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Technical and Economical Minimum Price Uses of the Incorporation of Some Substituting Raw Materials in Poultry Feeding

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A B S T R A C T

In order to study the minimum economical price of some substituting raw materials (Sorghum, triticale, rye, oat, pea, faba bean, colza grains, CGF, DDGS, colza meal, sun flower meal and peanut meal) according to variations of corn and soybean meal prices, as well as the crude protein level, we developed mathematical models to predict the minimum prices. The analysis of the global correlation showed that these raw materials can be regrouped into three classes according to their specifications, and their aptitude to substitute corn and/or soybean meal in poultry feed. The high coefficient of determination (>98%) indicated that variations of the minimum price of the feed can be explained by corn and soybean meal prices variations. Crude protein percentage can be used to improve the precision of these predictive models.

Key words: Concentrate; substitution materials; minimum price; predictive models; corn price; soybean meal price

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INTRODUCTION

Tunisian poultry concentrate manufacturing industry is widely based on the use of corn and soybean meal as sources of energy and protein. This situation made us dependant on international market prices, which are continuously increasing (Lapierre and Huard 1996; Lapierre and Pressenda 2000). To cope with this situation, many studies were carried out to substitute corn and soybean meal by local feed in order to reduce the cost of the produced concentrate.

The first objective of this work was to study variations of the minimum price of some substituting raw materials used in poultry feeding, according to variations of corn and soybean meal prices. The second one is to develop mathematical models to estimate the minimum price of these raw materials, whatever, the price of corn and soybean meal will be. Moreover, the models will consider the crude protein (CP) level of soybean meal when the substituting raw is a source of protein.

MATERIALS AND METHODS

Optimisation method

The study was undertaken to optimise the minimum price of some substituting raw materials by using linear programming method (Bernot 1979; Capon, 1979). This study analyses optimisation results obtained from Libra software, which uses the Simplex method to resolve linear models. Concentrate formulation for layers involves the use of corn and soybean meal. However, for broilers and turkeys soya oil is added to the feed.

According to Mai (2010) market prices during the period of the study were: 358.680 DT/T for corn, 646.8 DT/T for soybean meal and 752 DT/T for soya oil. We referred to Sauvant *et al.* (2002) for the composition and the nutritive value of raw as well as substituting materials.

Animal feeding requirements and limit of incorporation of raw materials are detailed in Table 1.

Two optimisations trials were simultaneously carried out. The first is based on the variation of corn and

Table 1: Raw materials and limit of their incorporation in the poultry concentrate

Feed	Broiler		Layer		Turkey	
	Min	Max	min	Max	min	Max
Corn	-	-	-	-	-	-
Soybean meal	-	-	-	-	-	-
Soya oil	4	4	-	-	4	4
Mineral and vitamin supplement	4	4	4	4	4	4
Crude Protein, g/kg	215		150		193	
ME : Metabolisable Energy, kcal/kg	2900		2800		2900	
Lysine, g/Kg	11.2		6.8		11.1	
Methionine, g/kg	4.7		3.0		3.3	

(Ferrando and al. 1989)

soybean meal prices (-20%, -10%, 0%, +25%, +50% and +75%), while the second included crude protein variation level of soybean meal (46%, 48% and 50%).

The validation of the predictive models consists of comparing estimated minimum prices to calculate ones, when corn and soybean meal prices are superior to 75% of the market.

Data analyses

Results of the optimisation were used to develop linear models to predict minimum prices of substituting raw materials. For each substituting material, the minimum price is regressed with multiple linear regression equation by corn and soybean prices and the crude protein level. Only materials having a minimum price highly correlated to corn or to soybean meal price and a regression coefficient (R^2) > 98% were retained. The selected model is as follow:

$Y = b_0 + b_1 x_1 + b_2 x_2 + b_3 x_3 + e$

With: Y: value of the response

b_0: constant of the model

b_1, b_2, b_3: regression coefficients

x_1, x_2: corn price, soybean meal price

x_3: crude protein level of soybean meal

RESULTS AND DISCUSSION

Sorghum, triticale, rye and oat

Sorghum, triticale, rye and oat minimum prices were highly correlated with the corn price. In layer feed, global correlation coefficients were 0.998, 0.997, 0.999 and 0.997 respectively for sorghum, triticale, rye and oat. The more the corn price increased, the more the minimum prices increase. However, a decrease of corn price from 358.68 to 322.812 results in a decrease of sorghum minimum price from 357.071 DT/T to 269.821 DT/T for turkey feed. This is true for oat (364.043 DT/T to 278.475 DT/T) when used for layer feed as well as triticale from (364.792 DT/T to 276.625 DT/T) when used for broiler.

Moreover, minimum prices of sorghum, triticale, rye and oat are weakly correlated with soybean meal price (0.064, 0.020, 0.145 respectively for layers, boilers and turkeys feed). An increase of the soybean meal from 485.1 DT/T to 646.8 DT/T resulted in a small increase of minimum price of these materials. Indeed, when the sorghum minimum price rises from 274.892 DT/T to 281.745 DT/T and triticale one increases from 277.046 DT/T to 283.608DT/T we observed a small correlation of rye minimum price with soybean meal price (0.194; 0.225 and 0.197 respectively for boiler, turkey and layer feed).

Since all these materials as well as corn are energy sources for animals, hence their minimum prices depend on corn price variations. Indeed, sorghum metabolisable energy value for poultry is equal to 3230 Kcal/Kg, that of triticale, rye and oat respectively equal to: 2840, 2350 and 2220 Kcal/Kg according to Sauvant and al. (2002). These energy values explain the high correlation to corn price, which metabolisable energy value is about 3130 Kcal/Kg. These results agree with those reported by Taga *et al.* (2008) and Dhaouadi and Najar (2009). Therefore, changes of soybean meal crude protein level are not significant. Predictive models can be developed only taking into account corn and soybean price as shown in Table 2.

Table 2: Predictive models of the minimum price of sorghum

Species	Predictive Model	R^2
Layers	0.598 + 0.977 CP + 0.028 SBP	0.999
Broilers	4.028 + 0.976 CP + 0.021 SBP	0.998
Turkeys	-3.235 + 0.973 CP + 0.002 SBP	0.999

Table 3: Predictive models of the minimum price of triticale

Species	Predictive Model	R^2
Layers	-0.794 + 0.959 CP + 0.040 SBP	1
Broilers	-0.272 + 0.960 CP + 0.030 SBP	1
Turkeys	-1.382 + 0.950 CP + 0.047 SBP	0.999

Table 4: Correlations of minimum prices of pea, faba bean, CGF and DDGS with which of corn and soybean for layer feed

Raw Material	Correlation with corn price	Correlation with soybean meal price	Correlation with soybean meal crude protein level
Pea	0.781	0.720	-0.066
Fababean	0.544	0.891	-0.068
CGF	0.845	0.694	-0.104
DDGS	0.660	0.841	-0.066
Colza grains	0.846	0.655	0.006

Table 5: Crude protein and metabolisable energy values of some substituting materials

Substituting Material	Crude Protein (%)	Metabolisable Energy (Kcal/Kg)
Pea	20.7	2430
Faba bean	26.8	2430
CGF	19.3	1800
DDGS	24.6	2170
Colza grains	19.1	3160

(Sauvant *et al.*, 2002)

Pea, faba bean, colza grains, corn gluten feed (CGF) and dried distillers (DDGS)

Global correlations of pea, faba bean, colza grains, CGF and DDGS minimum prices with those of corn and soybean meal, as well as soybean meal protein level are represented in Table 4.

Table 4 shows that, in addition to their high positive correlation with corn price, there is a high positive correlation with soybean meal price. In the case of layer feed, when soybean meal price varied from 485.1 DT to 646.8 DT, the minimum price of faba bean rises from 478.534 DT to 582.641 DT; that of DDGS rises from 413.952 DT to 482.076 DT and the CGF one increases from 395.602 DT to 441.879 DT.

Although they are highly correlated with soybean meal price, pea; faba bean; colza grains; CGF and DDGS are fewer dependants on the variations of crude protein level. Their correlation with soybean meal crude protein value is negative (except colza grain which correlation strives to 0). This result can be explained by the nutritive value of these raw materials which are both energy and nitrogen sources, as described in table 5.

Because they are simultaneously sources of protein and energy, these substituting raw materials can substitute partially or totally corn and soybean meal in poultry feed. Their minimum prices change according to the variation of corn and soybean meal prices. Furthermore, these materials are not affected so much by the variation of crude protein level. This result agrees with that reported by Taga *et al.* (2008).

Table 6: Predictive models of the minimum price of colza meal

Species	Predictive Model	R^2
Layers	346.047 + 0.306 CP + 0.689 SBP – 7.036 C.PROT	0.998
Boilers	471.731 + 0.329 CP + 0.667 SBP – 9.496 C.PROT	0.999
Turkeys	478.068 + 0.314 CP + 0.686 SBP – 9.879 C.PROT	0.997

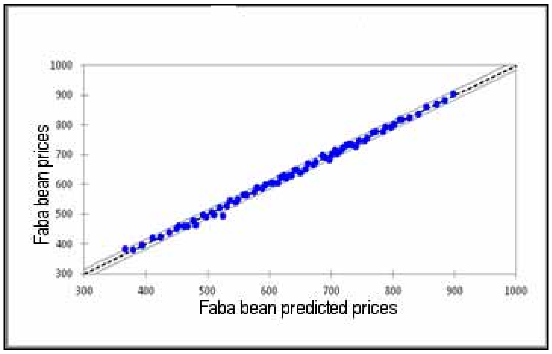

Fig. 1: Relation between predicted fababean minimum prices and experimental values

Coefficient of determination (R^2) of broiler models is equal to: 0.998 for pea and faba bean, 0.996 for DDGS and 0.999 for CGF. We conclude that there is a high linear relationship between minimum prices of these raw materials as well as corn and soybean meal prices. This result has for consequence a high correlation between the calculated and estimated values of the minimum price (Fig. 1).

Colza meal, sun flower meal, peanut meal

In contrast to sorghum; triticale and rye, colza meal; sun flower meal as well as peanut meal minimum prices are highly correlated with soybean meal price (respectively 0.970, 0.908 and 0.995 in the case of layer feed). Their correlation with corn price is low (0.407, 0.573 and 0.007 in the same case). When soybean price increases by 25%, sun flower meal minimum price increases by 84.704 DT/T. However, when corn price increases by 25%, minimum price of sunflower meal increases only by 42.494 DT%. Crude protein levels of these raw materials explain the reason of this high correlation with soybean meal price (33.7%, 33.4% and 48.9% respectively for colza meal, sun flower meal as well as peanut meal) (Sauvant and al. 2002). Indeed, these raw materials are protein sources, so they may be used to substitute soybean meal in poultry feed. Corn price variations have lower effect on minimum price prediction of protein sources.

There is very weak relationship between minimum prices and crude protein level of soybean meal, variation. Correlation between these two parameters is very low and negative. For example, in the case of broiler feed, all correlation coefficients are under 0.109. These results are in agreement with those reported by Taga and al. (2008) and Dhaoudi and Najar (2009). Because they are protein sources, colza meal; sun flower meal and peanut meal are not dependant on variations of crude protein level. Coefficient of determination of peanut layers model and colza meal turkeys model equals to 0.99 even though the parameter crude protein level is not considered. Table 6 illustrates the predictive models of peanuts price:

Manioc

Although an increase of corn price results in an increase of manioc minimum price, the more the soybean meal price increases the more the manioc minimum price decreases. In layer feed, when corn price increases from 269.01 to 358.68, manioc minimum price increases to 102.67 DT/T. However, the manioc minimum price decreases by 23.358 DT/T when soybean meal price increases from 485.1 to 646.8. Correlation analysis shows that manioc is positively and highly correlated with corn price (0.976 for turkey feed, 0.977 for boiler feed and 0.975 for layer feed), but its correlation to soybean meal is very low and negative (-0.06 for turkey and boiler feed, -0.109 for layer feed). This result confirms those reported by Taga and al. (2008) and Dhaouadi and Najar (2009). Manioc is, in one hand, an energy source, so that its price varies in the same way as the corn price. In the other hand, its crude protein level equals to 2.5% (Sauvant and al. 2002), thus it is less influenced by the variation of soybean meal price.

Summary

On the basis of raw materials nature, our results showed that raw materials can be classified into 3 groups. The first one includes d that is used as source of energy such as triticale, sorghum, rye and oat. The second one includes materials that are source of protein like colza meal, sun flower meal and peanut meal. The last one includes materials that are sources of energy and protein such as pea, faba bean, colza grains, corn gluten feed and dried distillers.

Substituting a part of corn and/or soybean meal, in addition to reducing feed cost are two practical uses of this classification. This allows decreasing costs caused by protein and energy import. This could be ensured if substituting materials are self produced and their prices are under estimated ones. In that way, substituting materials self produced can be an alternative to reduce our dependency on corn and soybean meal.

Validation of models

The validation of the models is important for testing their reliability and to specify their field of application. For this purpose, we compared minimum prices of raw materials estimated by regression equations to their real ones calculated by optimization using linear programming method. No significant differences were observed.

Conclusion

The minimum prices of substituting raw materials are in relation with corn and soybean meal ones. This relation is related to the raw material characteristics.

The high significant coefficient of determination suggests that the variations of corn and soybean prices could be used as the main predictors of minimum prices for the different substituting raw materials. Including protein level in predictive models is important to improve precision of substituting materials source of protein. This work should be completed by studying the effect of the incorporation rate of these substituting materials on production and reproduction of poultry performances, besides on the final product quality.

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