-.44	-.31	-.64	-.52	.06	-.18	-.13	.54	20
Yellow grain		1	.21	.74	.39	-.28	.13	-.06	-.35	.27
Red grain			1	.16	.54	-.05	.038	-.04	.005	.12
Slight mold				1	.44	-.23	.18	.004	-.37	.06
Severe mold					1	-.05	.28	-.01	-.11	-.08
Glumes						1	.53	-.01	.17	-.18
Log dry volume							1	.17	-.20	-.14
Log swelling incapacity								1	-.08	-.14
Log 100-seed weight									1	.12
Log protein										1

a. All the variables are transformed variables used in final regression.

observations is required Therefore, the sample collection has to be repeated for several days until the number of samples is sufficiently large The best time for sample collection was found to be during the peak marketing season, i e , between January and March

The analysis of data from samples collected monthly during the year 1979 in Hyderabad proved that after the peak marketing season, the grain becomes increasingly moldy Moldiness and the size of the seeds tend to remain the primary factors affecting price and dominating the price formation, so that other factors appear to become irrelevant once the peak marketing season is over Also during this post-season, less grain is being traded so that sample collection requires more time and effort As will be explained below, for reliable results samples should be collected for several years, if possible, to reflect the long run average consumer preference and not that of only one season

The amount of material needed per sample is less than 50 g and traders are quite willing to give that amount free of charge

2. Laboratory Analysis

One objective in developing the methodology has always been to provide a simple and quick way for a rapid screening of a large number of samples, using only a very small quantity of seed The tests involve the following procedures

(1) determination of the 100-seed weight
(2) counting the number of seeds with slight and severe mold
(3) counting the number of seeds with glumes
(4) measuring the dry volume of 10 g of seeds by the water displacement method
(5) observing the swelling of the seed after 6 hr of soaking in ordinary tap water, by measuring the volume increase and the weight increase of the soaked grains
(6) analyzing the sample for protein content

Apart from (6) protein analysis, all other tests can be carried out by an untrained person and without sopnisticated equipment Because of the soaking time required, one person working by himself is able to handle about 20 samples per day However, with several persons working in line, the number of samples, not only per day, but also per person were increased considerably

The above list of tests is the outcome of several years of searching Other measurements were tried but finally rejected because their contribution in explanatory power did not seem to justify the effort required to retrieve the information, such factors were moisture content, fat content, hardness of the grain, and color mix

Color mix was excluded from the tests because in conjunction with information about the sorghum's origin, it indicates nutritive and digestive qualities [1] Grain color alone rarely contributed more than a few percent in explanatory power but it made the results from samples taken in different places or periods appear to be more location or time specific than they actually are

3. Statistical Analysis

The data obtained from the above tests were transformed before deriving the regression equation, for reasons given below The original variables formed are

(1) 100-seed weight in g
(2) percent of grains with light mold
(3) percent of grains with severe mold
(4) percent of seeds with glumes attached
(5) dry volume in cm^3
(6) swelling incapacity, i e , increase in weight divided by increase in volume
(7) protein content, in percent

Since levels of market prices and quality mixes may vary from one day to the next, it was not possible to enter the prices and qualities directly into the analysis It was decided to generate a reference point and to set the actual observations in relation to this reference In the absence of any better way to define a reference quality, the average quality and the average price per market

1 This was the conclusion of a test in which five traders in Hyderabad market were given 92 samples of ICRISAT's World Collection of sorghum (see von Oppen 1978a) The traders were asked to hypothetically price the samples in line with present prevailing market prices Analysis of these hypothetical prices showed that only the evident characteristics, i e , color, seed size, glumes, and mold were reflected in the traders' assessment, while none of the cryptic characteristics such as dry volume, swelling capacity or protein contributed significantly During the test, the traders had mentioned that for a correct assessment they would need to gain experience in trading with these varieties

Table 2. Correlation matrix of transformed[a] variables in data set (B) four markets[b] combined, 198(

Variables[a]	Log price	Yellow grain	Red grain	Slight mold	Severe mold	Glumes	Log dry volume	Log swelling incapacity	Log 100-seed weight	Log protein
Log price	1	-.24	-.26	-.56	-.59	-.20	-.28	.06	.30	.19
Yellow grain		1	.13	.33	.11	-.11	-.01	-.01	-.04	.08
Red grain			1	-.05	.29	.03	-.10	-.02	-.06	.28
Slight mold				1	.18	.14	.33	-.07	-.19	-.18
Severe mold					1	.18	.31	-.05	-.20	-.09
Glumes						1	.46	-.04	-.10	-.05
Log dry volume							1	.01	-.20	-.28
Log swelling incapacity								1	-.05	-.10
Log 100-seed weight									1	.20
Log protein										1

All the variables are transformed variables used in final regression
Hyderabad, Bangalore, Poona, and Nagpur markets

day were taken as a reference against which to compare the individual qualities and prices. This is not ideal but it makes the observations more comparable across market days, than they would be otherwise.[2]

4. Interpretation and Verification of Results

The estimated coefficients and t-values provide information about the direction and size of the effect a variable has on the price of sorghum. This information can be used to predict the price of any new variety; especially if the values of the variables observed in the sample cover a wide enough range to embrace those values of the new variety (Table 3). By analyzing a sample of the new variety for the same qualities as described above and by multiplying the quality values with the estimated coefficients and summing according to the functional form used in the estimation equation, a prediction about the relative preference of that particular variety is generated.

To verify whether such predictions have any merit one can easily compare the predicted results with results of other more laborious tests to identify consumer preferences such as consumer panel tests.

This was done by using the 40 participants in the ongoing village study in Kanzara of Maharashtra State as the consumer panel (Bapna and von Oppen 1980). A set of 15 different sorghum varieties procured in the Hyderabad market was tested by a double blind procedure and the preferences expressed by the villagers were compared with the predicted market prices. The results show that the predicted market prices correlated better with expressed consumer preferences than did actual market prices.

Interestingly, by calculating these relationships independently for every size group it was found that the different groups of households had different capabilities in expressing their preferences for sorghum; while large farmers reported the most inconsistent preferences of all, the small farmers did best, followed by the landless and the medium size groups. As was confirmed later, larger farmers are not really eating much sorghum in Kanzara

2. For further details about the estimation model see von Oppen (1976). By explaining price variability on a particular market day as a function of variability in quality, the analysis leaves out the quantity-consumer expenditure dimensions of the problem. In doing so, it is implicitly assumed that the price and income elasticities are independent of quality. Lancaster (1971) and Theil (1976) have shown that this is not true. However, data that would permit a Lancaster/Theil type demand analysis are not available (von Oppen et al. 1979).

because they prefer and can afford to eat wheat and rice. Therefore, when similar verification trials are to be conducted in the future a preselection of a suitable consumer panel may be advisable.

Results

The present state of knowledge in the field of market-derived consumer preferences for sorghum in India is reflected in the results reported below. First, the estimation results of different data sets will be presented and discussed, explaining price as a function of quality characteristics. Second, the estimated parameters will be used for computing predicted consumer preferences in India of 25 new lines from the ICRISAT Sorghum Improvement Program. Finally, the predictions derived from the different data sets will be compared and conclusions will be drawn.

The data sets analyzed below were generated in two major sample collection efforts to gain insight into consumer preferences for sorghum in India (a) over time and (b) across space. The data were generated according to the methodology outlined above from the following samples:

(a) A total of 334 sorghum samples collected over 4 years (1977–1980) in one market, i.e., Osmangunj, Hyderabad.

(b) A total of 358 sorghum samples collected in 1 year (1980) in four markets in the major sorghum growing regions of India, i.e., in the cities of Hyderabad, Nagpur, Poona and Bangalore.

Sorghum Quality Preferences Over Time

Table 4 summarizes the results of the statistical analyses. It is found that for the 4 years combined, the adjusted $\bar{R}^2 = 0.64$, i.e., 64% of the variation in price is explained by the variation in the variables included in the multiple regression equation or by undefined variables associated with the included variables. Not only evident quality characteristics (e.g., moldiness, seed size) are very significantly explaining the price, but also the so-called cryptic characteristics such as the dry volume, the swelling incapacity, and the protein content of the grain.

The presence of glumes does not seem to be clearly affecting the prices, as in some years this effect is negative, but in another it shows a positive relationship to price, which may mean that the amount of glumes in the sorghum was generally low enough to be no real problem, except perhaps in year 1977; in the year 1980 when there was a positive association between glumes and price this would have been so because glumes happened to be found more frequently on those preferred types, but without causing concern.

All other variables are well behaving, i.e., whenever statistically significant they have the expected sign. Nevertheless, an F-test on the stability of the results over time shows that there are significant differences in the explanation of price as a function of the quality variables from year to year against all years. This is so because some variables such as glumes show opposite effects from one year to another.

However, the objective of this exercise is not so much to *explain* the consumer's preference (which would require a much more elaborate set of variables to be measured with much finer laboratory tests, than used here); instead of explaining, the goal is to *predict*. The predictions based on any of these individual year's estimates would not differ significantly.

Sorghum Quality Preferences Across Regions

Table 5 shows the results from four different wholesale markets, where the sorghum samples were collected during different weeks between January and March 1980.[3] The data are listed for the individual markets alone and in various combinations.

Comparing the individual data across markets, it was found that similar to the Hyderabad data over time, with the exception of "glumes" all other variables behave well, i.e., whenever significant, they have the expected sign. Generally, however, more insignificant variables are found, than in Hyderabad for individual years. Apart from mold and 100-seed weight the remaining variables appear to be rather insignificant. The picture is in fact similar to that which was found for Hyderabad during the off-season, when the effect of the other variables was dominated by these three evident

3. Hyderabad: January and February 1980.
Nagpur: March 1980, first week.
Poona: February, 18th to 23rd, 1980.
Bangalore: February 25th to March 1st, 1980.

Table 3. Means and variabilities of untransformed variables in two data sets, A and B and breeder's samples.

Variables (units)	Data Sets: A Hyderabad 1977–1980 combined				B 4 market combined[a] 1980				Breeder's samples used for predictions			
	Mean	CV (%)	Maximum	Minimum	Mean	CV (%)	Maximum	Minimum	Mean	CV (%)	Maximum	Minimum
Price (Rs/100 kg)	108.3	16.5	155.0	65.0	117.7	14.4	155.0	80.0	–			
Slight mold (%)	36.0	77.6	95.6	.7	47.0	45.3	87.0	2.3	47.2	28.0	69.0	27.8
Severe mold (%)	4.4	179.1	56.4	0	10.3	140.0	77.3	0	1.2	92.8	3.4	0
Glumes (%)	5.4	96.5	47.1	0	4.1	74.9	16.8	0	.089	364	1.6	0
Dry volume (cm^3 of 10 g)	7.85	3.0	9.2	7.5	7.88	3.1	8.5	7.5	7.66	1.7	7.9	7.4
Swelling incapacity (ratio)	1.04	5.8	1.47	.83	1.02	1.8	1.045	.745	1.015	1.2	1.039	1
100-seed weight (g)	2.73	16.3	3.64	1.68	2.80	17.2	4.74	1.68	3.19	7.14	3.80	2.81
Protein content (%)	8.1	13.1	11.4	4.9	7.5	14.3	11.3	4.6	9.95	13.0	11.6	7.3

a. Hyderabad, Nagpur, Poona, and Bangalore.

Table 4. Market price as a function of quality characteristics of sorghum in Osmangunj market, Hyderabad, 1977/1980, showing the coefficients for the multiple regression equation.

Equation	Variables							Statistics		
Year	Light mold	Severe mold	Glumes	Log dry volume	Log swelling incapacity	Log 100-seed weight	Log protein	$\bar{R}^2$	Observations	Error mean square
1977	−0.037	−0.198	−0.337	0.892	−0.201	0.276	0.300	0.76	64	0.03269
	(−2.2)	(−3.1)	(−4.9)	(2.6)	(−2.3)	(3.9)	(3.9)			
1978	−0.118	−0.179	−0.008	0.394	−0.201	0.310	0.145	0.58	98	0.1330
	(−6.3)	(−1.5)	(−0.1)	(0.9)	(−0.7)	(5.2)	(1.9)			
1979	−0.075	−0.324	0.089	0.407	−0.697	0.388	0.095	0.68	102	0.13938
	(−3.4)	(−5.3)	(0.7)	(0.9)	(−1.4)	(5.2)	(1.2)			
1980	−0.118	−0.246	0.413	−0.390	0.388	0.291	0.096	0.72	67	0.06516
	(−4.9)	(−6.3)	(2.2)	(−0.7)	(0.4)	(3.5)	(1.1)			
1977 to 1980, combined	−0.092	−0.271	−0.056	0.635	−0.331	0.323	0.165	0.64	334	0.43040
	(−10.0)	(−9.5)	(−1.0)	(2.8)	(−3.1)	(9.7)	(4.3)			

Numbers in parenthesis are t-values.

Table 5. Market price as a function of quality characteristics of sorghum in four markets and groups of markets in 1980, showing the coefficients for the multiple regression equation.

Equation	Variables							Statistics		
Market or market group	Light mold	Severe mold	Glumes	Log dry volume	Log swelling incap-city	Log 100-seed weight	Log protein	$\bar{R}^2$	Observations	Error mean square
Hyderabad	−0.118 (−4.9)	−0.246 (−6.3)	0.413 (2.2)	−0.390 (−0.7)	0.388 (0.4)	0.291 (3.5)	0.096 (1.1)	0.72	67	0.06516
Nagpur	−0.041 (−5.1)	−0.056 (−3.7)	−0.048 (−1.4)	0.083 (0.8)	−0.051 (−0.6)	0.052 (3.7)	0.015 (0.7)	0.49	122	0.01584
Poona	−0.134 (−6.1)	−0.242 (−6.2)	−0.280 (−1.7)	0.146 (0.5)	0.277 (0.4)	−0.034 (−0.5)	0.070 (1.2)	0.66	80	0.05187
Bangalore	−0.229 (−9.5)	−0.249 (−10.6)	0.270 (−1.4)	0.628 (1.7)	−0.725 (−0.9)	0.076 (1.0)	−0.083 (−1.0)	0.73	86	0.09011
Hyderabad + Nagpur	−0.092 (−7.3)	−0.146 (−6.4)	0.097 (1.4)	0.210 (1.0)	0.064 (0.3)	0.111 (3.8)	0.056 (1.3)	0.50	190	0.14113
Hyderabad + Poona	−0.134 (−8.7)	−0.207 (−8.3)	0.102 (0.8)	−0.109 (−0.4)	0.398 (0.7)	0.126 (2.5)	0.062 (1.3)	0.67	148	0.13326
Hyderabad + Bangalore	−0.188 (−12.1)	−0.232 (−12.5)	−0.046 (−0.4)	0.308 (1.0)	−0.397 (−0.6)	0.125 (2.4)	−0.068 (−1.3)	0.70	154	0.17850
Nagpur + Poona + Bangalore	−0.104 (−9.8)	−0.181 (−13.0)	−0.136 (−2.0)	0.432 (2.5)	−0.090 (−0.5)	0.057 (2.1)	0.058 (1.8)	0.56	290	0.24730
Hyderabad + Poona + Bangalore	−0.167 (−13.6)	−0.221 (−13.9)	−0.123 (−1.2)	0.318 (1.4)	−0.074 (−0.2)	0.072 (1.7)	0.013 (0.3)	0.68	235	0.24361
Hyderabad + Nagpur + Poona + Bangalore	−0.120 (−12.4)	−0.189 (−14.2)	−0.046 (−0.7)	0.353 (2.1)	−0.045 (−0.2)	0.085 (3.2)	0.043 (1.4)	0.58	358	0.33913

characteristics. Possibly the time of data collection in the other market places might not have been chosen optimally, although it could not have been too far off, with *rabi* harvests generally appearing in the markets in February. Another more relevant explanation may be that just one year's, and here only a few days', data are not quite enough for getting a picture of the long run position of consumer preferences in a particular market. Given the many shortcomings of the methodology it is obvious that only very large data sets covering several years will bring out the true facts, by "washing out" the temporary phenomena which are irrelevant for the long run purpose of constructing a reliable quality preference index.

The tests of interregional stability of sorghum preferences in 1980 are consequently giving mixed results. While some combinations are statistically homogeneous, others are not. The market which brings in most noise is Nagpur, where the regression is explaining only 49% of the variability in price, and which is considerably below the others, with explanatory power ranging from 66% to 73%. The combination of all markets' data gives coefficients as presented in Table 5, row 10, comparing these coefficients with those measured in Hyderabad over time (Table 4, row 5), it is obvious that generally the orders of magnitude and statistical significance and $\bar{R}^2$ for all variables are lower.

However, taking these generally much weaker regional results and using them for prediction, it is found that the Hyderabad data over time and the regional data generate very similar results. For instance, using the coefficients from the Hyderabad time series regression equation for predicting the samples collected in the four markets, predicted and actual prices are found to be significantly correlated with a correlation coefficient of $r = .70$; vice versa using the regression results from the four markets for predicting Hyderabad prices yields predictions which correlate with actual prices to the degree of $r = .74$.

Predicted Consumer Preferences of 25 New Varieties

The Sorghum Improvement Program of ICRISAT provided 25 samples of new lines of sorghum for analysis according to the above methodology.

The 25 samples were analyzed only once for the above listed qualities, i.e., without replication. For each sample the amount found for a particular quality was multiplied by the respective estimation coefficient to get a weighted quality value; all of the weighted quality values in the equation were then added according to the functional form used in the estimation yielding a predicted value of consumer preference or a consumer preference index for sorghum (SPI).

The SPI is a market derived prediction of the relative price of sorghum based on the weighted quality characters, relevant to sorghum consumers.

In Table 6, two SPI's are presented which were calculated for the 25 new sorghum lines on the basis of estimation coefficients from two different sets of data as described above: (a) estimates from

Table 6. Consumer preferences of 25 sorghum samples valued and ranked by a preference index based on (A) estimations from one market over 4 years and (B), estimations from four markets in 1 year.

	Index A		Index B	
Sample no.	Valuation	Ranking	Valuation	Ranking
22	1.2099	1	1.1408	1
1	1.1688	2	1.1145	4
4	1.1330	3	1.0996	7
14	1.1318	4	1.1189	2
11	1.1311	5	1.0451	16
3	1.1267	6	1.1159	3
2	1.1233	7	1.1050	6
5	1.1173	8	1.0418	17
8	1.1166	9	1.0707	10
25	1.1082	10	1.0880	8
21	1.1040	11	1.1110	5
16	1.0955	12	1.0515	14
23	1.0938	13	1.0853	9
15	1.0928	14	1.0600	12
13	1.0847	15	1.0503	15
18	1.0832	16	1.0288	19
10	1.0822	17	1.0408	18
19	1.0812	18	1.0554	13
6	1.0729	19	1.0110	22
12	1.0630	20	1.0682	11
9	1.0375	21	1.0170	21
24	1.0302	22	.9939	24
7	1.0146	23	1.0038	23
17	.9963	24	1.0216	20
20	.9649	25	.9831	25

one market over 4 years and (b) estimates from four markets in 1 year.

Table 6 also lists the ranking of the 25 lines according to these two SPI. A comparison of both the rankings shows that they are highly correlated. In fact, the correlation coefficient is .83, which implies a correlation significant at 1% level of probability. Inspection of Table 6 shows for instance that if one wanted to retain the 10 best samples and/or discard the 10 worst, then in both cases 8 samples would be selected by either index which are the same, while only 2 samples would differ depending upon which of the two SPI were applied. A comparison of the preferences predicted by the two SPI is also given in Figure 1, which depicts how a selection of the 10 best or 10 worst samples overlaps for 8 samples in each case. Naturally, anyone who feels that neither of the two SPI by itself but a combination of both provide a better criterion for the selection of quality, may want to choose instead of lines AA or BB in Figure 1, a cut-off line such as CC for compromise.

Unresolved Issues in Applying the SPI

The above example of applying the SPI on 25 sorghum lines is convincing because of its simplicity and consistency. However, several questions require further study in collaboration with the Sorghum Improvement Program for gaining more experience and confidence in applying the SPI.

(A) Replication of laboratory tests. The laboratory tests for quality of the 25 samples were

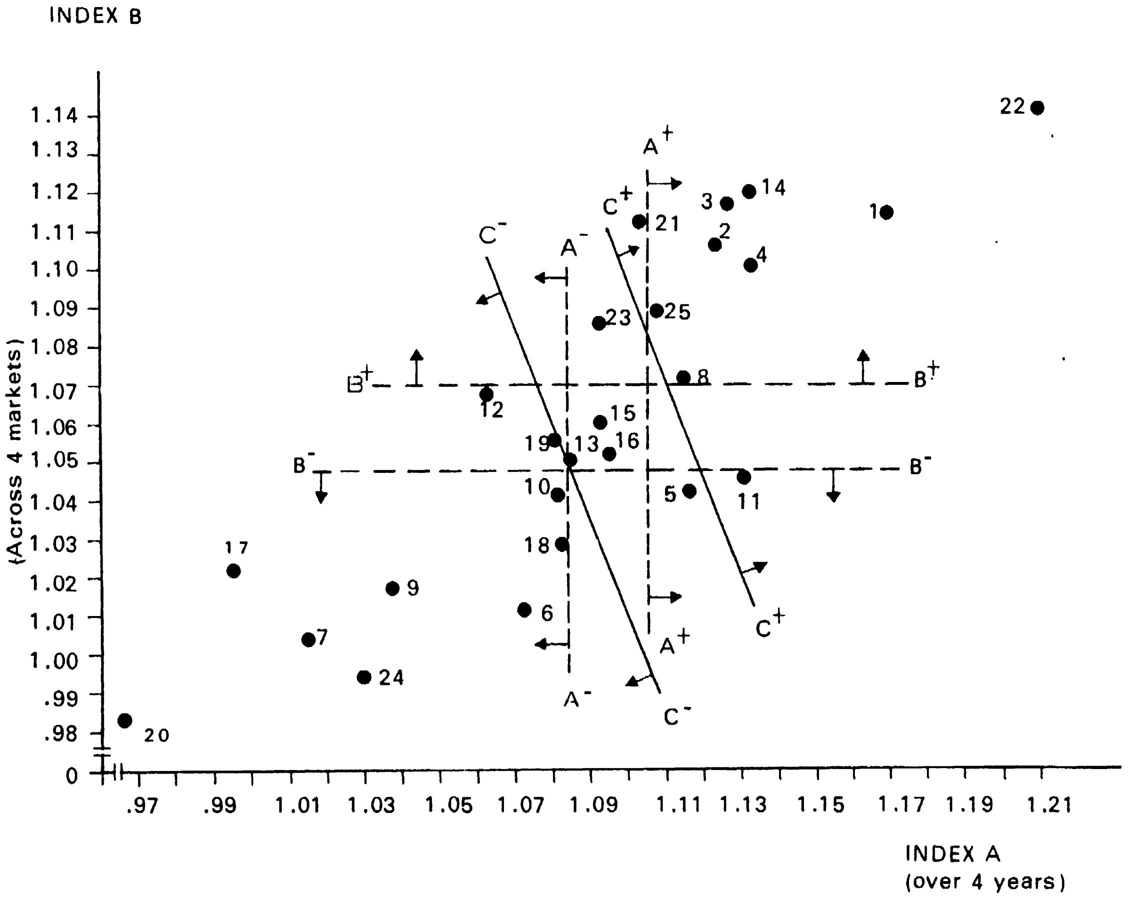

Figure 1. Valuation of 25 sorghum samples according to preference index A versus B and delineation of 10 samples of highest values and 10 of lowest based on these indices or on a combination index C. Note: *For example, line A^+A^+ delineates the 10 highest value samples to the right; line C^-C^- delineates the 10 lowest value samples to the lower left; the number with the dot indicates sample number.*

initially done without replication and one mistake occurred in the determination of the 100-seed weight of a sample. Replications in the laboratory tests would help to avoid similar mistakes in the future, although this would, of course, increase the laboratory effort required for deriving the SPI.

(B) The impact of moldiness. As shown in Table 3, the proportion of molded grains in the market samples was on average 40% in the case of one market over 4 years, and 57% in the case of four markets in 1 year, and grain mold contributed importantly to the explanation of price in the estimate equations (Tables 4 and 5).

The sorghum breeders are sure that the material which they provided in the 25 samples was generally without mold. Nevertheless, some samples with grains that had a slightly dull appearance were classified as slightly moldy. This obviously affected the SPI of these particular samples in a negative way.

The classification may have been incorrect because without any particular training at the time of this first assessment, the person who analyzed the samples may have mistaken the dull grains for moldy ones; on the other hand, his assessment may also be indicative of what the average consumer would perceive, seeing the dull grain. However, in the future it will be necessary to resolve this issue and to establish in collaboration with the plant pathologists, some way of more clearly distinguishing moldy from unmoldy grains.

A more general issue arising at this point is that of the growing conditions of the seed material. If produced under protected and irrigated conditions, a cultivar's actual performance under farmers' field conditions may not be revealed; yield, but probably more so quality are likely to be affected. The value of the methodology would be greatly enhanced if material grown under farmers' field conditions could be used.

(C) Identification of other relevant quality characters. As it stands, the SPI predicts well and consistently identifies quality differences between grains that to the naked eye are almost identical in appearance; however, even though the quality characters included in the SPI are relevant, and explain about 60 to 70% of the market price variations, there is still a possibility that additional quality characters could be identified which might further improve the SPI.

For instance, particle size of the flour may be such a characteristic, which might be worth considering, once a standardized method exists for measuring it in a small sample.

(D) Verification of results in village tests. The ultimate answer, whether the SPI is applicable or not, can only be given by the sorghum consumer who lives in the village and whose "daily bread", i.e., his livelihood, depends upon sorghum. Similar to the test of a household panel of village consumers in Kanzara, mentioned above, in which market samples were used, further tests should be carried out using material from the Sorghum Improvement Program. Such tests with rural consumers would permit comparisons between the villagers' assessment and the SPI, or any other preference index. This would also provide a check about the possibility of extrapolating information about preferences derived from existing material traded in the market to new varieties not yet available in the market channels.

Conclusions

A method of identifying relevant quality characteristics, as reflected in market prices, has been developed. The degree to which each characteristic influences the market price of sorghum is estimated. These estimated coefficients serve as weights in jointly assessing all relevant qualities and predicting the overall consumer preference of any new sorghum line.

The preference index for sorghum (SPI) can be derived with the help of simple laboratory tests and routine statistical computations, so that a large number of samples can be screened in a short time.

The SPI was derived in one case from time series data and in another case from cross-section data and produced rankings for both cases which were highly correlated, thus indicating the robustness of this method of predicting consumer preferences.

A few issues require further attention of researchers including the following: the number of replications of laboratory tests required for reliability; guidelines for identification of mold; the possibility of including other relevant characters; and field verification of the SPI.

Resolving these issues will help to increase the confidence and efficiency for an application of the SPI in selecting sorghum lines for good consumer acceptance.

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