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A NEW GUIDE FOR POULTRY DIET FORMULATION WITH SOME AID TABLES

(With 15 Tables)

By

H.M. ABDEL –HAFEEZ and SAMAR S. TAWFEIK

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دليل جديد لتركيب علائق الدواجن مع بعض الجداول المساعدة

حسن محمود عبد الحفيظ ، سمر سيد توفيق

إن تركيب العلائق يمكن القيام به يدويا أو بواسطة الكمبيوتر وبرغم تطور برامج الكمبيوتر إلا أن الطريقة اليدوية تعتبر عمل جيد من الممكن لأى متخصص أن يقوم بتكوين حتى أعقد التركيبات. وتركيب العلائق هى عملية معقدة تشتمل على معادلات مستنبطة ومتكررة وعمليات حسابية عديدة ولتقليل هذه الحسابات اليدوية فقد تم الاستعاضة عن الكثير منها بما تم تسميتة بالجداول المساعدة محتوية على أرقام تم استخرجها بحسابات مسبقة. ويستلزم عند عمل العلائق توافر معلومات عن الاحتياجات الغذائية للطائر والتركيب الكيميائى لمواد العلف والطرق الحسابية لعمل العلائق. وفيما يخص الاحتياجات الغذائية فمن المفترض أن يتوافر فى الغذاء ٤١ عنصر غذائى بناء على نوع الطائر وسنه ومستواه الانتاجى إلا أنه قد أمكن اختصارها إلى ١١ عنصر عند حساب تركيب العلائق تشمل الطاقة التمثيلية وتقدر بالسعر الحرارى/ كيلو جرام من العليقة والبروتين والكالسيوم والفسفور والصوديوم فتحسب كنسبة مئوية من العليقة والمتبقى من الاحتياجات كالعناصر المعدنية النادرة والفيتامينات والأحماض الأمينية وإضافات الأعلاف تضاف على مستوى الطن من العليقة. ولاستيفاء هذه الاحتياجات قد تم استخدام الذرة وكسب فول الصويا كمواد علف أساسية ومسحوق الحجر الجيرى وفوسفات الكالسيوم وملح الطعام كمصادر للعناصر المعدنية الكبرى والمثيونين واللسين المنتجين تجاريا لتعويض النقص المتبقى فى العليقة بعد حساب مدى مساهمة مواد العلف بهما أما العناصر المعدنية الصغرى والفيتامينات فيتم إمدادها بواسطة إضافة بريمكس مصنع تجاريا وبالكميات التى تنص عليها الشركة المنتجة. وفى بعض الحالات يستدعى الأمر استخدام دهون أو زيوت أو مسحوق سمك أو نخالة قمح. وهناك خمس طرق لحساب العلائق تم تطبيق طريقتين منها فى هذا البحث وهى طريقة المربع لبيرسون وطريقة المعادلات الآنية مع استنباط أربعة مجموعات من الجداول المساعدة تحتوى مجموعة منها على التركيب الكيميائى لكميات مختلفة من مواد العلف وأخرى على العناصر المعدنية فى كميات مختلفة من مصادرها والمجموعة الثالثة تحتوى على مخاليط من الذرة ومسحوق فول الصويا وفقا لمختلف النسب من الطاقة إلى البروتين أما المجموعة الأخيرة فهى لمخاليط من الدهون وكسب فول الصويا لتصويب مستوى الطاقة أو البروتين فى العليقة. ولتطبيق الطريقتين المقترحتين يتبع الأتى: ففى الطريقة الأولى (طريقة المربع): تأخذ كميات ملاحق الأملاح المعدنية الكبرى من الجداول المساعدة- يعدل مستوى الاحتياج من الطاقة

والبروتين– تحسب نسب الذرة والصويا أما على أساس الطاقة أو البروتين باستخدام المربع– تصوب نسبة المادة الغذائية الأخرى باستخدام جداول مخاليط الدهون وفول الصويا أما في استخدام الطريقة الثانية: تأخذ كميات ملاحق العلائق للأملاح المعدنية الكبرى من الجداول المساعدة– يعدل مستوى الاحتياج من الطاقة والبروتين– تأخذ نسب الذرة وفول الصويا من الجداول (موفرة بذلك وقت كثير يستهلك فى الحسابات)– تعدل النسب ليكون المجموع مائة وحدة– تصوب نسبة الطاقة والبروتين (إذا أحتاج الأمر لذلك) باستخدام جداول مخاليط الدهون ومسحوق فول الصويا.

SUMMARY

Diet formulation can be done either by hand or by using the computer. In addition to the computer programs the hand calculation is increasing and forming a good job, and it is possible for any specialist to formulate even rather complex diets. To reduce hand calculations what is called "aid tables" are established containing already established computations. To mix diets, information about nutrient requirements, feed composition, and methods of formulation are needed. The nutrient requirements can be reduced into eleven estimates. Commonly in formulations we use corn, soybean meal as basal feeds, limestone, calcium phosphate, common salt, methionine and lysine, and premixes. In some instances fat or oil, fish meal, and wheat bran may be used. Of the five methods of diet formulation, the square and simultaneous equations are the two applied in this paper using four groups of aid tables. The tables include the chemical composition of different amounts of feeds, the elements in different amounts of supplements, corn/soya mixtures made according to different C/P ratios, and lastly mixtures of fat and soya for energy and crude protein correction. In the first amounts of mineral supplements are picked from the aid tables, needs of energy and crude protein are corrected, corn and soybean meal proportions are calculated on crude protein or energy- basis then the other nutrient is corrected using fat/soya tables. In simultaneous method, and after estimating the mineral supplements and correcting the energy and crude protein needs, the proportions of corn and soybean meal are read from the simultaneous substitute table saving too much time for calculation. The proportions are reduced to the balance 100 units and energy and crude protein could be corrected using the fat/soya tables.

Key words: *Ration formulation, square method, simultaneous equations, aid tables, poultry*

INTRODUCTION

Ration formulation can be defined as a complex process by which nominated feed ingredients are mixed to provide the animal by the needed amounts of nutrients prescribed for the given stage of performance, and at reasonable cost. The diet formulation can be done either by hand or by using the computer technology.

In spite of the wide use of computer technology still it does not eliminate the need to formulate diets by hand. In hand formulation too many mathematical problems and equations are derived and solved and a series of algebraic calculations must be performed. By hand it is possible for any specialist to formulate even the rather complex poultry diets. In addition, the computer programs are stressing on formulating diets of the least cost kinds, which in spite of being nutritionally adequate, it may not be the most economic. It is conclusively the monetary net return from using these or any other formulations that counts.

As a general, ration formulation is a complex process involving balancing between the main classes of nutrients and within the nutrient group. It is a kind of deriving and solving repetitive equations for which recently the computer is called for. In this paper it was found it is a good job and valuable to reduce the hand calculations by already established computations displayed in tables, we call it the "aid tables", and fast the process by setting a set of new well defined procedures derived through fixed working steps.

The information required to mix diets is firstly about the nutritional requirements, nutrient composition of commonly used and available feeds and costs. Secondly is the choosing of the feasible method of formulation.

Nutritional requirements of poultry:

The standard source for nutrient requirements is the most recent ninth revised edition of NRC issued in 1994. Feeding standards are tables listing the amounts of the nutrients required by poultry for the different productive functions. These standards are necessary guides in ration formulation, especially that of NRC which is the most widely used one satisfying the needs of all or most breeds and strains. Samar *et al.* (1991) formulated diets for three different broiler chicken breeds on NRC standards – basis where it was sufficiently efficient for growth and weight gain. In NRC (1994) the amounts of forty two nutrients needed are considered for chickens, turkeys and quails; 26 in ducks; and 12 in geese. Little information has been published describing amino acid, mineral, or vitamin requirements in geese and ducks. The requirements established in tables are due to revision, by specific outstanding researchers committee, of the data of so many studies on the same species. The values given often represent an approximation of the published data in the different researches.

Usually all the mineral elements, except Ca, P & Na, and all the vitamins are supplied partially by the feed ingredients and supplemented, in excess, by the premixes commercially produced for poultry. The same will be applied for all the essential amino acids which are supplied by feeds used in the diet and only Met and Lys are the ones which can be supplemented, if needed for, as they are commercially produced at reasonable cost. Eventually in ration formulation the information related to nutrient requirements can be reduced into 4 main items expressed as energy, CP, macrominerals and premixes and a total of eleven estimates MEn, CP, Met, Met + Cys, Lys, Ca, non-phytate P, Na, and two supplements mineral and vitamin premixes and additives if needed for, of which amino acids, premixes and additives are added in kg per ton and by turn are not involved in the formulation process.

Feeding standards are not so precise, as still in many situations the needs can not be determined with great accuracy for poultry or experimental data are lacking. In these cases approximations and extrapolations are the solution. Also, economy, feed palatability, physical nature of diets, individual animal differences, management and stresses effect, are not considered. Thus, many variables, that alter the nutrient requirements, are difficult to be included quantitatively in tables. In addition, the standards are stated with no margin of safety, which should be added according to conditions (NRC, 1994). From time to time the standards are revised and some figures changed to keep with new information and feeding practices.

Feed ingredients

Feeds are initially divided into basal feeds mainly supplying energy, and protein feeds of animal and plant sources. The feeds then are nominated or chosen on protein or energy cost- basis and substitution for the basal and standard feeds corn and soybean meal could be practiced using equations extracted using the more simple square method, single or double.

The feeds are needed to be supplemented for energy, minerals, vitamins and amino acids using fats or oils, limestone, dicalcium phosphate or monocalcium phosphate, common salt, methionine and lysine, and premixes for vitamins and trace elements. The premixes and amino acids are added on ton - basis while the other supplements are added on percentage - basis and eventually dilute the content of the diet either from energy or crude protein. This can be solved by calculating the supplements needed in percentage at first and then correcting the figures for energy and CP as related to the balance of 100. The diluting effect of supplements can be corrected as in the following example.

Correcting energy and protein needs in a broiler diet:

Requirements for non-phytate P 0.45, Ca 1.0 and Na 0.20 % are satisfied using the supplements dicalcium phosphate, limestone and salt, by the following amounts:

Dicalcium phosphate (18.7% P & 22% Ca) needed = 0.45 ÷ 0.187 = 2.406%

The amount of Ca in the supplement = 2.406 × 0.22=0.529

Ca needed to be supplemented by limestone = 1.0 - 0.529 = 0.471

Limestone (38 % Ca) needed = 0.471 ÷ 0.38 = 1.24%

Salt (39 % Na) needed = 0.2 ÷ 0.39 = 0.51%

Total supplements = 2.406 + 1.24 + 0.51 = 4.156%

Needs for energy 3200 kcal/kg and CP 23% will be corrected as follows:

$$\text{MEn} = 3200 \div \frac{(100 - 4.156)}{100} = 3338.8 \text{ kcal/kg diet}$$

$$\text{CP} = 23 \div \frac{(100 - 4.156)}{100} = 24\%$$

In spite of the increase in energy and protein values the calorie/protein ratio remains the same at 139.13 (3200 ÷ 23 or 3338.8 ÷ 24).

The feeds nominated to be used in this paper to supply energy or protein are the standard feeds, corn and soybean meal. In certain conditions and diets fish meal and wheat bran may be needed to be used. On cost – basis other feeds could be substituted using the square method single or double and equations extracted from.

Feeds are inherently variable in its analysis and at every formulation it is impractical to analyze each feed batch for its nutrient content, especially the analyses do not differ greatly. Reliance must be placed on feed composition data that have been compiled on the basis of many laboratory analyses or extrapolated estimation equations.

Ration formulation methods

In making poultry diets most of the needed nutrients are added as supplements; minerals, vitamins or amino acids. Some are added in percentage needing to consider its amount in the diet composition, and the others are added in kg per ton of ready formulated and determined ingredients. For making mixtures of specified CP % or MEn density five methods are available. They are trial-and-error, 2 × 2 matrix, square, simultaneous equations, and computer methods (Pond *et al.,* 1995; Cheeke, 2005; and Matthew and Moji, 2008). In the first four methods, nothing more than simple algebra is required to formulate rather complicated diets, techniques useful for hand formulation. In trial - and - error method feeds are interchanged repeatedly until the right combination is found. It needs a knowledge about available feeds and supplements, feeding restrictions, and feed proportions commonly used to start with before correction to match or cover the needs. In practice it takes time and appears to be tiresome (Talat, 2004 and Matthew and Moji, 2008). The 2 × 2 matrix is an alternative for simultaneous equation method, some people find it more easier and quicker (Jerry, 2004). The matrix and simultaneous methods provide a way of solving for two nutritional needs such as energy and protein through the use of two ingredients.

The square method and the simultaneous are the two methods tried to be applied in this paper, the first is modified to be used to formulate rations involving three sources and two nutrients but in another way than that conventional. The square method is derived to satisfy one nutrient while the second nutrient is corrected using a correcting fat/soya table established in this paper. The simultaneous equations are used to formulate rations from a combination of two sources and involving one nutrient when one of the equations is "dummy" or two nutrients deriving each of the two equations for one nutrient. This method needs time to get the two feeds proportions(as shown in the following example) and so was designed to be substituted by a table supplying the proportions and nutrient content of the different mixtures.

a- Simultaneous equations method for one nutrient (e.g. CP%):

CP% in decimal × X + CP% in decimal × Y = CP% needed Original equation (1)

X + Y = 100 kg feed Dummy equation (2)

The dummy equation is multiplied by crude protein in order that the X term in the dummy will cancel out with the original equation after subtraction. Using a corn (X) of 8.5% CP and soybean meal (Y) of 44% and a need for 23% the solution will be as follows:

Original equation (1)	$0.085\,X + 0.44\,Y = 0.23$
Dummy equation (2)	$X + Y = 100$ and becomes
Equation (3)	$0.085\,X + 0.085\,Y = 8.5$

The solution

$$0.085\,X + 0.44\,Y = 23 \quad \text{Original equation (1)}$$
$$0.085\,X + 0.085\,Y = 8.5 \quad \text{Dummy equation (3)}$$
$$0.355\,Y = 14.5$$

Y = 40.85 kg of 44 % protein supplement per 100 kg feed or 40.85%

The balance of 100 kg is for corn which also can be extracted through substituting our newly acquired value for Y in the original equation.

b- Simultaneous equations for two nutrients:

CP equation:	$0.085\,X + 0.44\,Y = 23$
MEn equation:	$3.350\,X + 2.230\,Y = 320$ (MEn in 100 g)

If we compare the coefficients for the corn (X) in both equations, we derive an adjustment factor of 39.41(3.35 ÷ 0.085) which is needed to balance the two equations.

Thus if we multiply the CP equation by 39.41, the X terms will cancel out after subtracting two equations as follows:

$$3.35X + 17.34\,Y = 906.43$$
$$3.35X + 2.23\,Y = 320.00$$
$$15.11\,Y = 586.43$$
$$Y = 38.81$$

By substitution in either equations we find X to be 69.69. In this method X could not be considered the balance of 100 as the sum of X and Y may be less or more than 100.

In this case X + Y=38.81 + 69.69 =108.5 a value more than 100 units, and needs to be reduced to less than 100 with the consideration of the mineral supplements added. So simultaneous equations method is only valid for two nutrients like Ca and P with absolute amounts for the supplements used and unlimited or not restricted. Also it is suitable for animals fed in separate amounts. The method makes a mixture from corn and soybean meal having CP and MEn with the same C/P ratio but not limited to be included in 100 units. Otherwise one nutrient can only be satisfied using one equation and reserving the other to be 'dummy' limiting the two ingredients to be in two proportions on percentage - basis.

Aid tables

The mathematical procedures in ration formulation started with calculating the amounts of supplements needed by dividing the needed nutrient by the percentage of the nutrient in the supplement. This is followed by applying the simultaneous or the modified square method to compute the ingredients proportions. Then the amounts of the amino acids content are needed to be estimated in order to get the amino acids needed to be supplemented.

The aid tables were designed to save most or all of the time spent in mathematics and resulted in diets either having the same C/P ratio as in the simultaneous substitute method or in addition could be corrected to achieve the optimal levels of ME and CP as in simultaneous and modified square methods.

The aid tables established in this paper can be divided into four groups, the first group (5 tables) shows the chemical composition of different amounts of the commonly used feeds, corn, soybean meal, wheat bran, and fish meal. The amounts in each feed differs according to its rate of use as an ingredient in the diet mixture. The second group of aid tables (4 in number) is that of Ca, P and Na supplements.

The third group of tables (2 in number) is the C/P ratio – corn/soya mixtures and composition, one table with soybean meal 44% CP and other with the 48.5% level. The tables started with a C/P ratio of 100 and ended with 300, a range sufficient to cover all poultry diets from turkey starter (100) to turkey breeder – holding ration (240). The rest of ratios from 240 to 300 is to cover ranges resulted from the relation of energies to remained proteins after subtracting the sharing of a high – protein feed as fish meal for example.

The fourth group of tables (4 in number) is for mixtures of fat and soybean meal, with the same corn CP % in two tables and the same corn energy in the others.

1- Energy and protein feeds aid tables (group I)

Tables (1 to 5) show the analysis of corn, soybean meal, fish meal and wheat bran for metabolizable energy, crude protein, methionine, methionine - and - cystine and lysine amounts varying from 30 to 100 in corn, 10 to 50 in soybean meal of 44% and 48.5% CP, 1 to 10 in fish meal and 2 to 30 in bran. Corn and soybean meal are the main standard feeds for energy and protein, fish meal to supplement protein quantity and quality, while bran is to be piled in the slack space to supply fibers and the least amount of energy or crude protein.

2- Calcium, phosphorus, and sodium supplements did tables (group II)

Four tables (6 to 9) were established, providing the amount of the supplement needed for a given amount of nutrient, the first two for P needs and its equivalence from the two standard and available supplements, the dicalcium - and monocalcium - phosphate and the last two tables are for Ca and Na and its supplements limestone and common salt, respectively. The P tables started with 0.1% level as the smallest amount needed to be supplemented in a diet containing a large amount of fish meal, for example, or any other feed rich in available phosphorus, and ended with 0.65 on maximum. The Ca table started with 0.1% and ended with 4% while Na started with 0.1 and ended with 0.2. The tables allow for hand formulation readily - calculated supplements, to the nearest 0.01 in P and Na and 0.1 in Ca and amounts were chosen on the allowance-side more than requirement one.

3- C/P ratio – based corn/soya mixtures aid tables (group III)

To extract these tables (10 & 11) simultaneous equations were substituted by an equation built up on the basis of C/P ratios and the proposition of certain nutrient densities in the two main and standard feeds corn and soybean meal with reference to NRC (1994):

a-The CP % of corn is considered 8.5 while two levels are used in soybean meal, 44 and 48.5.

b-The content for the amino acids Met, Met + Cys and Lys are estimated using the regression analysis (NRC, 1994) in which the intercept (a) and the regression coefficient (b) differ according the protein content.

c-The energy content of corn (8.5% CP) in NRC is 3350 kcal, MEn/kg and of the soybean meal, 44 and 48.5% CP, is 2230 and 2440, respectively.

d-The calorie-protein or energy-protein ratio is the number of energy units in kg divided by the percent of crude protein in the mixture.

The equation created in this paper depends upon the substitution rate between the two feeds and effect on C/P ratio as follows:

$$\text{C/P ratio of corn} = \frac{3350}{8.5} = 394.12$$

Substituting 1% of corn by soybean meal will change the C/P ratio from 394.12 to 377.05 as follows:

$$\text{99\% corn and 1 \% soybean – mixture} = \frac{3350 - [(3350 - 2230) \div 100]}{8.5 + [(44 - 8.5) \div 100]} = 377.05$$

Considering the following symbols:

MEn of corn = A MEn of SBM = B A – B = 1120
CP % of corn = a CP % of SBM = b b – a = 35.5
C/P ratio = C
Corn = Y SBM = X

$$C = \frac{A - [(A - B) \div 100]\,X}{a + [(b - a) \div 100]\,X}$$

By substituting the figures for energies and CP% the equation will be :

$$C = \frac{3350 - 11.2\,X}{8.5 + 0.355\,X}$$

$$8.5\,C + 0.355\,X\,C = 3350 - 11.2\,X$$

So by substituting the first factor of C/P ratio in the equation the units of soybean meal included in the corn / soya mixture can be computed.

Corn or Y is the balance of 100. From the feeds proportions the CP and amino acids are calculated where they were included in the C/P ratio tables.

4- Fat / soya correction mixtures aid tables (group IV)

Fat is mixed with soybean meal to form a mixture having the same level of protein in corn (8.5%) and used to replace corn to correct the MEn of the diet (Tables 12 & 14). On the other hand soybean meal and fat are combined in a mixture having the MEn of corn and used to correct the crude protein (Tables 13 & 15). Square method is the method used to determine each's proportion. As fats differ in its MEn according to its type or blend the tables started with a fat of 5000 MEn/kg and ended with 10000. Using these mixtures allows diet formulation applying the simple square method forming a corn/soya mixture having the optimal CP% or the MEn density.

How to use the aid tables in formulation:

I- Using the "Pearson" square method:

1- Of the eleven items needed to be satisfied in diet formulation, the mineral and vitamin premix or premixes, additives, and the amino acids methionine and lysine supplementations are added in amounts per ton after diet formulation and before mixing.

2- The Ca, P and Na needs are added in the form of its supplements, on percentage-basis, using the respective conversion tables. In case of adding protein of animal origin the Ca, P and Na supplements should be reduced in amounts equivalent to that supplied by the animal protein. The following example is to formulate a broiler starter diet.

Tabulated needs:

MEn, Kcal/kg	3200	Av. P, %	0.45
CP, %	23	Ca, %	1.0
Lys, %	1.1	Na, %	0.20
Met, %	0.5	C/P ratio	139.13
Met + Cys, %	0.9		

Mineral supplements using the mineral conversion tables:

The need for available phosphorous is equivalent to 2.41 dicalcium phosphate which contains 0.529 Ca. The remaining amount of Ca needed equals 0.471 (1 - 0.529) and is equivalent to 1.32 LS. The need of 0.2% Na can be satisfied by the addition of 0.51 % salt.

Total mineral supplements added in percentages is 2.41 + 1.32 + 0.51 = 4.24 and the balance of 100 units is 95.76. So the CP needed is 23 ÷ 0.9576 = 24.02% and MEn = 3200 ÷ 0.9576 = 3341.7 kcal /kg

3- Satisfying the energy and protein using "Pearson" square method:

Solve the equation by using the square method to combine corn with soybean meal and satisfying the first item CP or the second MEn.

Corn 8.5 → 19.98= 56.28% reduced by multiplying by 0.9576 to be included in a mixture containing supplements, so equals 53.89

24.02

SBM 44 → 15.52= 43.72 % reduced by multiplying by 0.9576 to 41.87

35.5

MEn of the mixture = (3350 × 0.5389) + (2230 × 0.4187) = 2739.02 with a deficient of (3200 – 2739.02) 460.98 kcal.

4- Energy correction using the fat /soya mixture (8.5% CP):

By reference to table12 supplementation by fat/soya mix with 8.5% CP and 7288.6 MEn, it needs:

$460.98 \div (7288.6 - 3350) \times 100 = 11.7$

Corn = 53.89 - 11.7	= 42.19
Soybean meal = 41.87 + (11.7 × 0.19 32)	= 44.13
Fat = 11.7 × 0.8068	= 9.44
Supplements	= 4.24
	100

By using the fat/soya tables the square method could be used and balancing two nutrients, and achieving the optimal nutrient level.

II- Using the simultaneous equations substitute tables:

The equation substituting deriving of simultaneous equations is worked out on the computer, translated in the form of a table with 8 columns. The first column is for energy-protein ratio starting by 100 and ending with 300, while the second and third columns are the corn and soybean meal ingredients of the mix, expressed in percentage. Referring to table 9-4 (NRC, 1994) for the AAs, the amounts of Met, Met + Cys & Lys in 100 units of the mixtures are calculated. The table was established for a soybean meal of 44% CP and repeated for soybean meal of 48.5 % CP.

An example to use, the corrected energy in kcal/kg is divided by the corrected CP% to get the C/P ratio, from the simultaneous substitute aid tables the proportions of corn and soybean meal are picked and amounts reduced to occupy the balance of 100 after adding the mineral supplements. The equivalent amounts of energy and CP% in the corrected mixture are calculated where it could be supplemented using the fat/soya tables if conditions allow the addition of fat, otherwise the mixture is fed as it is just satisfying the C/P ratio and levels of energy and CP as low as corn and soybean meal supply even diluted by mineral supplements.

Introduction of fish meal or / wheat bran:

When fish is going to be used its content from energy, crude protein, amino acids and minerals should be considered. The fish nutrients are subtracted from the bird requirements and fish meal space added to the supplements. Corn and soybean meal will occupy the balance of 100.

Bran is added to diets low in energy density. When the proportions of corn and soybean meal are extracted from the C/P ratio tables, they should be reduced to the degree of needed energy satisfaction and the slack space resulted filled with bran according to a certain rule. The following is an example.

MEn needed 2900 kcal/kg
CP% needed 12%
C/P ratio needed 241.7

Proportions and nutrient content in aid table corrected for 241.7

Corn	Soybean meal	MEn	CP%
87.75	12.25	3238.5	13.4

Proportions and nutrient content after supplements addition (say 4%)

Corn	Soybean meal	MEn	CP%
84.24	11.76	3109.0	12.86

The energy is needed to be reduced by 209 kcal (3109 – 2900) and crude protein by 0.86% (12.86 – 12).

The amount of corn and soybean meal should be reduced by 0.933 (12 ÷ 12.86) to

Corn	Soybean meal	MEn	CP%
78.60	10.97	2900	12.00

The slack space $= 96 \times (1 - 0.933) = 6.43$

To occupy the slack space by a feed without changing the density of energy or percentage of crude protein, the bran is introduced at the rate of 1½ slack space and soybean meal is removed at ½ of it.

Amount of bran added	MEn	CP%
$6.43 \times 1.5 = 9.645$ having	125.4	1.5

Amount of soybean removed	MEn	CP%
$6.43 \times 0.5 = 3.215$ having	71.8	1.4

By using this rule we fill the original slack space which did not greatly change the CP% but slightly increased the MEn, than optimal, by about 50 kcal in this example, changing the C/P ratio from that needed 141.7 (2900 ÷ 12) to 144.1 (2953.6 ÷ 12.1), a difference can be neglected.

Table 1: Approximated chemical composition of corn for amounts starting at 30 with 5 intervals to 100 units.

Amonut*	MEn (kcal)	CP	Met	Met + Cys	Lys
30	1005.0	2.550	0.054	0.108	0.078
35	1172.5	2.975	0.063	0.126	0.091
40	1340.0	3.400	0.072	0.144	0.104
45	1507.5	3.825	0.081	0.162	0.117
50	1675.0	4.250	0.090	0.180	0.130
55	1842.5	4.675	0.099	0.198	0.143
60	2010.0	5.100	0.108	0.216	0.156
65	2177.5	5.525	0.117	0.234	0.169
70	2345.0	5.950	0.126	0.252	0.182
75	2512.5	6.375	0.135	0.270	0.195
80	2680.0	6.800	0.144	0.288	0.208
85	2847.5	7.225	0.153	0.306	0.221
90	3015.0	7.650	0.162	0.324	0.234
95	3182.5	8.075	0.171	0.342	0.247
100	3350.0	8.500	0.180	0.360	0.260

* The figures are decimal fractions of one kg for energy while for the protein and amino acids they are in percentage units.

- Each 0.05 kg adds 167.5 kcal while every 5% units add 0.425 CP, 0.009 Met, 0.018 Met+Cys, and 0.013Lys.

Table 2: Approximated chemical composition of soybean meal (44%CP) for amounts starting at 10 with 2 intervals to 50 units.

Amount*	Men (kcal)	CP	Met	Met + Cys	Lys
10	223.0	4.40	0.062	0.128	0.269
12	267.6	5.28	0.074	0.154	0.323
14	312.2	6.16	0.087	0.179	0.377
16	356.8	7.04	0.099	0.205	0.430
18	401.4	7.92	0.112	0.230	0.484
20	446.0	8.80	0.124	0.256	0.538
22	490.6	9.68	0.136	0.282	0.592
24	535.2	10.56	0.149	0.307	0.646
26	579.8	11.44	0.161	0.333	0.699
28	624.4	12.32	0.174	0.358	0.753
30	669.0	13.20	0.186	0.384	0.807
32	713.6	14.08	0.198	0.410	0.861
34	758.2	14.96	0.211	0.435	0.915
36	802.2	15.84	0.223	0.461	0.968
38	847.4	16.72	0.236	0.486	1.022
40	892.0	17.60	0.248	0.512	1.076
42	936.6	18.48	0.260	0.538	1.130
44	981.2	19.36	0.273	0.563	1.184
46	1025.8	20.24	0.285	0.589	1.237
48	1070.4	21.12	0.298	0.614	1.291
50	1115.0	22.00	0.310	0.640	1.345

* The figures are decimal fractions of one kg for energy while for the protein and amino acids they are in percentage units.

- Each 0.02 kg adds 44.6 kcal while every 2% units add 0.88 CP, 0.0124 Met, 0 .0256 Met+ Cys, and 0.0538 Lys.

Table 3: Approximated chemical composition of soybean meal (48.5%CP) for amounts starting at 10 with 2 intervals to 50 units

*Amount**	*MEn (kcal)*	CP	*Met*	*Met+Cys*	*Lys*
10	244.0	4.85	0.067	0.139	0.296
12	292.8	5.82	0.080	0.167	0.355
14	341.6	6.79	0.094	0.195	0.414
16	390.4	7.76	0.107	0.222	0.474
18	439.2	8.73	0.121	0.250	0.533
20	488.0	9.70	0.134	0.278	0.592
22	536.8	10.67	0.147	0.306	0.651
24	585.6	11.64	0.161	0.334	0.710
26	634.4	12.61	0.174	0.361	0.770
28	683.2	13.58	0.188	0.389	0.829
30	732.0	14.55	0.201	0.417	0.888
32	780.8	15.52	0.214	0.445	0.947
34	829.6	16.49	0.228	0.473	1.006
36	878.4	17.46	0.241	0.500	1.066
38	927.2	18.43	0.255	0.528	1.125
40	976.0	19.40	0.268	0.556	1.184
42	1024.8	20.37	0.281	0.584	1.243
44	1073.6	21.34	0.295	0.612	1.302
46	1122.4	22.31	0.308	0.639	1.362
48	1171.2	23.28	0.322	0.667	1.421
50	1220.0	24.25	0.335	0.695	1.480

* The figures are decimal fractions of one kg for energy while for the protein and amino acids they are in percentage units.

- Each 0.02 kg adds 48.8 kcal while every 2% units add 0.97CP, 0.0134 Met, 0 .0278 Met+ Cys, and 0.0592 Lys.

Table 4: Approximated chemical composition of fish meal, herring, for amounts starting at 1.0 with 1.0 intervals to 10 units.

*Amount**	*Men(kcal)*	*CP*	*Met*	*Met + Cys*	*Lys*
1	3.19	0.723	0.022	0.029	0.055
2	6.38	1,446	0.043	0.058	0.109
3	9.57	2.169	0.065	0.086	0.164
4	12.76	2.892	0.086	0.115	0.219
5	15.95	3.615	0.108	0.144	0.274
6	19.14	4.338	0.130	0.173	0.328
7	22.33	5.061	0.151	0.202	0.383
8	25.52	5.784	0.173	0.230	0.438
9	28.71	6.507	0.194	0.259	0.492
10	31.90	7.230	0.216	0.288	0.547

* The figures are decimal fractions of one kg for energy while for the protein and amino acids they are in percentage units.

- Each 0.01 kg adds 31.9 kcal while every 1% unit adds 0.723CP, 0.0216 Met, 0 .0288 Met+ Cys, and 0.0547 Lys.

Table 5: Approximated chemical composition of wheat bran for amounts starting at 2 with 2 intervals to 30 units.

*Amount**	*Men (kcal)*	*CP*	*Met*	*Met + Cys*	*Lys*
2	26	0.314	0.005	0.011	0.011
4	52	0.628	0.009	0.022	0.022
6	78	0.942	0.014	0.033	0.033
8	104	1.256	0.018	0.044	0.044
10	130	1.570	0.023	0.055	0.055
12	156	1.884	0.028	0.066	0.066
14	182	2.198	0.032	0.077	0.077
16	208	2.512	0.037	0.088	0.088
18	234	2.826	0.041	0.099	0.099
20	260	3.140	0.046	0.110	0.110
22	286	3.454	0.051	0.121	0.121
24	312	3.768	0.055	0.132	0.132
26	338	4.082	0.060	0.143	0.143
28	364	4.396	0.064	0.154	0.154
30	390	4.710	0.069	0.165	0.165

* The figures are decimal fractions of one kg for energy while for the protein and amino acids they are in percentage units.

- Each 0.02 kg adds 26 kcal while every 2% units add 0.314CP, 0.0046 Met, 0 .0110 Met+ Cys, and 0.0122 Lys

Table 6: Phosphorous and calcium content of monocalcium phosphate for amounts starting at 0.1 with 0.01 intervals to 0.65 unit of available phosphorous

Available phosphorous	*Supplement*	*Calcium Content*	*Available phosphorous*	*Supplement*	*Calcium content*
0.10	0.463	0.076	**0.38**	1.759	0.289
0.11	0.509	0.084	**0.39**	1.806	0.296
0.12	0.556	0.091	**0.40**	1.852	0.304
0.13	0.602	0.099	**0.41**	1.898	0.312
0.14	0.648	0.106	**0.42**	1.944	0.319
0.15	0.695	0.114	**0.43**	1.991	0.327
0.16	0.741	0.122	**0.44**	2.037	0.334
0.17	0.787	0.129	**0.45**	2.083	0.342
0.18	0.833	0.137	**0.46**	2.130	0.350
0.19	0.880	0.144	**0.47**	2.176	0.357
0.20	0.926	0.152	**0.48**	2.222	0.365
0.21	0.972	0.160	**0.49**	2.269	0.372
0.22	1.019	0.167	**0.50**	2.315	0.380
0.23	1.065	0.175	**0.51**	2.361	0.388
0.24	1.111	0.182	**0.52**	2.407	0.395
0.25	1.158	0.190	**0.53**	2.454	0.403
0.26	1.204	0.198	**0.54**	2.500	0.410
0.27	1.250	0.205	**0.55**	2.546	0.418
0.28	1.296	0.213	**0.56**	2.593	0.426
0.29	1.343	0.220	**0.57**	2.639	0.433
0.30	1.389	0.228	**0.58**	2.685	0.441
0.31	1.435	0.236	**0.59**	2.732	0.448
0.32	1.482	0.243	**0.60**	2.778	0.456
0.33	1.528	0.251	**0.61**	2.824	0.464
0.34	1.574	0.258	**0.62**	2.870	0.471
0.35	1.621	0.266	**0.63**	2.917	0.479
0.36	1.667	0.274	**0.64**	2.963	0.486
0.37	1.713	0.281	**0.65**	3.009	0.494

- Monocalcium phosphate contains 16.4% Ca and 21.6% P (NRC, 1994 for sheep).
- Each 0.01unit available phosphorous needed equals the addition of about 0.0463 unit monocalcium phosphate which consequently adds about 0.0076 unit Ca.

Table 7: Phosphorous and calcium content of dicalcium phosphate for amounts starting at 0.1 with 0.01 intervals to 0.65 unit available phosphorous

Available Phosphorous	Supplement	*Calcium content*	*Available phosphorous*	*Supplement*	*Calcium content*
0.10	0.535	0.118	**0.38**	2.033	0.448
0.11	0.589	0.130	**0.39**	2.087	0.460
0.12	0.642	0.141	**0.40**	2.140	0.472
0.13	0.696	0.153	**0.41**	2.194	0.484
0.14	0.749	0.165	**0.42**	2.247	0.495
0.15	0.803	0.177	**0.43**	2.301	0.507
0.16	0.856	0.189	**0.44**	2.354	0.519
0.17	0.910	0.200	**0.45**	2.408	0.531
0.18	0.963	0.212	**0.46**	2.461	0.543
0.19	1.017	0.224	**0.47**	2.515	0.553
0.20	1.070	0.236	**0.48**	2.568	0.566
0.21	1.124	0.248	**0.49**	2.622	0.578
0.22	1.177	0.259	**0.50**	2.675	0.590
0.23	1.231	0.271	**0.51**	2.729	0.602
0.24	1.284	0.283	**0.52**	2.782	0.613
0.25	1.338	0.295	**0.53**	2.836	0.625
0.26	1.391	0.307	**0.54**	2.889	0.637
0.27	1.445	0.318	**0.55**	2.943	0.649
0.28	1.498	0.330	**0.56**	2.996	0.661
0.29	1.552	0.342	**0.57**	3.050	0.672
0.30	1.605	0.354	**0.58**	3.103	0.684
0.31	1.659	0.366	**0.59**	3.157	0.696
0.32	1.712	0.377	**0.60**	3.210	0.708
0.33	1.766	0.389	**0.61**	3.264	0.720
0.34	1.819	0.401	**0.62**	3.317	0.731
0.35	1.873	0.413	**0.63**	3.371	0.743
0.36	1.926	0.425	**0.64**	3.424	0.755
0.37	1.980	0.436	**0.65**	3.478	0.767

-Dicalcium phosphate contains 22.0% Ca and 18.7% P (NRC, 1994 for poultry).
-Each 0.01unit available phosphorous needed equals the addition of about 0.0535 unit dicalcium phosphate which consequently adds about0.0118unit Ca.

Table 8: Calcium content of limestone for amounts starting at 0.1 with 0.1 intervals to 4.0 units.

Calcium Needed	*Supplement*	*Calcium needed*	*Supplement*
0.1	0.263	**2.1**	5.527
0.2	0.526	**2.2**	5.790
0.3	0.790	**2.3**	6.054
0.4	1.053	**2.4**	6.317
0.5	1.316	**2.5**	6.580
0.6	1.579	**2.6**	6.843
0.7	1.842	**2.7**	7.106
0.8	2.106	**2.8**	7.370
0.9	2.369	**2.9**	7.633
1.0	2.632	**3.0**	7.896
1.1	2.895	**3.1**	8.159
1.2	3.158	**3.2**	8.422
1.3	3.422	**3.3**	8.686
1.4	3.685	**3.4**	8.949
1.5	3.948	**3.5**	9.212
1.6	4.211	**3.6**	9.475
1.7	4.474	**3.7**	9.738
1.8	4.738	**3.8**	10.002
1.9	5.001	**3.9**	10.265
2.0	5.264	**4.0**	10.528

- Limestone contains 38% Ca (NRC, 1994 for poultry).
- Each 0.1% Ca needed equals the addition of about 0.2632 limestone.

Table 9: Sodium content of common salt for amounts starting at 0.1 with 0. 01 intervals to 0.2 unit

Sodium	*Supplement*	*Sodium*	*Supplement*
0.10	0.256	**0.16**	0.410
0.11	0.282	**0.17**	0.436
0.12	0.308	**0.18**	0.461
0.13	0.333	**0.19**	0.487
0.14	0.359	**0.20**	0.512
0.15	0.384		

- Common salt contains 39% Na (NRC, 1994 for poultry).
- Each 0.01% Na added equals the addition of about 0.0256% common salt.

Table 10: Corn and soya (44%CP) proportions in mixtures with different C/ P ratios starting at 100 with 5 intervals to 300.

C/P ratio	C1 (%)	S1 (%)	MEn1 (kcal/kg)	CP1 (%)	Met1 (%)	Met+Cys1 (%)	Lys1 (%)
100	46.467	53.533	2750.4	27.504	0.416	0.853	1.561
105	49.304	50.696	2782.2	26.497	0.403	0.826	1.492
110	51.940	48.060	2811.7	25.561	0.391	0.802	1.428
115	54.397	45.603	2839.2	24.689	0.381	0.780	1.368
120	56.691	43.309	2864.9	23.875	0.371	0.758	1.312
125	58.839	41.161	2889.0	23.112	0.361	0.739	1.260
130	60.854	39.146	2911.6	22.397	0.352	0.720	1.211
135	62.748	37.252	2932.8	21.724	0.344	0.703	1.165
140	64.532	35.468	2952.8	21.091	0.336	0.686	1.122
145	66.215	33.785	2971.6	20.494	0.329	0.671	1.081
150	67.804	32.196	2989.4	19.929	0.322	0.656	1.042
155	69.309	30.691	3006.3	19.395	0.315	0.642	1.006
160	70.735	29.265	3022.2	18.889	0.309	0.629	0.971
165	72.089	27.911	3037.4	18.408	0.303	0.617	0.938
170	73.375	26.625	3051.8	17.952	0.297	0.605	0.907
175	74.599	25.401	3065.5	17.517	0.292	0.594	0.877
180	75.766	24.234	3078.6	17.103	0.287	0.583	0.849
185	76.878	23.122	3091.0	16.708	0.282	0.573	0.822
190	77.940	22.060	3102.9	16.331	0.277	0.563	0.796
195	78.956	21.044	3114.3	15.971	0.273	0.554	0.771
200	79.927	20.073	3125.2	15.626	0.268	0.545	0.748
205	80.857	19.143	3135.6	15.296	0.264	0.536	0.725
210	81.749	18.251	3145.6	14.979	0.260	0.528	0.703
215	82.605	17.395	3155.2	14.675	0.257	0.520	0.683
220	83.427	16.573	3164.4	14.384	0.253	0.512	0.663
225	84.216	15.784	3173.2	14.103	0.249	0.505	0.644
230	84.976	15.024	3181.7	13.834	0.246	0.498	0.625
235	85.707	14.293	3189.9	13.574	0.243	0.491	0.607
240	86.411	13.589	3197.8	13.324	0.240	0.485	0.590
245	87.089	12.911	3205.4	13.083	0.237	0.479	0.574
250	87.744	12.256	3212.7	12.851	0.234	0.473	0.558
255	88.376	11.624	3219.8	12.627	0.231	0.467	0.542
260	88.986	11.014	3226.6	12.410	0.228	0.461	0.528
265	89.575	10.425	3233.2	12.201	0.226	0.456	0.513
270	90.145	9.855	3239.6	11.999	0.223	0.451	0.499
275	90.696	9.304	3245.8	11.803	0.221	0.446	0.486
280	91.230	8.770	3251.8	11.613	0.219	0.441	0.473
285	91.746	8.254	3257.6	11.430	0.216	0.436	0.461
290	92.247	7.753	3263.2	11.252	0.214	0.431	0.448
295	92.732	7.268	3268.6	11.080	0.212	0.427	0.437
300	93.203	6.797	3273.9	10.913	0.210	0.423	0.425

- C1 is yellow corn and S1 is soybean oil meal.
- MEn, CP and AA content of the two ingredients are according to NRC (1994) feed analysis tables.

Table 11: Corn and soya (48.5%CP) proportions in mixtures with different C/ P ratios starting at 100 with 5 intervals to 300.

C/P ratio	*C 2 (%)*	*S2 (%)*	*MEn2 (kcal/kg)*	*CP2 (%)*	*Met2 (%)*	Met+Cys2 (%)	*Lys2 (%)*
100	49.084	50.916	2886.7	28.867	0.429	0.884	1.635
105	51.908	48.092	2912.4	27.737	0.416	0.855	1.558
110	54.520	45.480	2936.1	26.692	0.403	0.828	1.488
115	56.942	43.058	2958.2	25.723	0.391	0.803	1.423
120	59.194	40.806	2978.7	24.822	0.380	0.780	1.362
125	61.294	38.706	2997.8	23.982	0.370	0.759	1.305
130	63.257	36.743	3015.6	23.197	0.360	0.738	1.252
135	65.095	34.905	3032.4	22.462	0.351	0.720	1.202
140	66.820	33.180	3048.1	21.772	0.343	0.702	1.156
145	68.443	31.557	3062.8	21.123	0.335	0.685	1.112
150	69.971	30.029	3076.7	20.512	0.327	0.669	1.071
155	71.414	28.586	3089.9	19.935	0.320	0.654	1.032
160	72.777	27.223	3102.3	19.389	0.313	0.640	0.995
165	74.068	25.932	3114.0	18.873	0.307	0.627	0.960
170	75.292	24.708	3125.2	18.383	0.301	0.614	0.927
175	76.454	23.546	3135.7	17.918	0.295	0.603	0.896
180	77.559	22.441	3145.8	17.477	0.290	0.591	0.866
185	78.610	21.390	3155.4	17.056	0.285	0.580	0.838
190	79.612	20.388	3164.5	16.655	0.280	0.570	0.810
195	80.568	19.432	3173.2	16.273	0.275	0.560	0.785
200	81.481	18.519	3181.5	15.907	0.271	0.551	0.760
205	82.355	17.645	3189.4	15.558	0.266	0.542	0.736
210	83.190	16.810	3197.0	15.224	0.262	0.533	0.714
215	83.991	16.009	3204.3	14.904	0.258	0.525	0.692
220	84.758	15.242	3211.3	14.597	0.255	0.517	0.672
225	85.494	14.506	3218.0	14.302	0.251	0.509	0.652
230	86.202	13.798	3224.4	14.019	0.248	0.502	0.633
235	86.882	13.118	3230.6	13.747	0.244	0.495	0.614
240	87.536	12.464	3236.6	13.486	0.241	0.488	0.597
245	88.165	11.835	3242.3	13.234	0.238	0.482	0.580
250	88.772	11.228	3247.8	12.991	0.235	0.476	0.563
255	89.356	10.644	3253.1	12.757	0.232	0.470	0.547
260	89.920	10.080	3258.3	12.532	0.229	0.464	0.532
265	90.465	9.535	3263.2	12.314	0.227	0.458	0.517
270	90.991	9.009	3268.0	12.104	0.224	0.453	0.503
275	91.499	8.501	3272.6	11.901	0.222	0.448	0.490
280	91.990	8.010	3277.1	11.704	0.219	0.443	0.476
285	92.465	7.535	3281.4	11.514	0.217	0.438	0.463
290	92.926	7.074	3285.6	11.330	0.215	0.433	0.451
295	93.371	6.629	3289.7	11.151	0.212	0.428	0.439
300	93.803	6.197	3293.6	10.979	0.210	0.423	0.427

- C2 is yellow corn and S2 is soybean oil meal.
- MEn, CP and AA content of the two ingredients are according to NRC (1994) feed analysis tables.

Table 12: Fat / soya mixtures containing the same level of protein in corn (8.5 %) starting at fat of 5000 kcal, MEn/kg with 500 intervals to 10000 units.

MEn in fat used	*% of fat in mixtures*	*Fat ingredient, MEn*	*% of soya in mixtures*	*Soya meal, MEn*	*Mixtures, MEn*	*Mix/corn difference*
5000	80.68	4034.0	19.32	430.8	4464.8	114.8
5500		4437.4			4868.2	1518.2
6000		4840.8			5271.6	1921.6
6500		5244.2			5675.0	2325.0
7000		5647.6			6078.4	2728.4
7500		6051.0			6481.8	3131.8
8000		6454.4			6885.2	3535.2
8500		6857.8			7288.6	3938.6
9000		7261.2			7692.0	4342.0
9500		7664.6			8095.4	4745.4
10000		8068.0			8498.8	5148.8

- Soybean meal, MEn = 2230 kcal/kg and CP% = 44 (NRC, 1994 for poultry).

Table 13: Soya / fat mixtures containing the same level of energy in corn (3350 kcal) starting with fat of 5000 kcal, MEn/kg with 500 intervals to 10000 units

MEn in fat used	*Fat/soya* difference*	*Fat/corn ▫ difference*	Soya %	*Fat %*	*Crude protein %*
5000	2770	1650	59.57	40.43	26.21
5500	3270	2150	65.75	34.25	28.93
6000	3770	2650	70.29	29.71	30.93
6500	4270	3150	73.77	26.23	32.46
7000	4770	3650	76.52	23.48	33.67
7500	5270	4150	78.75	21.25	34.65
8000	5770	4650	80.59	19.41	35.46
8500	6270	5150	82.14	17.86	36.14
9000	6770	5650	83.46	16.54	36.72
9500	7270	6150	84.59	15.41	37.22
10000	7770	6650	85.59	14.41	37.66

- Soybean meal, MEn = 2230 kcal/kg and CP% = 44.

* The difference between fat and soybean meal energy on the left side of square in the square method.

▫ The difference between the energy of fat on the upper left side and corn energy in the center of the square.

Table 14: Fat / soya mixtures containing the same level of protein in corn (8.5 %) starting with fat of 5000 kcal, MEn/kg with 500 intervals to10000 units

MEn in fat used	*% of fat in mixtures*	*Fat ingredient Men*	*% of soya in mixtures*	*Soya meal MEn*	*Mixture, MEn*	*Mix/corn Difference*
5000	82.47	4123.5	17.53	427.8	4551.3	1201.3
5500		4535.9			4535.9	1185.9
6000		4948.2			4948.2	1598.2
6500		5360.6			5360.6	2010.6
7000		5772.9			5772.9	2422.9
7500		6185.3			6185.3	2835.3
8000		6597.6			6597.6	3247.6
8500		7010.0			7010.0	3660.0
9000		7422.3			7422.3	4072.3
9500		7834.7			7834.7	4484.7
10000		8247.0			8247.0	4897.0

- Soybean meal, MEn = 2440 kcal/kg and CP% = 48.5 (NRC ,1994 for poultry).

Table 15: Soya / fat mixtures containing the same level of energy in corn (3350 kcal) starting with fat of 5000 kcal, MEn/kg with 500 intervals to 10000 units

MEn in fat used	*Fat/soya* difference*	*Fat/corn ▫ difference*	*Soya %*	*Fat %*	*Crude protein %*
5000	2560	1650	64.45	35.55	31.26
5500	3060	2150	70.26	29.74	34.08
6000	3560	2650	74.44	25.56	36.10
6500	4060	3150	77.59	22.41	37.63
7000	4560	3650	80.04	19.96	38.82
7500	5060	4150	82.02	17.98	39.78
8000	5560	4650	83.63	16.37	40.56
8500	6060	5150	84.98	15.02	41.22
9000	6560	5650	86.13	13.87	41.77
9500	7060	6150	87.11	12.89	42.25
10000	7560	6650	87.96	12.04	42.66

- Soybean meal, MEn = 2440 kcal/kg and CP% = 48.5.

* The difference between fat and soybean meal energy on the left side of square in the square method.

▫ The difference between the energy of fat on the upper left side and corn energy in the center of the square.

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