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COST-BENEFIT RELATIONSHIPS IN QUALITY PROTEIN MAIZE PRODUCTION

By

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As shown in various papers of this conference, Opaque-2 maize has a very significant nutritional advantage over common maize both in human and animal nutrition. With its high quality protein, Opaque-2 maize provides an opportunity for reducing widespread malnutrition caused by shortage of certain essential amino acids in the diet of low income families in developing countries. However, superior nutritional quality does not by itself assure that Opaque-2 maize will find its way into the diet of those who are short on high quality protein. A number of technical, social and economic requirements must be met before it can be expected that a self-sustained production and consumption will take place.

The present paper deals with certain economic issues related to its production and consumption. The objectives of the paper are (1) to discuss the social and private benefits and costs of expanding the production and utilization of Opaque-2 maize, (2) to identify differences between social and private benefits and costs and (3) to suggest public policy measures aimed at reducing such differences to assure that the potential net benefits from Opaque-2 maize are fully utilized.

After a short definition of social and private benefits and costs, the paper analyzes briefly the potential benefits of Opaque-2 maize to the countries of South America. Then an analysis is made of the benefits and costs to the consumer, the livestock producer and the maize producer and the paper terminates with a discussion of social benefits and costs and possible government intervention aimed at obtaining the potential social

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benefits from the production and consumption of Opaque-2 maize. Since the economics of utilizing Opaque-2 maize in processed foods will be considered separately at this symposium, this paper focuses on the utilization for direct human consumption and animal feed.

Social vs. private benefits and costs

Social benefits and costs refer to the benefits and costs to society as a whole from the production and utilization of Opaque-2 maize while private benefits and costs refer to the benefits and costs to the individual person or enterprise involved in its production, marketing and consumption. As will be shown in analyses to follow, social benefits and costs may differ considerably from private benefits and costs. Private benefits and costs may be such that potential net social benefits will not be realized unless certain corrective measures are introduced.

Potantial benefits of Opaque-2 maize - the case of South America

Approximately 22 percent of the maize used in South America is used for direct human consumption, while 62 percent is utilized as animal feed (9).

Some countries use a high percentage of the total maize production for direct human consumption, such as Bolivia (81%), Colombia (72%) and Ecuador (52%). The average per capita consumption of maize in South America in 1970 was estimated at 20.6 kg. Maize plays a major role in the human diet in countries such as Bolivia, Venezuela, Paraguay, Colombia and Brazil while it is of little importance in Uruguay, Chile and Argentina (Table 1).

Table 1 shows the estimated intake of the two essential amino acids

Table 1. Quantity of maize utilized for human consumption in South America, 1970; its estimated lysine and tryptophan content and the potential content of a similar quantity of Opaque-2 maize

Country	Annual consumption 1/		Lysine intake 2/ (Gr./cap.)		Tryptophan intake 2/ (Gr./cap.)	
	Total (1000 tons)	Kg. per capita	Actual (Common maize)	Potential (Opaque-2 maize)	Actual (Common maize)	Potential (Opaque-2 maize)
Argentina	122	5.0	13.5	26.3	3.2	6.9
Bolivia	213	43.2	116.6	226.8	27.2	59.2
Brazil	2.111	22.6	61.0	118.7	14.2	31.0
Chile	26	2.7	7.3	14.2	1.7	3.7
Colombia	495	23.4	63.2	122.9	14.7	32.1
Ecuador	130	21.4	57.8	112.4	13.5	29.3
Paraguay	92	38.7	104.5	203.2	24.4	53.0
Peru	261	19.3	52.1	101.3	12.2	26.4
Uruguay	5	1.7	4.6	8.9	1.1	2.3
Venezuela	458	41.7	112.6	218.9	26.3	57.1
South America	3.913	20.6	55.6	108.2	13.0	28.2

1/ Source: FAO (9)

2/ Estimated on the basis of the following lysine and tryptophan content in grams per kilo of whole grain (7, p. 261):

	Lysine	Tryptophan
Common maize	2.70	0.63
Opaque-2 maize	5.25	1.37

lysine and tryptophan from maize during 1970 and the potential intake of these amino acids if all the common maize used for human consuption were changed to Opaque-2 maize. As shown in Table 2, if the per capita maize consumption for 1970 were maintained and all maize was of the Opaque-2 type, the average per capita lysine needs would be fulfilled from maize alone in Bolivia, Venezuela and Paraguay, while it would supply more than 50 percent of total needs in Brazil, Colombia, Ecuador and Peru. Opaque-2 maize would supply more than 90 percent of all tryptophan needs in Bolivia and Venezuela and would provide more than 50 percent of total needs in Paraguay, Colombia and Brazil (Table 3). Hence, given the shortage of essential amino acids in the diets of low income families in Latin America, we may conclude that the introduction of Opaque-2 maize could carry with it great nutritional benefits.

The limitations of this analysis should be recognized. Average national consumption data do not reflect intra country differences. Adequate average per capita consumption is of little importance to the disadvantaged groups with a high level of malnutrition. Although the quantity of maize consumed may be expected to be positively correlated with incomes up to a certain income level, maize is a commodity consumed in relatively large quantities by low income families in most Latin American countries. Hence, average consumption data may be less biased in the case of maize than in the case of certain other products such as meats, milk, fruits and vegetables.

Another factor not reflected by the average data is that related to the differences between the amino acid needs of children and adults. Also in this case, however, average data for maize may be less biased than those

Table 2. Estimated average lysine intake from common maize and potential intake from Opaque-2 maize as compared to needs (Mgs./day per capita)

Country	Present intake from common maize		Potential intake from Opaque-2 maize	
	Mgs./day	% of need 1/	Mgs./day	% of Need 1/
Argentina	37.5	6.9	73.1	13.4
Bolivia	323.9	59.5	630.0	115.8
Brazil	169.4	31.1	329.7	60.6
Chile	20.3	3.7	39.4	7.2
Colombia	175.6	32.3	341.4	62.8
Ecuador	160.6	29.5	312.2	57.4
Paraguay	290.3	53.4	564.4	103.8
Peru	144.7	26.6	281.4	51.7
Uruguay	12.8	2.4	24.7	4.5
Venezuela	312.8	57.5	608.1	111.8
South America	154.4	28.4	300.6	55.3

1/ Estimated on the basis of the needs of young adults of 544 mg./day (1), p. 13).

Source: Estimated from Table 1.

Table 3. Estimated average tryptophan intake from common maize and potential intake from Opaque-2 maize as compared to needs (Mgs./day per capita)

Country	Present intake from common maize		Potential intake from Opaque-2 maize	
	Mgs./day	% of need 1/	Mgs./day	% of need 1/
Argentina	8.9	5.3	19.2	11.4
Bolivia	75.6	45.0	164.4	97.9
Brazil	39.4	23.5	86.1	51.3
Chile	4.7	2.8	10.3	6.1
Colombia	40.8	24.3	89.2	53.1
Ecuador	37.5	22.3	81.4	48.5
Paraguay	67.8	40.4	147.2	87.6
Peru	33.9	20.2	73.3	43.6
Uruguay	3.1	1.8	6.4	3.8
Venezuela	73.1	43.5	158.6	94.4
South America	36.1	21.5	78.3	46.6

1/ Estimated on the basis of the needs of young adults of 168 mg./day (1, p. 13).

Source: Estimated from Table 1.

for certain other products due to the importance of maize in the diets of small children. Finally, global data such as those used in the above analysis are frequently collected under adverse conditions and may not describe the real situation in an exact manner. Hence, rather than exact figures we may consider the data as approximate magnitudes.

Benefits and costs to the consumer

The above analysis refers to potential nutritional benefits. The potential benefits to the consumer may occur in two ways: (1) Through improved nutrition resulting in improved health, increased earnings capacity and improved well-being, and (2) Through savings obtained by substituting Opaque-2 maize for other more expensive foods such as milk, meats and beans, maintaining the nutritional level constant.

When discussin consumer benefits it is important to distinguish between subjective and "real" benefits. Subjective benefits are determined by the individual consumer on the basis of his preference function while "real" benefits are measured by some objective standards such as increased intake of essential amino acids or reduced disease frequency or severity. Furthermore, benefits and costs to the individual, in the following referred to as private benefits and costs, may differ from benefits and costs to society (social benefits and costs). Reduced medical costs, for example, may reduce social costs but have little influence on private costs. This section is limited to private benefits and costs, while social benefits and costs will be discussed in a later section.

In a free market economy, we expect consumer decisions to be made in such a way as to maximize subjective benefits given the income con-

straint. Subjective benefits may differ greatly from "real" benefits. Lack of knowledge is one factor which may cause such difference. When more than half of a group of Colombian homemakers interviewed, preferred common maize to Opaque-2 maize at equal prices, it was primarily because they dis not know how to prepare Opaque-2 maize (4). Furthermore, the homemakers were not made aware of the nutritional advantages of Opaque-2 maize. In another study (3) a group of persons were asked to evaluate various dishes prepared from common and Opaque-2 maize. Although no statistical analysis on the results is reported, it appears that the persons found no significant differences between dishes prepared from common maize and those prepared from Opaque-2 maize. Hence, although the two studies are not directly comparable 1/, the results suggest that an educational campaign explaining methods of preparation would greatly enhance the acceptance of Opaque-2 maize or, to use our earlier terminology: increase subjective benefits derived from Opaque-2 maize relative to that derived from common maize.

The impact of information concerning the nutritional advantages of Opaque-2 maize on acceptance is not clear. A considerable knowledge of relative nutritional values of traditional foods was found among low income rural (producers) and urban consumers in Colombia (4). The reasons why one food had a higher nutritional value than another were not generally understood. Hence, information relating the nutritional value of Opaque-2 maize to that of some well-known foods such as milk and meats may

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1/ Consumer choice during purchasing is one of the important variables excluded from the latter study.

improve considerably the acceptance of Opaque-2, thereby reducing the difference between subjective and real benefits of Opaque-2 maize, while information on the higher quality protein might have little impact on acceptability.

As indicated in the previous discussion, the consumer does not automatically change from a nutritionally inferior, well-known food to a nutritionally superior new food even though the price of the two foods is equal. As will be discussed later, there is reason to believe that Opaque-2 maize will have to be priced above common maize to assure its production. The question then is whether the subjective benefits obtained from changing from common to Opaque-2 maize exceeds the subjective costs associated with the change. In other words: How much is the low income consumer willing to pay for an additional quantity of lysine and tryptophan? We do not know!

While we are waiting for more research to be done on the relation between subjective value of food and its nutritional value particularly with respect to Opaque-2 maize, we may attempt to estimate certain "real" benefits to the consumer of Opaque-2 maize on the basis of the costs of obtaining the same nutrition from alternative sources.

One alternative might be fortification of common maize with lysine and tryptophan. Adding 0.3 percent L-lysine and 0.07 percent DL-tryptophan to maize, Rosenfield (8) estimated the cost of fortification to be U.S.$13.61 per metric ton of maize. The amino acid prices used in the analysis were: L-lysine, U.S.$2.20/kg. and DL-tryptophan, U.S.$10.00/kg. The world market price for maize is presently around U.S.$50/ton. Assuming that the nutritional value of the above fortified maize is equal to

that of Opaque-2 maize, Opaque-2 maize could comman a price 27 percent above that of common maize from the point of view of nutrition.

Lysine is presently available on the Colombian market at a price of approximately U.S.$6/kg., the exact price being determined by the quantity purchased. No price was obtained for tryptophan on the Colombian market. Let us assume for this analysis, that tryptophan could be imported at a price of U.S.$25/kg. The current producer price of common maize in Colombia is approximately U.S.$90 per ton. Assuming that the price of Opaque-2 maize would need to be 10 percent above that of common maize to compensate for yield differences, the additional cost to the consumer would be U.S.$9 per ton. Fortified maize could be made available at a price of U.S.$125 per ton. Hence, Opaque-2 maize would supply additional lysine and tryptophan considerably more inexpensive than would fortification.

Rather than use synthetic amino acids as the "best" alternative it might be more realistic to compare the nutritional and monetary value of Opaque-2 maize to that of other available foods. One method would be to establish minimum cost, nutritionally adequate diets by means of a linear programming model where Opaque-2 maize is included among the foods available.

Benefits and costs to the livestock producer

While benefits and costs to the consumer are difficult to measure because of individual preferences and the difficulty of quantifying the benefits associated with improved human nutrition, benefits and costs related to the utilization of Opaque-2 maize in livestock production are relatively easy to estimate.

Table 4 and Figures 1 and 2 show the results of an economic evaluation of Opaque-2 maize for swine in Colombia (6). The analysis was carried out using relative prices rather than actual market prices at the time of study, to develop models with applicability under any set of prices. Diets of common maize and soybean oilmeal were compared to Opaque-2 maize diets for each of the four periods: gestation, lactation, growing (20-50 kg. live weight) and finishing (50-90 kg.).

The following diets were compared:

Period		Diets compared
Gestation	I.	Common maize (74%) and soybean oilmeal (23%) - CMS
	II.	Opaque-2 maize (97%) - OM
Lactation	I.	Common maize (79%) and soybean oilmeal (17%) - CMS
	II.	Opaque-2 maize (96%) - OM
Growing	I.	Common maize (81%) and soybean oilmeal (16%) - CMS
	II.	Common maize (96%) - CM
	III.	Opaque-2 maize (90%) and soybean oilmeal (6%) - OMS
	IV.	Opaque-2 maize (96%) - OM
Finishing	I.	Common maize (81%) and soybean oilmeal (16%) - CMS_{16}
	II.	Common maize (91%) and soybean oilmeal (6%) - CMS_6
	III.	Common maize (96%) - CM
	IV.	Opaque-2 maize (96%) - OM

The data used for the economic analysis were obtained from nutritional experiments carried out by Dr. Jerome Maner, CIAT and others. The biological results used in the economic evaluation are published in various journals.

Opaque-2 maize may replace common maize and all or part of the protein supplement. Hence, in addition to the relative nutritional values of common and Opaque-2 maize, the relative benefits and costs of substituting Opaque-2 maize for common maize depends on the relative prices of the two

Table 4. The maximum price of Opaque-2 maize relative to the price of common maize and soybean oilmeal that can be paid without reducing net returns

Period	Diets compared 1/	a 2/	b 2/	Maximum price of Opaque in percent of price of common maize if price of soybean oilmeal is:	
				150% of the price of common maize	200% of the price of common maize
Gestation	CMS and OM	0.767	0.239	113	125
Lactation	CMS and OM	0.838	0.176	110	119
Growing	CMS and OMS	0.665	0.104	82	87
	CMS and OM	-0.208	0.221	12	23
	CM and OMS	2.381	-0.067	228	225
	CM and OM	1.996	0.000	200	200
Finishing	CMS_{16} and OM	0.810	0.158	105	113
	CMS_6 and OM	0.988	0.064	108	112
	CM and OM	1.363	0.000	136	136

1/ See text for explanation of codes.

2/ The coefficients a and b refer to the model $P_o/P_c = a + b\ (P_s/P_c)$ explained in the text.

Figure 1. The relative net returns from the various diets as a function of the price of soybean oilmeal - The growing period

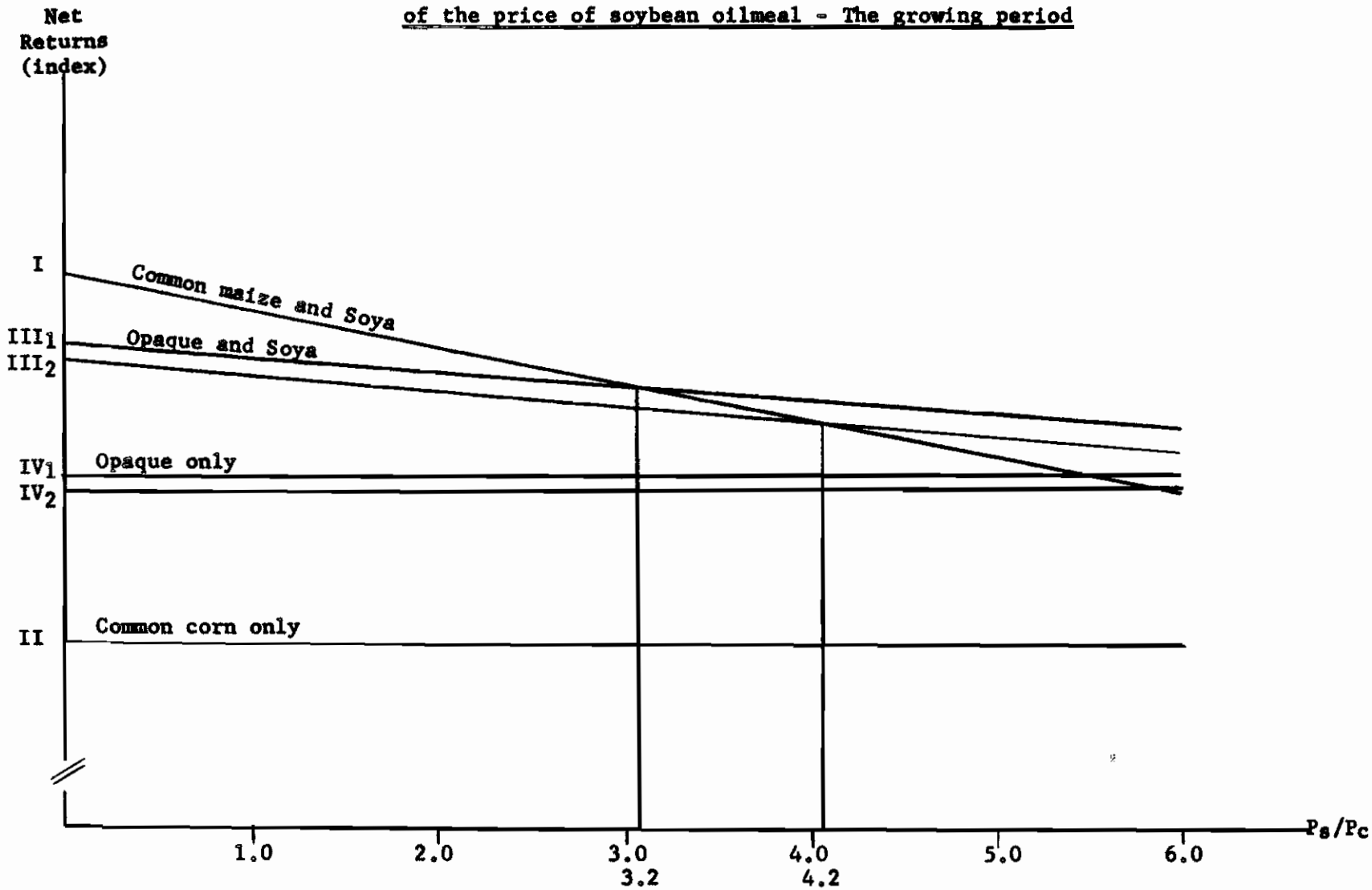
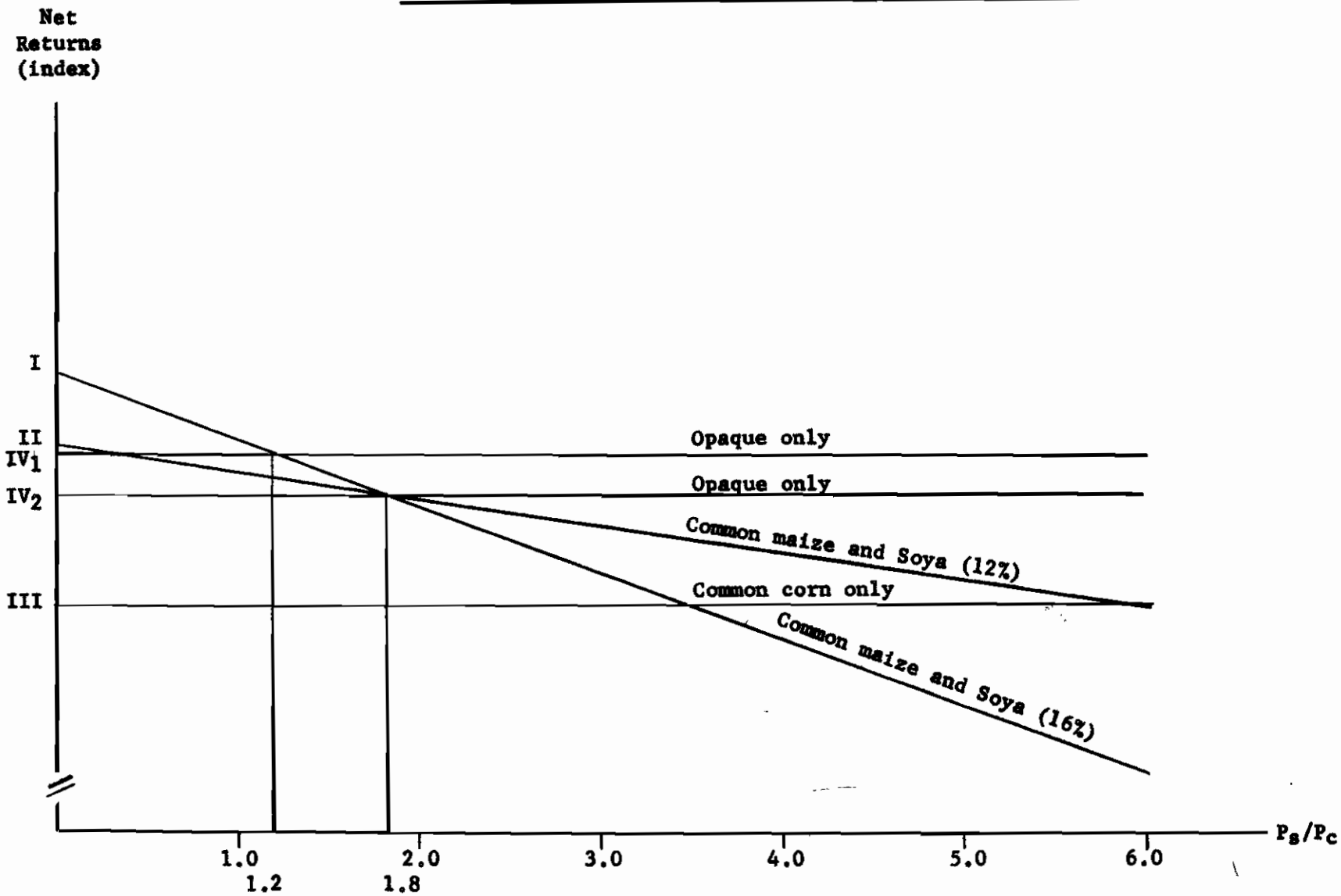


Figure 2. The relative net returns from the various diets as a function of the price of soybean oilmeal - The finishing period



maizes and the protein supplement.

Table 4 shows the estimated maximum price of Opaque-2 maize relative to the price of common maize at which the producer could increase net returns by substituting Opaque-2 maize for common maize in the diets for each of the four periods of the swine life cycle. Hence, if the estimated maximum price is above the market price for Opaque-2 maize, the swine producer who is presently using a common maize diet could increase net returns by shifting to Opaque-2 maize.

The relationship between the maximum price of Opaque-2 maize and the price of common maize and soybean oilmeal is expressed as:

$$P_o/P_c = a + b\ (P_s/P_c)$$

where

P_o = price of Opaque-2 maize

P_c = price of common maize

P_s = price of soybean oilmeal

The coefficients a and b may be interpreted as coefficient of an ordinary regression equation. Hence, for each unit change in (P_s/P_c), the coefficient b shows the resulting change in (P_o/P_c) 1/.

The maximum price of Opaque-2 maize relative to the price of common maize that the swine producer would be willing to pay can be estimated directly from the coefficients a and b for any soybean oilmeal price.

The utility of the model may be illustrated with a hipothetical example. Suppose that a swine producer can purchase common maize at U.S.$60/ton, soybean oilmeal at U.S.$100/ton and Opaque-2 maize at U.S.$65/ton. Given these market prices, the producer wants to know whether to use a

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1/ A complete description of the mathematical model may be found in (6).

common maize - soybean oilmeal diet or an Opaque-2 diet during finishing.

The maximum price he can pay for Opaque-2 maize may be calculated directly from the model: $P_o/P_c = a + b\ (P_s/P_c)$ or, using the coefficients shown in Table 4 and the above prices: $P_o/P_c = 0.810 + 0.158\ (100/6) = 1.073$. Hence, the producer can pay up to 7 percent more for Opaque-2 maize. But in the example the market price of Opaque-2 maize was 8 percent above that of common maize (5/60), hence under these prices, the producer should use the common maize - soybean oilmeal diet.

Table 4 shows the estimated maximum prices of Opaque-2 maize, for soybean oilmeal prices equal to 150 and 200 percent of the price of common maize. If the price of soybean oilmeal is 150 percent of the price of common maize it would be economically sound to substitute Opaque-2 maize for common maize during gestation if the price of the former is not more that 13 percent above the price of common maize. During lactation, the data suggest that Opaque-2 maize should replace common maize and soybean oilmeal only if the price of Opaque-2 maize were less than 10 percent above that of common maize. If the price of soybean oilmeal is twice the price of common maize it would be recommendable to use Opaque-2 maize up to a price of 25 percent above that of common maize during gestation and 19 percent above during lactation.

If a protein supplement is available at a reasonable cost it does not seem economical to substitute Opaque-2 maize for common maize during the growing period (20-50 kg.). However, if no protein supplement is available, hence the diet is one of common maize only, the feed costs may be reduced considerably by utilizing Opaque-2 maize. During the finishing period (50-90 kg.) it would be economically sound to replace a common

maize - soybean oilmeal diet with 16 percent soybean oilmeal by an Opaque-2 diet if the price of Opaque-2 maize were less than five percent above the price of common corn, and soybean oilmeal was available at a price equal to 150 percent of the common corn price. A diet consisting of common maize only should be replaced by an Opaque-2 diet unless the price of the latter is more than 36 percent above the price of the former.

Up to this point, the analysis has been aimed at estimating the maximum price of Opaque-2 maize that could be paid by the swine producer without reducing net returns under selected relative prices of soybean oilmeal and common maize.

Another method of analysis would be to establish certain price relationships between Opaque-2 and common maize and estimate the relative net returns of the various diets as a function of the price of soybean oilmeal. Figures 1 and 2 show the relationship between relative net returns for each of the diets and the price of soybean oilmeal for the two periods, growing and finishing. Two alternatives are shown with respect to the prices of Opaque-2 and common maize: (1) price of Opaque-2 maize equal to that of common maize, and (2) ten percent above. Each line in the figures refers to a diet. The numbers I - IV refer to the numbers given the diets in the text. The lines marked III_1, and IV_1, in Figure 1, and IV_1 in Figure 2 represent the Opaque-2 diets if the price of Opaque-2 maize is equal to that of common maize, and the lines marked III_2 and IV_2 in Figure 1, and IV_2 in Figure 2 represent the situation where the price of Opaque-2 maize is 10 percent above that of common maize.

To maximize net returns, the swine producer should select the diet represented by the top line, given the price of soybean oilmeal. Hence,

he would use diet I (common corn and soybean oilmeal) during the growing period unless the price of soybean oilmeal was above 320 percent of the price of common maize. If the price of soybean oilmeal were that high, the common maize diet should be replaced by Opaque-2 maize and soybean oilmeal if Opaque-2 maize were available at the same price as common maize. If it were 10 percent more expensive, the replacement should not take place unless the price of soybean oilmeal was above 420 percent of the price of common maize.

If Opaque-2 maize were available at the same price as common maize, the former should be used during the finishing period when the price of soybean oilmeal is more than 20 percent above that of common maize. If the price of Opaque-2 maize is 10 percent above that of common maize, Opaque-2 maize should be used only if soybean oilmeal costs more that 180 percent of the price of common maize.

The above analysis indicates that it would be economically sound to substitute Opaque-2 for common maize during gestation, lactation and finishing unless a very inexpensive protein supplement is available or unless the price of Opaque-2 maize is considerably higher than that of common maize. The use of Opaque-2 maize during the growing period does not seem recommendable unless protein supplement is unavailable or commands a very high price.

It should be noted that the data used for the above analysis refer to experiments with pure breed swine using high levels of management. It is not known to what extent the results would be valid for non-pure breed swine under low levels of management. Furthermore, it should be emphasized that the analysis did not attempt to estimate absolute net profits from

swine production but merely relative net profits associated with diets of Opaque-2 and common maize.

The results found in the above analysis are similar to those obtained in an analysis carried out in Brazil (2). In the Brazilian analysis it was found that if a protein supplement were available at a reasonable price Opaque-2 maize would not be the most economical feed during the growing period. Comparing an Opaque-2 diet to a maize based commercial concentrate it was found that the producer could pay up to 18 percent more for Opaque-2 maize than for common maize during the finishing period, given the existing prices of protein supplements. Compared to a common maize diet without protein supplement it was estimated that it would be economically sound to use Opaque-2 maize during the growing period unless its price was above 236 percent of the price of common maize and during finishing unless its price was above 125 percent of the price of common maize.

Benefits and costs to the producer

The benefits and costs to the producer of Opaque-2 maize may be analyzed in terms of three variables: (1) expected cost of production and on-farm storage, (2) expected farm price of Opaque-2 maize and (3) the risk and uncertainty determining the extent to which the expectations materialize. As in previous sections of this paper, the discussion will focus on a comparison between Opaque-2 and common maize, hence it will deal with relative rather than absolute values of costs, price, risk and uncertainty.

Relative costs. Except for higher seed prices there seem to be no apparent reasons why the cost of production per unit of land related to Opaque-2 maize would differ from that related to a normal maize hybrid. If,

however, the yield capacity of Opaque-2 is below that of the best normal hybrids, as seems to be the case in Colombia, the cost of production per unit of output will be higher for Opaque-2 maize. The cost of on-farm storage of Opaque-2 maize is also likely to exceed that of common maize because Opaque-2 maize appears to be less resistant to insect attacks (4, p. 28).

For the farmer who is presently growing a local variety with low yield capacity, the adoption of Opaque-2 maize is likely to increase yields considerably provided, of course, that the Opaque hybrid is suited for the particular ecological conditions. In this case the cost of production per unit of output is likely to decrease. However, costs could be decreased further if a higher yielding normal hybrid were introduced.

Relative price. The price of Opaque-2 maize relative to that of common maize may be expected to be determined by certain supply and demand factors as well as government policy measures. Relative production costs, risk and uncertainty are expected to be the most important supply factors. If Opaque-2 maize is expected to yield less than common maize or if risk and uncertainty is perceived to be larger, the maize producer will be willing to produce Opaque-2 maize only at a price sufficiently superior to compensate for these adverse factors. The most important price determining factors on the demand side are likely to be relative consumer preferences, prices of available substitute products, consumer purchasing power and the rate of technical substitution between Opaque-2 maize and other products available. The latter factor refers primarily to the demand for Opaque-2 maize for livestock feed and processed foods.

If the maize buyer, being a consumer, livestock producer or processing firm, prefers Opaque-2 maize to common maize he may be willing to pay a premium for Opaque-2 maize, hence a mutually satisfactory price may be established and a self-sustained production assumed. If Opaque-2 maize is not preferred and its yields are inferior, it is not likely that a mutually satisfactory price can be established without government intervention.

Risk and uncertainty. Changing from common to Opaque-2 maize may increase subjective producer risk and uncertainty for three reasons: (1) Opaque-2 maize seems to be less resistant to insect attacks, (2) when initially introduced, Opaque-2 maize may not have a well established market, and (3) the fact that it is a new product, by itself tends to increase subjective risks. Although no general monetary cost figures can be placed on these risk and uncertain factors, it is likely that the farmer will change to the production of a higher risk product only if expected gains compensate for additional subjective risk and uncertainty.

Based on the above, we may conclude that a self-sustained, large scale production of Opaque-2 maize may be difficult to promote among farmers that are aware of a normal hybrid with higher expected yields or lower subjective risk unless its price is above that of common maize. The magnitude of the needed price differential would be determined by yield differences, magnitude of the subjective risk and uncertainty and the risk avoiding behavior of the producer. The market will permit the necessary price differential only if the difference in buyer preference is sufficiently large. If this is not the case, certain government intervention will be needed to assure a self-

sustained production and utilization of Opaque-2 maize.

The discussion up to this point has been focused on commercial production. The potential benefits to the subsistance farmer are merely those of the producer and consumer combined. The subsistance farmer who is presently growing a local variety with low yield potential may increase yields, and improve the quality of his diet by introducing Opaque-2 maize. Hence, in addition to a better diet he may be able to produce a marketable surplus. Once he has been reached with the hybrid seed his best alternative to Opaque-2 maize is not the local variety but a common hybrid that may out-yield Opaque-2 maize. He is then faced with the same decisions as the commercial producer and the consumer, and one possible outcome might be that he produces sufficient Opaque-2 maize for home consumption, and thereby obtains the potential consumer benefits, and produces either Opaque-2 or common maize for sale depending on relative yields and prices, and thereby maximizes producer net returns.

Social benefits and costs and government intervention

While benefits and costs to the individual persons and firms involved in the production, marketing and consumption of Opaque-2 maize may be relatively easy to estimate, there is no unique measure of benefits and costs to society. One measure which might be used in the case of Opaque-2 maize is the impact on human nutrition per unit of resources used. The cost of obtaining similar impacts on human nutrition using other acceptable means and the impact on employment, incomes and income distribution are parts of the measure.

If the goal to society is improving the protein quality of the diet

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of low income families, a number of alternative strategies may be considered. In addition to the promotion of Opaque-2 maize, these would include (1) breeding for higher quality protein in other staple foods such as cassava and rice, (2) expanding the production and consumption of foods presently containing high quality protein such as pulses, meats and milk, (3) fortification, and (4) improve the utilization of the foods presently available through consumer education, income distribution, etc. The choice of strategy would then be based on the relative contribution of each one to the above goal per dollar spent. Increasing the availability of low cost, high quality protein in a form acceptable to the consumer and raising the real incomes of the low income families through increased earnings and reduced food prices are the key factors for success no matter which strategy is chosen.

In the case of the present floury Opaque-2 maize, government intervention is likely to be needed to bridge the gap between private and social net benefits. If a flint type high lysin maize with a high yield capacity were developed, the need for government intervention is likely to be reduced severely (4).

As shown previously, the potential nutritional impact of substituting Opaque-2 maize for common maize in South America appears to be very large indeed. This we may call the social benefits. However, as discussed above, the consumer may be unwilling to substitute Opaque-2 maize for common maize, particularly if the price of the former is above that of the latter (4). If the price of Opaque-2 maize is not superior to that of common maize, the producer may be unwilling to change. These factors are due to private benefit-cost relationships. Hence, government intervention may be needed to:

(1) assure that the farm price of Opaque-2 maize is sufficiently high to permit its production and (2) inform the consumer of the nutritional value of Opaque-2 maize and means of overcoming differences in cooking characteristics. During the introductory phases, government action may also be needed to assume certain risk and uncertainty both in production and marketing.

A price support program establishing reasonable minimum prices both at the farm and the retail level along with a promotional campaign aimed at consumer education would probably be the most efficient government intervention in most cases 1/. The cost of such programs would depend primarily on the yield difference between Opaque-2 and common maize and the willingness and ability of the consumers to pay a premium for Opaque-2 maize once made aware of the differences with respect to nutrition and cooking characteristics. In the case of Colombia, assuming that the farm price of Opaque-2 maize needed to be 10 percent above the price of common maize to compensate for yield differences and further assuming that the consumer would buy Opaque-2 maize only at a price equal to that of common maize, the annual government cost of maintaining a price support program if all maize used for human consumption were Opaque-2 maize, would be U.S.$4.3 million (4, p. 11).

Before concluding, one other possible government policy measure should be mentioned. If and when it can be ascertained that the potential social

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1/ Results from a recent study in Colombia (4) suggest that the initial promotion of the production and consumption of Opaque-2 maize may be severely hampered by the reluctance of the marketing agencies to handle Opaque-2 maize. The hesitancy is primarity due to risk and uncertainty with respect to consumer demand. A minimum price at the retail level would severely reduce such risk and uncertainty.

net benefits from substituting Opaque-2 for common maize are large but cannot be realized because subjective private net benefits are higher cor common maize due to relative yields, consumer preferences, etc., the government may decide to prohibit the production and distribution of seed of common maize. Before such a measure is introduced, the government should assure the availability of Opaque-2 maize hybrids or varieties suited for all maize producing regions within the country.

The possible implications of the measure should be carefully studied before it is introduced. If consumers are willing to pay a considerably higher price for common maize than for Opaque-2 maize, the farmer may decide to grow a local variety hence produce his own seed. The net result in this case might be a drastic reduction in the total quantity of maize produced. However, if consumers are indifferent as to Opaque-2 and common maize, the area presently grown with normal hybrids and improved varieties is likely to be grown with Opaque-2 maize, the net effect on production being determined by the yield handicap of Opaque-2 maize. The author is not suggesting that the production and distribution of all common seed be prohibited in countries where sufficiently Opaque-2 seed is available, but merely mentioning it as a possible policy measure for consideration.

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