NutriSolver Ver. 1.00

User Manual

1. General description

NutriSolver Ver. 1.00 is a complete animal nutrition software package. It can formulate and balance rations for all kinds of animals both ruminant and non-ruminant. Feed quantities can be expressed either in kilograms per day (Kg/d) or in percentages, in dry matter or as fed basis. It can be used by almost anyone with basic skills in how to operate a computer but requires a solid theoretical background in animal nutrition.

The basic elements of the program are the nutrients file, the dummy - nutrients file, the nutrient ratios file, the profiles file, the raw materials file, the formulas file, the products file, the specifications file, the customers file and the equations file. Not all of those elements are self-explanatory regarding the purpose they serve, so further information is required to understand their function.

Rations consist of formulas and products. The difference between the two is that a formula is the description of a ration and a product is the ration itself. Formulas in short are sets of linear constraints that must be met by the ration. These sets of constraints are solved with the use of the linear programming algorithm and the solution is the desired ration. There is only one problem though. This ration is "volatile"; it will change when the feed costs change or when the constraints change or when the nutrient composition of the selected feeds change etc. Therefore, there must be a separate file to save the actual solution so that all the aforementioned changes won't affect it. This file is the products file. Also, having the solution in a separate file can be quite handy because it can be processed further. Products can be defined and analyzed independent of formulas.

Every ration (formula or product) is assigned to a profile and a customer. Profiles are a means to describe different animal species and/or production purposes. Every time a new profile is defined the user has to specify the nutrients and the nutrient ratios that aim to its purpose. For example, a profile for dairy cows would only include those nutrients and nutrient ratios specific to dairy cow nutrition. Other profiles would include different sets of nutrients and/or ratios.

Specifications are formulas without the "selected feeds" part. They can be perceived as "reusable constraints". They comprise of a requirements column, a minimum column and a maximum column. Usually requirements and minimums coincide, but not always. Specifications can be called from within a formula to speed up the input process or from within a product in order to validate it. Unlike rations they are only assigned to a profile.

It is possible to use nutrients as variables in a mathematical expression to describe another nutrient. This expression is an equation. Unfortunately, when it comes to "variables" the nutrients file is not enough. For instance, it would be nice to define digestibilities to calculate feed energy content, but digestibilities

are not nutrients and their definition in the nutrients file would create confusion. This is where the dummy-nutrients file comes in handy. All kinds of extraordinary coefficients (digestibilities, degradations rates, passage rates etc.) can be added into that file and used in equation definition.

Nutrients, dummy-nutrients and nutrient ratios can be practically infinite, but there is a limit as to how many profiles, raw materials and customers can be defined. That' s because the latter require a numerical code assigned to them which cannot exceed 32767. The same limit applies to specifications per profile as well. On the other hand, formulas and products don't fall into that category because their definition code is alphanumerical, so their number can be practically infinite too.

NutriSolver, as already mentioned, formulates least-cost rations (linear programming). It can also balance mixes with Pearson' s Square method. In the case of least-cost rations, if the initial constraints are inconsistent a relaxation methodology is applied until a feasible linear problem is reached. The cost optimized solution for this problem is presented as an alternative to the initial infeasible ration. Least cost optimization takes place only for that final problem. Cost is not taken into consideration during the relaxation procedure. This approach, however, does not warranty the best alternative and does not work in every possible circumstance, but it provides a means to understand what is wrong with the initial problem.

Formulated rations (products) can be processed further in many ways. The user can select a subset of a ration's feeds and generate mixes or sub-mixes etc. Many times a ration is formulated to serve as a raw material in another ration. NutriSolver provides a simple way to save a ration's nutrient content as a raw material in the raw materials file. Last but not least, in NutriSolver it is very easy to apply ration type transformation (dry matter to as fed and the opposite).

2.1 Nutrients file

In NutriSolver an unlimited number of nutrients can be defined. Additions, deletions and modifications are easily applied in nutrient's data table (figure 1). To add a new nutrient you should simply type its name and measurement unit in the blank line of the table ("*Nutrient*" column, up to 20 characters). In the "*Order*" column the user specifies the order of appearance of nutrients in tables and lists. In nutrient's table is both unnecessary and superfluous to define the **dry matter** nutrient. Feed's nutrient composition is stored in dry matter basis and the value of dry matter itself is stored in the raw material's definition file (in grams per kilogram).

Renaming a nutrient is also a trivial task. The user simply types the new name to the appropriate cell. Deletion takes place through the delete button in the tool bar. A nutrient **cannot be deleted** if it is a part of a nutrient ratio **or** if non-zero constraints are assigned to it in formulas **or** it happens to be an energy/protein nutrient in a profile **or** it is used in equation definition.

Users should not define nutrients in ways that a nutrient ratio is implied. The same holds when the nutrient content is expressed as a percentage. Although such definitions are not prohibited, the user must bare in mind that in those cases only mix-rations will compute. For instance, in the case of Ca(%DM), a nutrient ratio is implied. Let's assume that the desired constraint for Ca(%DM) in a daily ration (Kg/d) for a dairy cow is Ca(%DM)=0.6. If this constraint is entered in the nutrient section the ration won't be solved; remember, in daily rations raw material quantities are expressed in kilograms. The correct way is to define a nutrient ratio, like Ca(gr)/DM(gr), and request for the constraint Ca(gr)/DM(gr)=0.006 to hold. Of course there would be no problem if the ration's kind was a "mix". The same restriction applies if we define the nutrient Ca(%). Don't be confused by the fact that raw material nutrient content is saved in dry matter basis. Although in NutriSolver Ca(%) and Ca(%DM) are of the same raw material nutritional composition context, those definitions are different. As already mentioned, in Ca(%DM) a nutrient ratio is implied.

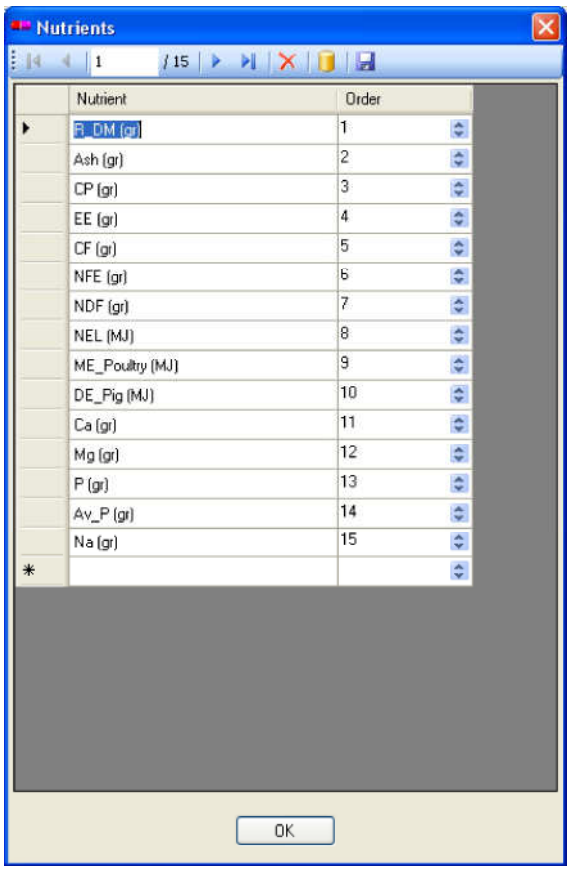


Figure 1. *Nutrient definition form.*

2.2 Dummy - nutrients file

Dummy nutrients are those "nutrients" that are used as coefficients in numerical operations in conjunction with the regular (dietary) nutrients. Examples of dummy nutrients are apparent digestibility coefficients, amino acid ileal digestibility coefficients, degradation rates, passage rates and so on. The values of those coefficients are independent of the way the dietary nutrient composition values are stored. For example, if the crude protein digestibility of a raw material is equal to 70% (or 0.70) this value is the same whether crude protein itself is stored in dry matter basis or in as fed basis.

Dummy nutrients are exclusively used in equation definition. They are defined the same way as regular nutrients (figure 2).

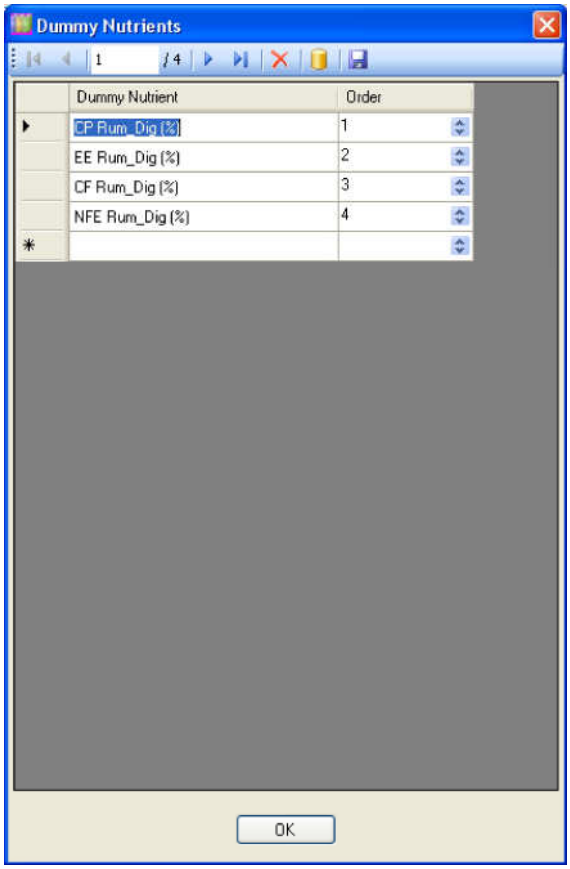


Figure 2. *Dummy nutrient definition form.*

2.3 Nutrient ratios file

Ratios specify a relationship between two nutrients in the form of a fraction. One nutrient serves as the numerator and another as the denominator. The form of nutrient ratios definition is presented in figure 3. A new nutrient ratio is always added in the blank line of the table, by specifying the numerator nutrient, the denominator nutrient, the order of appearance and the constraint limit modification factor (CLMF%).

Note: Dry matter nutrient is included in the lists [DM (gr)].

CLMF is a parameter that is used if the initial constraints of a formula are inconsistent and, therefore, the resulting linear problem is infeasible. It serves as a relaxation guideline for the particular nutrient ratio constraint. Values of CLMFs should be chosen between 2 and 5%. Smaller values would result in slower rates of convergence towards a feasible linear programming problem. Larger values would result in undesirable dietary allowances.

It is possible to modify and/or delete a nutrient ratio. However, in the case of modification, the new ratio would point to those limits set for the previous one. In order to delete a nutrient ratio, no limits have to be specified for it in any formula.

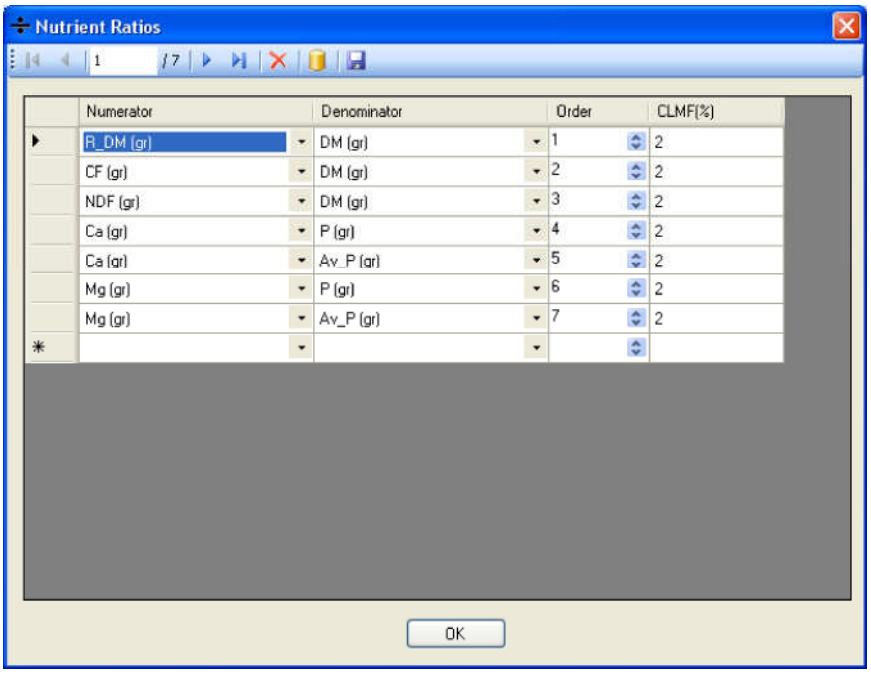


Figure 3. *Nutrient ratio definition form.*

2.4 Profiles file

As already mentioned in the introduction, profiles are a means to describe different animal species and/or production purposes. In each profile the user has to specify the nutrients and the nutrient ratios that aim to its purpose. For example, a profile for dairy cows would only include those nutrients and nutrient ratios specific to dairy cow nutrition. Other profiles would include different sets of nutrients and/or ratios. In addition, every formula, product and specification must be assigned to a profile.

In order to define a new profile the user must input its code (unique positive integer greater than zero), its description (unique name), the energy nutrient, the protein nutrient and all nutrients and nutrient ratios that must be included in analyses and reports (figure 4). Energy and protein nutrients serve as target nutrients when a mix ration (product-mix) is balanced with Pearson's Square method. You can use the arrow buttons in the tool bar to navigate through existing profiles or select the desired profile from the "*GoTo*" drop down list.

Profiles can be added, deleted, modified and copied (duplicated). In order to delete a profile, you must first delete all its nutrients and nutrient ratios from the respective tables. When a profile is copied (duplicated) a new profile is created with a new code and a new description, but with the same characteristics (energy and protein nutrients, list nutrients and nutrient ratios). The user can modify the newly created profile as he or she pleases.

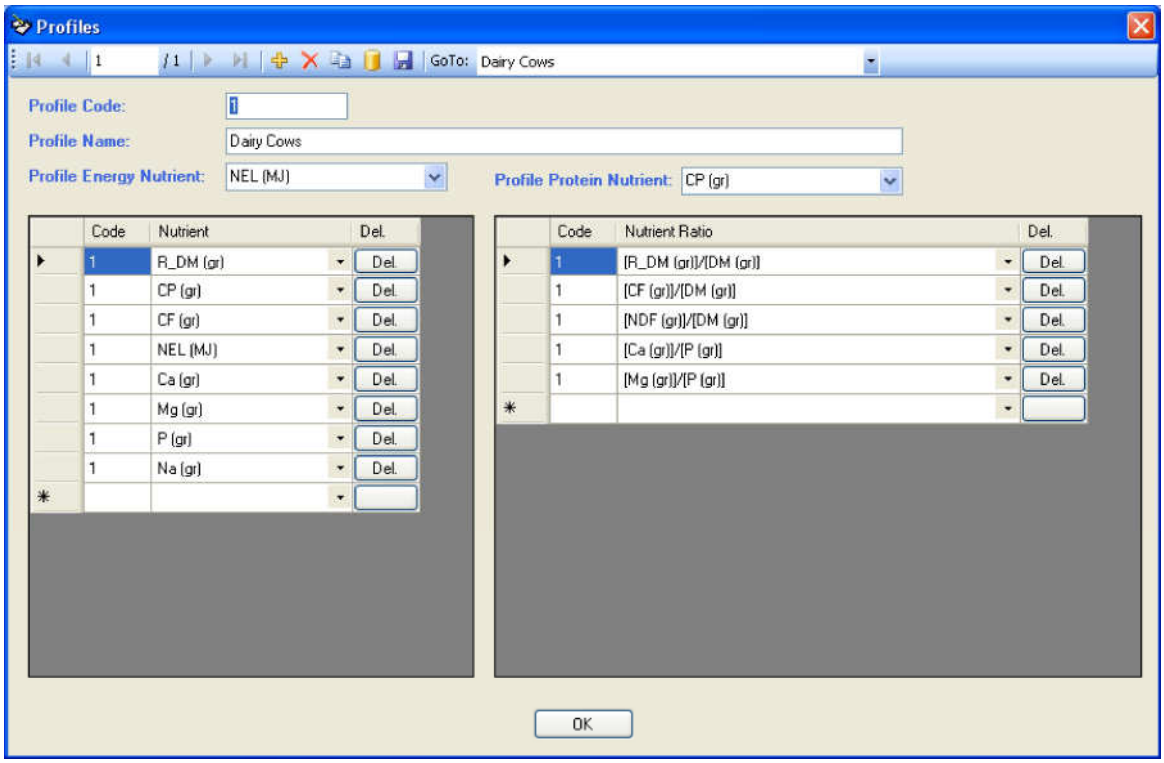


Figure 4. *Profile definition form.*

2.5 Raw materials file

Raw materials file described in this paragraph corresponds to the feeds **Master File**. Raw materials' prices and compositions can be personalized according to individual customer (producer) needs, but this is the file that serves as the reference point. When a raw material is not found within a customer's definition, its nutrient composition and price is selected from the Master File.

Every food entered has a code (unique positive integer greater than zero), a name (unique), dry matter content (grams per kilogram), a price (monetary unit per ton as fed), information concerning how the feed is used in feed plans among different animal species (optional), nutrient composition (dry matter basis) and dummy nutrient composition (figure 5). You can use the arrow buttons in the tool bar to navigate through existing raw materials or select the desired feed from the "*GoTo*" drop down list. Feeds can be sorted by name or by code. Raw materials can be added, modified, copied and deleted like profiles.

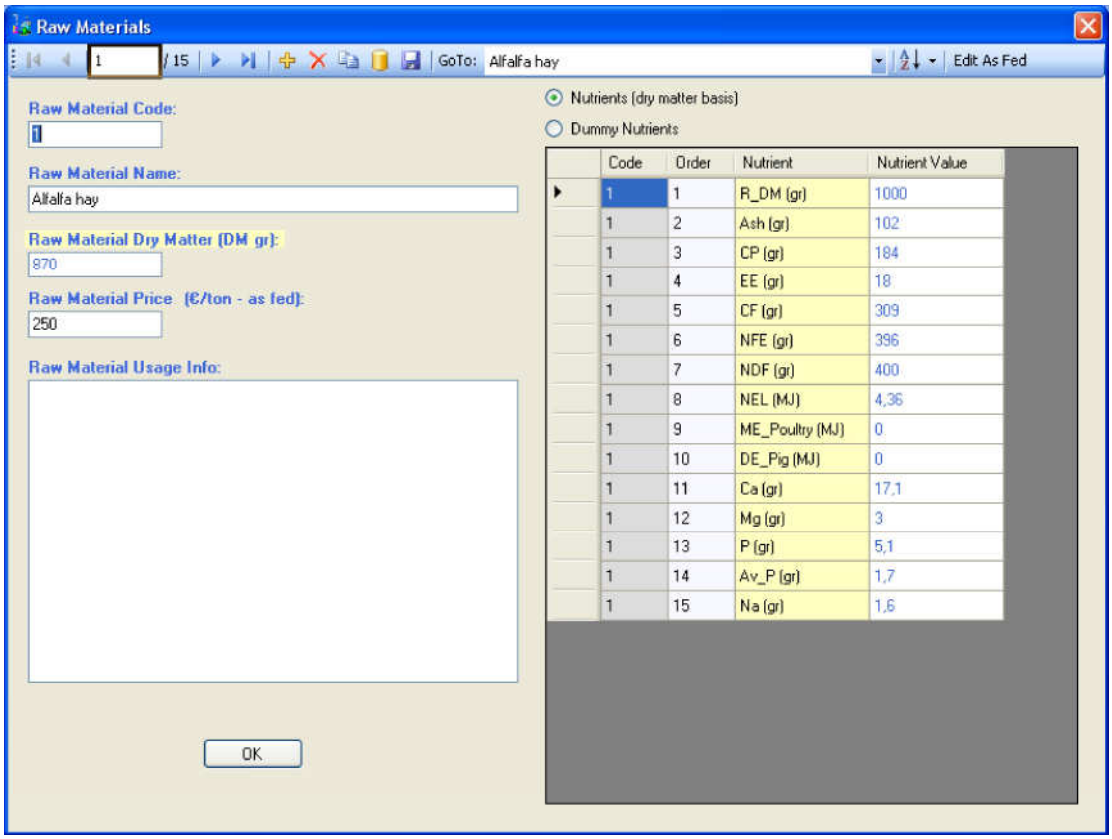


Figure 5. *Raw material definition form.*

Many times the composition of a raw material is available only in an as fed basis. In these cases it would be most inconvenient to transform the composition in dry matter basis using an external application, and then re-enter it in NutriSolver. That is why NutriSolver offers an alternative approach which is much more practical. The user must simply enter the feed's dry matter value and then press the "*Edit As Fed*" button in the tool bar. Immediately a new window appears in which the feed's composition is presented in as fed basis (figure 6). This as fed composition can be edited and by pressing the "*OK*" button the user returns to the parent window (figure 5), but the altered as fed nutrient values are updated into their dry matter basis equivalents.

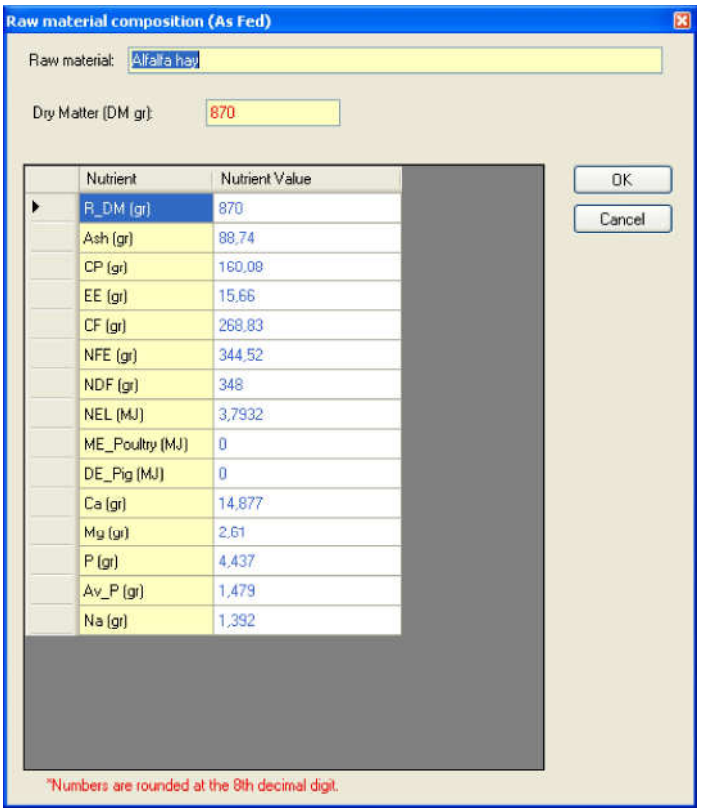


Figure 6. *Raw material composition as fed.*

2.6 Customers file

In NutriSolver every ration (formula or product) is assigned to a customer (producer). Each customer has a code (positive integer greater than zero) which must be unique and an enterprise name (also unique). More information data about a customer can be inserted in a separate table (figure 7). Those information fields are customizable and their declaration takes place in the parameter section of the application. Their type is text.

Customers can be added, modified or deleted. We cannot delete customers with rations. We can use the arrow buttons in the tool bar to navigate through existing customers or select the desired one from the "*GoTo*" drop down list. Customers can be sorted by their enterprise name or by their code.

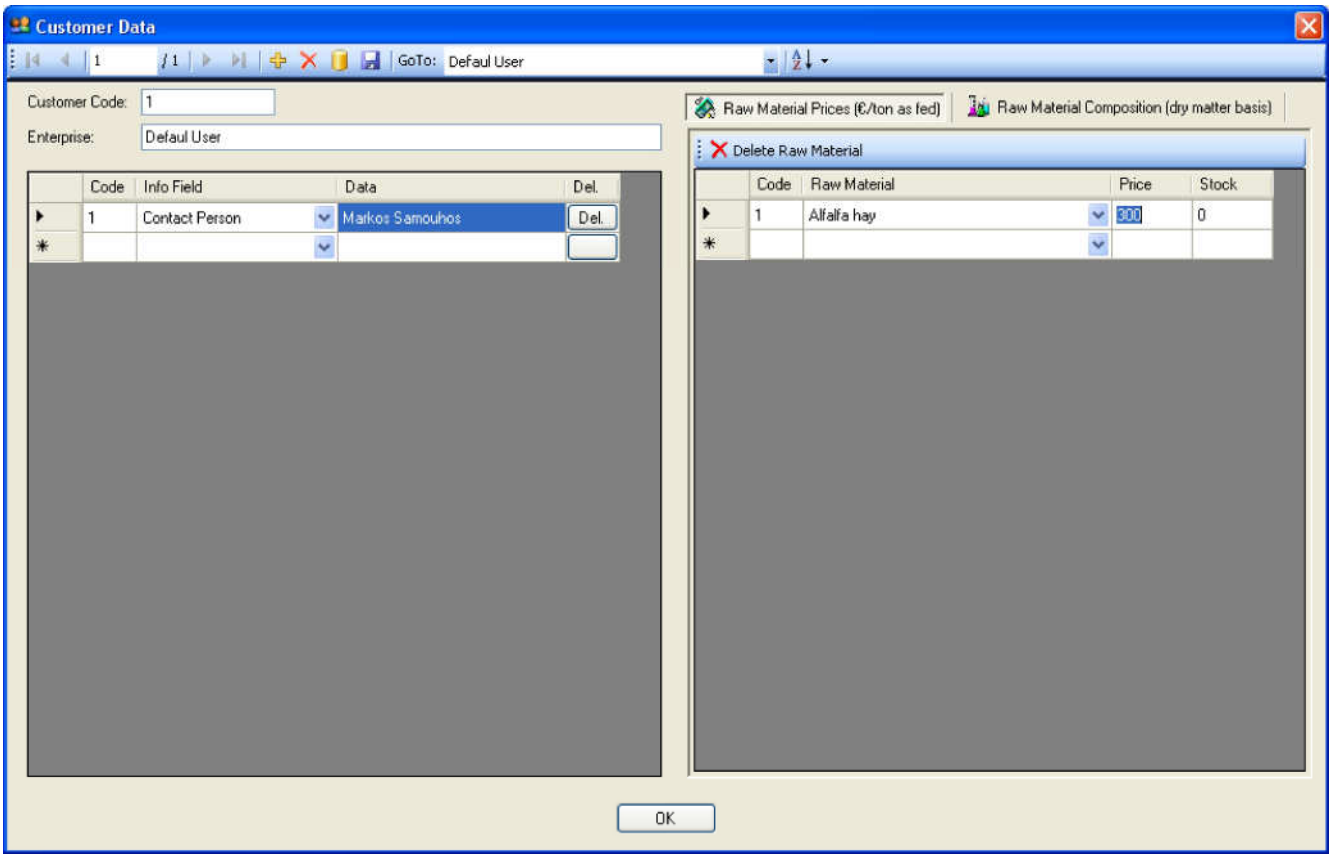


Figure 7. *Customer definition form.*

Raw material costs, raw material stocks and raw material compositions can be personalized by customer (figures 7 and 8). Costs and available stocks are edited in a different table than feed composition data. In fact, we can have different feeds selected in those two tables. In the raw material composition section, in order to import the desired raw materials we have to push the button with the '*add table*' icon in the secondary tool bar. After that, a selection list appears with all the available raw materials and the user can choose those of his preference. We navigate through the selected raw materials with the "*GoTo*" drop down list. We can also access the as fed composition through the "*Edit AsFed*" tool bar option.

Note: Multiple raw material selection is performed with the <Ctrl> and <Shift> keys and the right mouse button, just like when selecting multiple files in the Windows File Explorer.

When importing a feed's composition the initial nutrient composition is the one declared in the raw materials' Master File. We can change those data according to the actual characteristics of the feed used by the producer. Although all feeds can be imported for every customer this is both superfluous and a bad practice. The idea behind this capability was to avoid duplicate declarations in the Master File when a customer owns a raw material whose composition differs slightly than the one that is declared in our own raw materials file. For all other feeds, Master File's compositions can be used when analyzing or formulating rations. Import of many or even all feeds per customer would create duplicate information, wasted space storage, longer access times for read/write operations, longer process times and confusion. So don't overuse this feature.

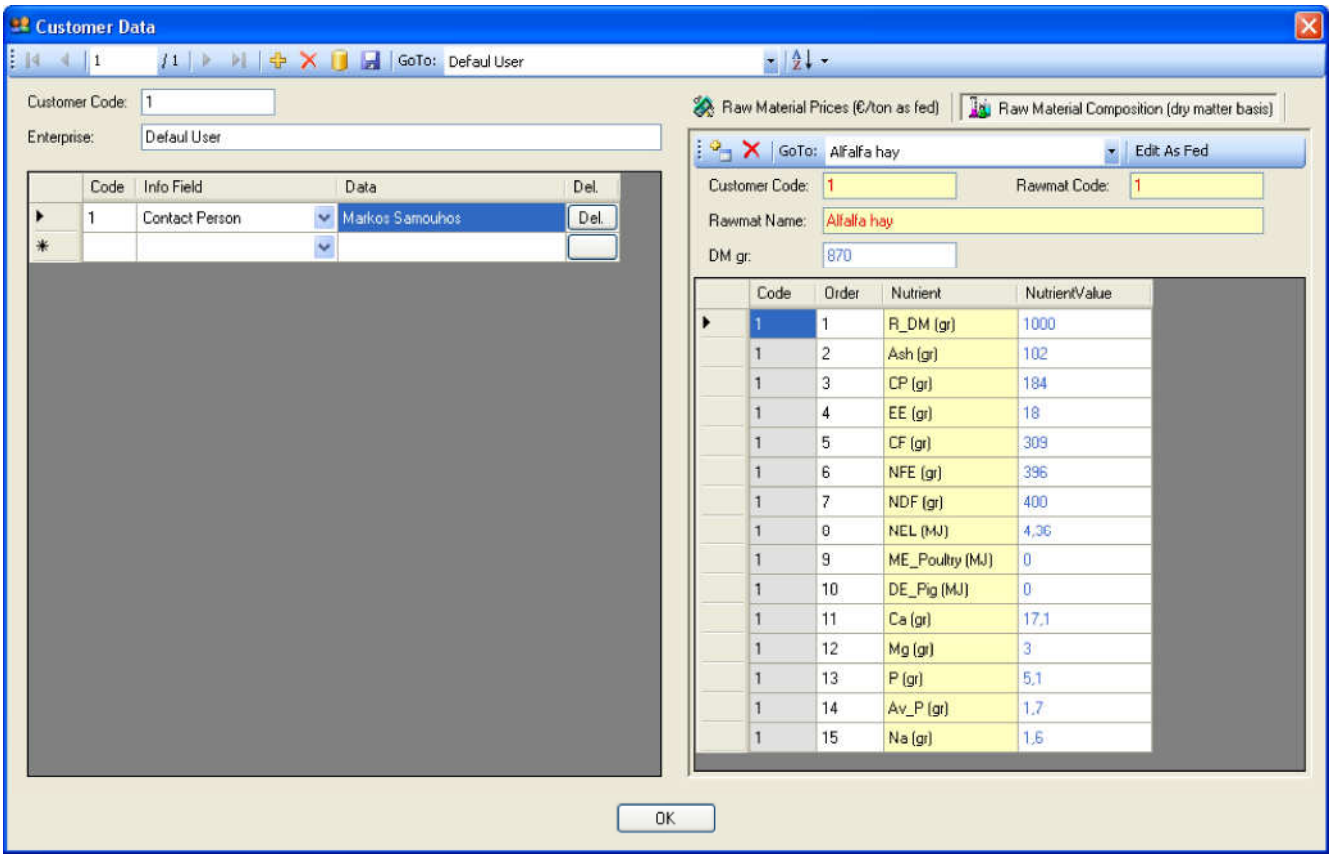


Figure 8. *Customer definition form - raw material composition section.*

2.7 Equations file

An equation is a mathematical expression that uses nutrients and dummy nutrients as independent variables to describe a relationship between them and a target nutrient. All nutrients can serve as target nutrients and for each nutrient only one equation definition is allowed. The relationship an equation describes is of theoretical nature. This means that due to errors in the analytical procedures inconsistencies may arise. The user must always keep that in mind when he observes discrepancies between the actual data and the calculated data.

The equation's editor windows form strongly resembles that of a calculator (figure 9). Two panels exist in the far right of this form. One for the numbers and operators and another for functions and symbols. There are also two lists. One for the selection of nutrients and another for the selection of dummy nutrients. Above those lists lies the equation definition text box and above that the target nutrient selection field.

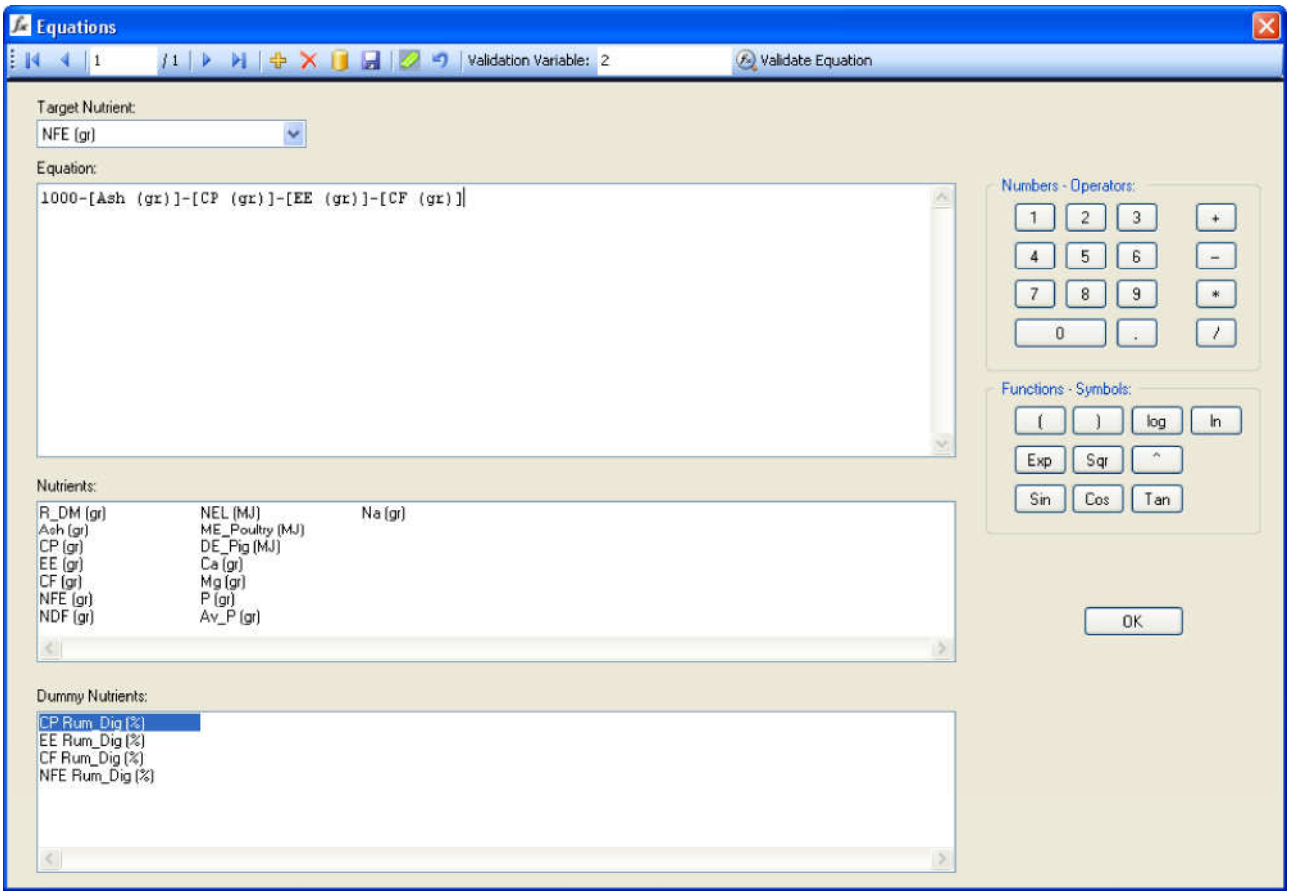


Figure 9. *Equation definition form.*

To add a new equation simply press the "*Add*" button in the tool bar. Next select the target nutrient from the drop down list and then enter the equation expression in the equation definition text box. In order to avoid making mistakes, this text box is not editable from the keyboard. Elements (numbers, functions, nutrients and so on) are selected with the mouse and are inserted in the cursors' location. So it is very easy to enter omitted text. In order to delete a part of an expression simply select that part with the mouse, the same way you do it in a text editor, and then press the "*Eraser*" button in the tool bar. Unlimited "*Undo*" is available for all editing operations.

Note: Dry matter nutrient is not included in the nutrients list. All nutrient values are stored in dry matter basis. So, if dry matter is required in an equation definition simply use the value of 1000 to express it in grams or the value of 1 to express it in kilograms.

In order to validate the entered equation expression use the validation variable. In this variable's text box the user can enter a numerical value of his/hers choice. Then simply press the "*Validate Equation*" button in the tool bar. During the validation process all entered variables receive the value of the validation variable. If validation fails the user is notified with a message.

2.8 Formulas file

A formula is the description of a ration. This description consists of nutrient constraints, nutrient ratio constraints and raw material constraints. Their combination represents a linear programming problem in which the objective function is the ration's cost. This cost has to be minimized with no constraint being violated. Available formulas are listed in the application's main window (figure 10), provided that "*Formulas*" are selected from the "*Category*" drop down list.

Formulas are assigned to a profile and a customer. Therefore, the listed formulas are only a sub set of those stored in the respective file. Profile and customer selection is performed in their respective drop down lists.

Formulas can be added, deleted, copied. We can also perform certain other operations on them like storing their nutrient and nutrient ratio constraints in to the specification file, saving their formulated ration as a product and editing their feed composition and prices. All those operations can be performed by their respective menu option in the "*Operations*" drop down button.

It is very easy to define a new formula. The user has to type into the blank line of the table the formula's code, a short description, its kind (Kg or mix), its type (AsFed or Dry) and then press the "*Save*" button in the tool bar. The comment field is optional.

A formula's code is alphanumeric, up to 10 characters long. It has to be unique among the same profile and customer. This means that the same code can be used by another formula as long as it belongs to a different customer and/or profile.

The kind and the type of the formula 'tells' the program how to treat its raw material quantities. If the kind is "Kg" then this means that the ration is a daily ration and feedstuff quantities are expressed in kilograms per day. A "mix" is a ration in which feedstuff quantities are expressed in percentages and they sum up to 100%. An "AsFed" type declares that feed quantities are as fed quantities and a "Dry" type that feed quantities are dry matter quantities. Don't be confused by the fact that raw material composition is stored in dry matter basis. The 'type' corresponds to the ration itself and has nothing to do with the expression of raw material composition. 'Type' is an inherent ration attribute, which stands by itself no matter how raw material composition is stored.

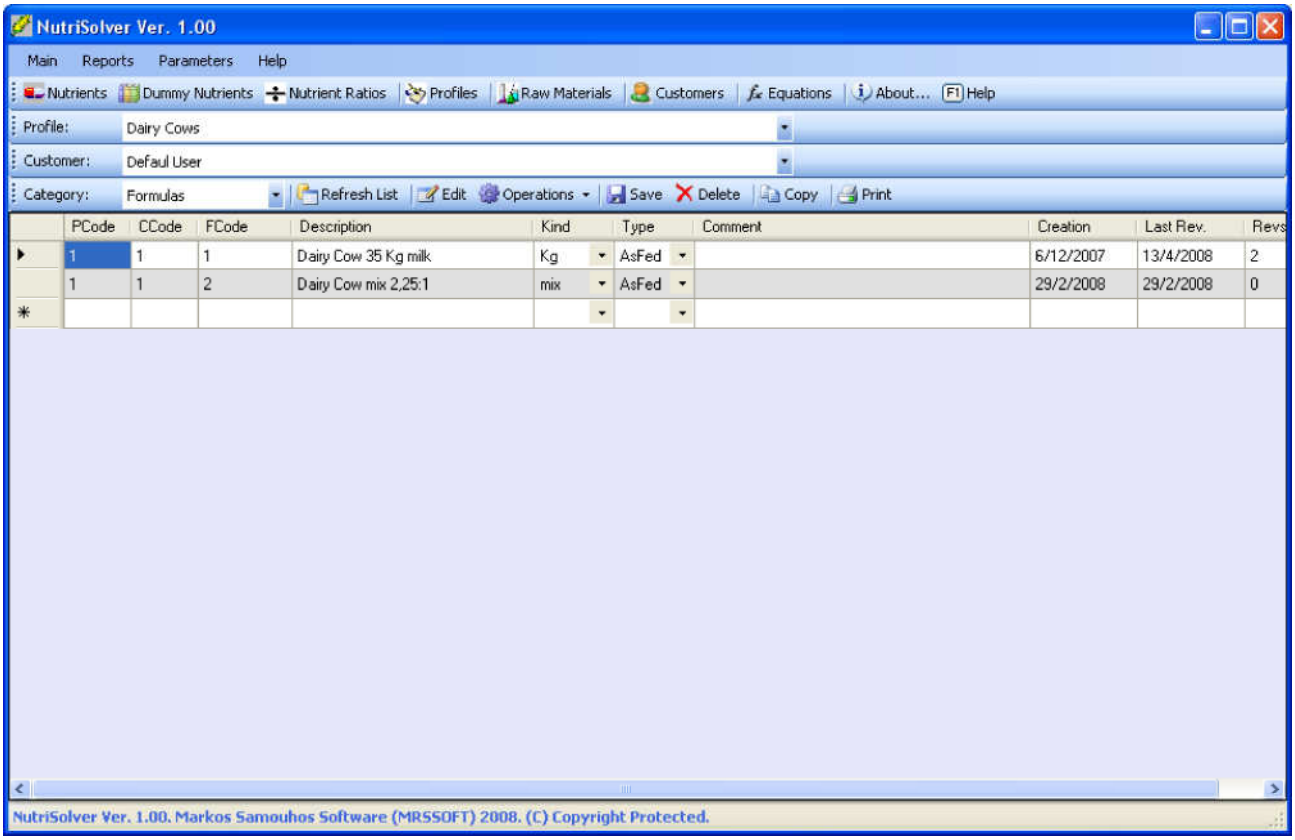


Figure 10. *Application's main window.*

2.9 Products file

This file includes rations that are the result of a formula processing or rations that are edited manually. Products, like formulas, have an alphanumeric code, a description, a kind and a type. Besides the comment field, there are two other optional fields as well; the consumption quantity (CQ in Kg) and the production quantity (PQ in Kg). More information about these fields is presented in part III of this manual.

2.10 Specifications file

Specifications are dietary templates that serve as reusable constraints. They can be called from within a formula in order to to speed up the input process or from within a product in order to validate it. Their definition requires the completion of two fields. A numerical code and a description. The code and the description fields have to be unique among the profile in which a specification is defined in.

3.1 Least cost rations (linear programming)

In order to process a formula, the user must first select it from the formula's table (figure 10) and then click the "*Edit*" button in the tool bar. Moments later a form appears which includes the formula's description and attributes (figure 11).

At the upper side of the form the user can view formula's information which includes formula's code, description, customer and comment. Right underneath, the tool bar appears. Further down there is a panel splitted in three parts. The left part is used for nutrient constraint editing. The upper right part is used for nutrient ratio constraint editing and, finally, the down right part is used for raw material constraint editing. Last, at the far down side of the form there are four buttons; one for ration formulation with the linear programing algorithm, one for recalculating the ration's characteristics, one for generating reports and one for returning back to the main window.

Raw material selection is carried out in the raw material's table with the help of drop down lists. A feed can be deleted by clicking the "*Del*" button in the corresponding table row. Minimum and maximum allowable usage is entered in the two columns that are on the left of the feed's name. When ration formulation and balancing is completed, feed quantities appear in the "*Quantity*" column of the table. Quantity values are editable and the nutrient characteristics of the ration are automatically computed when the <Enter> key is pressed (or when the "*Calculate*" button is clicked). In the last column of the raw material's table there is a clickable icon in each row. When it is clicked an info message appears which presents information about the usage of the respective feed.

In a similar way, the user can edit the nutrient and nutrient ratio constraints in the corresponding tables. Nutrients and nutrient ratios included in those tables are those that are selected for the profile that the formula belongs to. Unlike the raw material's table, nutrient and nutrient ratio analysis column cells are not editable, because their values depend upon the quantities of the included raw materials. Information icons also exist in the nutrient and nutrient ratio tables. When clicked, a window appears in which the composition of all selected raw materials is presented for the specific nutrient or nutrient ratio.

Note: Zero bounds are ignored. Zero indicates the lack of a constraint. Therefore, a selected raw material with both bounds set to zero represents a raw material that can be included in the ration without limit. If we desire to apply only a minimum bound, the maximum should be set to zero and the linear programming algorithm just ignores it.

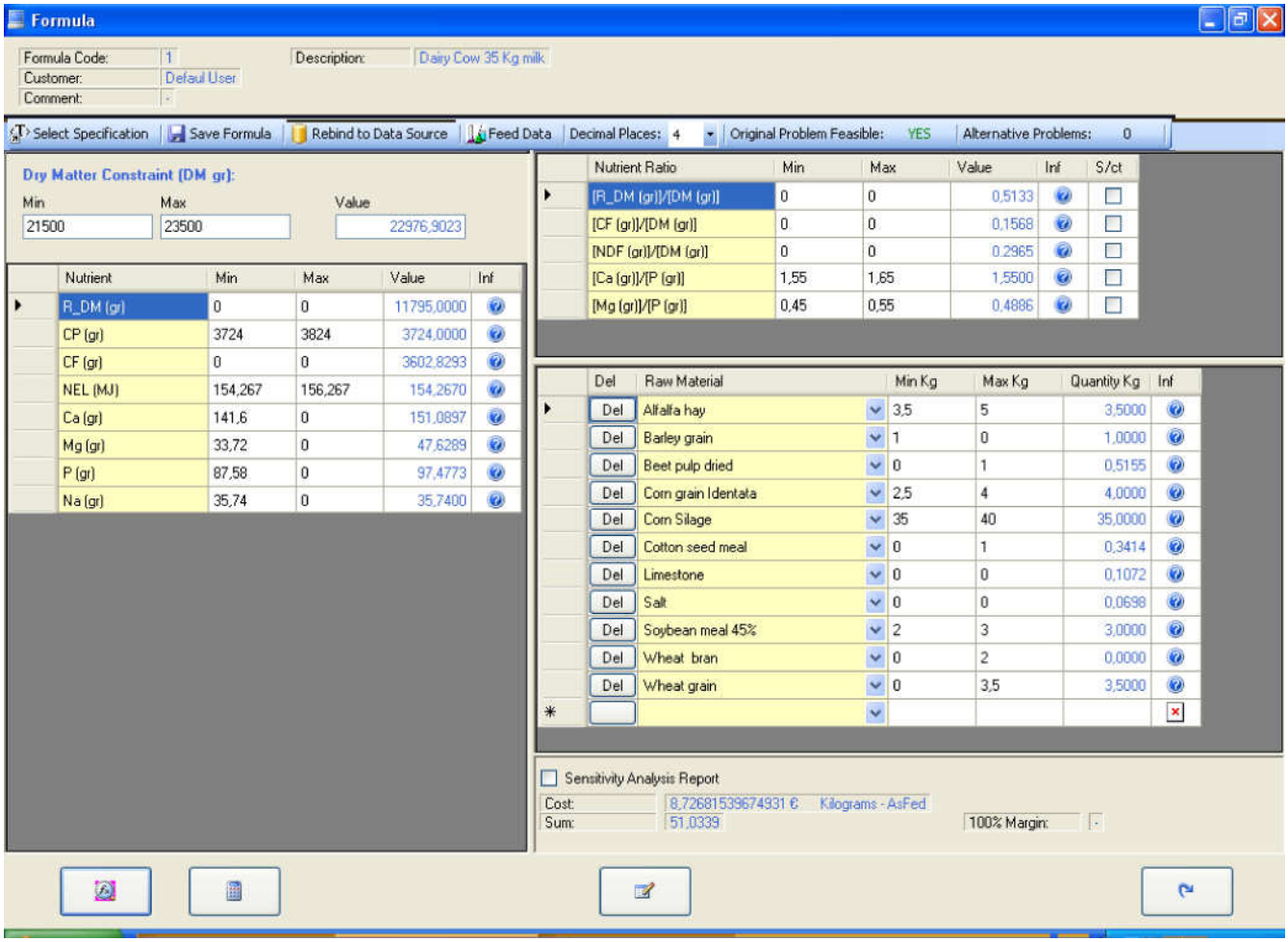


Figure 11. *Formula editing window*.

By clicking the "*Formulate*" button the linear programming algorithm executes. If the problem is feasible then it is optimized and the solution is presented in the quantity column of the feed's table. Immediately, nutrient and nutrient ratio values are updated as well as the ration's cost. If the initial problem is not feasible then the constraint relaxation procedure is automatically activated (unless the user has turned off that option) and alternative linear problems are formulated and processed until a feasible one occurs. Then that one is solved with the linear programming algorithm and its solution is presented as an alternative to the initial infeasible problem. As far as nutrient ratios are concerned, the user can set them "strict" by checking their respective check box. This means that no relaxation will be applied to them.

By selecting the "*Feed Data*" tool bar button the user can edit raw material prices, available stock levels and nutrient composition. On clicking the "*Select Specification*" button in the tool bar, a window appears in which all available specifications for the current profile are listed. When the user selects one, the nutrient and nutrient ratio constraint values are updated with those entered in the selected specification.

A printable report with the formula's characteristics is generated by clicking the "*Generate Report*" button. This report can be extracted in *.xls and *.pdf file formats. However, in this report sensitivity analysis for the linear programming parameters is not included.

In order to generate a report that includes sensitivity analysis information the user has to check the "*Sensitivity Analysis Report*" check box and click the "*Formulate*" button. If the linear problem is feasible then automatically a report is generated that includes that information as well. If the problem is infeasible then the constraint relaxation procedure is activated instead.

Sensitivity analysis includes the following information:

- Included raw material's price lower and upper bounds for which the solution remains the same.
- Rejected raw material's marginal prices in order to be included in to the solution.
- The binding constraints, their shadow prices, and the sensitivity analysis for their bound value.

Binding constraints are those that are precisely met. If the lower bound of a constraint is precisely met then by decreasing its value the value of the objective function will decrease as well (cheaper ration). If the bound increases, the value of the objective function will increase too (more expensive ration). The exact opposite behavior is expected when the upper bound of a constraint is precisely met. The general rule is that by relaxing a binding constraint the ration will become cheaper and the other way around.

Shadow price represents the cost of a single unit of a binding constraint. If a binding constraint relaxes by one (1) unit then the decrease in the ration's cost will be equal to the shadow price of that constraint. The cost will increase by the same amount if the constraint becomes even more binding by a single unit. If the modification of the constraint bound is lesser or greater than a single unit then the decrease or increase of the ration's cost will be equal to the product of the shadow price multiplied by the bound's modification (increment or decrement).

However, constraint bounds cannot be modified arbitrarily. Those bounds have bounds of their own and the latter are presented in the sensitivity analysis of the binding constraint limits. Constraint modification outside those boundaries may result in a linear problem with a new basis (the sensitivity analysis will be different) or, in the worst case scenario, in an infeasible linear problem.

Sensitivity analysis does not apply to nutrient ratio constraints. This is due to the nature of those constraints. A ratio is a fraction. Fractions cannot be understood by linear procedures, unless they are linearized. That is, the denominator must be multiplied by the constant factor (the bound value) and the product must be subtracted from the numerator. The result of the linearization process is that the right hand side value is always equal to zero. So, the sensitivity analysis applies to the linearized form of the original constraint and to the zero valued bound. This is why in the case of nutrient ratios shadow prices and the rest of the sensitivity analysis have no meaning.

3.2 Saving constraints as specifications

Constraints set for nutrients and nutrient ratios are nothing but ration specifications. Therefore, it's only natural to be able to save them in specifications file so that they can be used later in other formulas or products. In order to do that the user must first choose the desired formula from the table and then select the menu option "*Operations*" > "*Save constraints as specification*". In the dialog form that will appear he/she should provide a numerical code and a description for the new specification and then to click the "*OK*" button.

3.3 Saving a formulated ration as a product

Although the formulated ration (solution) is stored when the formula is saved, this does not warranty the longevity of this solution. Changes in feed prices and/or

feed nutrient composition would result in a new ration that will eventually replace the previous one. So, after a formula is saved the user can "move" this solution to the products file.

The procedure is quite simple. The user must first choose the desired formula from the table and then select the menu option "*Operations*" > "*Save ration data as product*". In the dialog form that will appear the user should provide an alphanumerical product code, select a producer, give a description for the new product and then click the "*OK*" button.

3.4 Edit a formula's raw materials

Editing nutrient composition, prices and available stocks for specific raw materials could be cumbersome when we have to access the entire raw materials file. It's much more convenient to perform the same operations by accessing only the raw materials in a formula or a product. We can do that by selecting the menu option "*Operations*" > "*Edit formula's feed data*".

3.5 Copy formula

In order to copy (duplicate) a formula we select "*Copy*" from the tool bar menu.

4.1 Product editing and formulation

In order to process a product, the user must first select it from the product's table and then click the "*Edit*" button in the tool bar. Moments later a form appears which includes the product's description and attributes (figure 12).

At the upper side of the form the user can view product's information which includes product's code, description, customer and comment. Right underneath, two tool bars appear. Further down there is a panel splitted in two parts. The left part is used for raw material editing. The right part is used for presenting the product's nutrient and nutrient ratio analysis. Last, at the far down side of the form there are three buttons; one for recalculating the ration's characteristics, one for generating reports and one for returning back to the main window.

Raw material selection is carried out in the raw material's table with the help of drop down lists. A feed can be deleted by clicking the "*Del*" button in the corresponding table row. Feed quantities are entered in the "*Quantity*" column of the table. The nutrient characteristics of the ration are automatically computed when the <Enter> key is pressed (or when the "*Calculate*" button is clicked). In the "*Fix*" column the user can select those raw materials whose quantities won't reset when the corresponding menu option in the tool bar is selected. The "*Order*" column serves as a sorting column for the feeds. It is in this column where feed's inclusion order in the ration is declared. In the last column of the raw material's table there is a clickable icon in each row. When it is clicked an info message appears which presents information about the usage of the respective feed.

Although ration formulation usually takes place in the formula's section, it is possible to balance a mix in the product's section as well. The balancing is applied with the Pearson's Square method and it concerns only the energy and the protein content of the mix. The user has to specify the desired levels for the energy and the protein in the respective text boxes in the tool bar and then click the "*Formulate*" icon. The only constraint is that the "free" raw materials must be equal to three or more.

"Free" raw materials are those whose quantities are set to zero percent (0%). There is a chance, however, that the balanced mix is not satisfactory. In this case the user can reset feed quantities by clicking the "*Reset Feed Quantities*" menu button in the tool bar. Reseting will have no effect on "fixed" raw materials, as already mentioned in a previous paragraph. It is possible to force inclusion quantities for certain feedstuffs, such as inorganic sources or premixes, but always keep in mind that the "free" raw materials number should be greater or equal to three (and even then it is not warranted that the mix will balance).

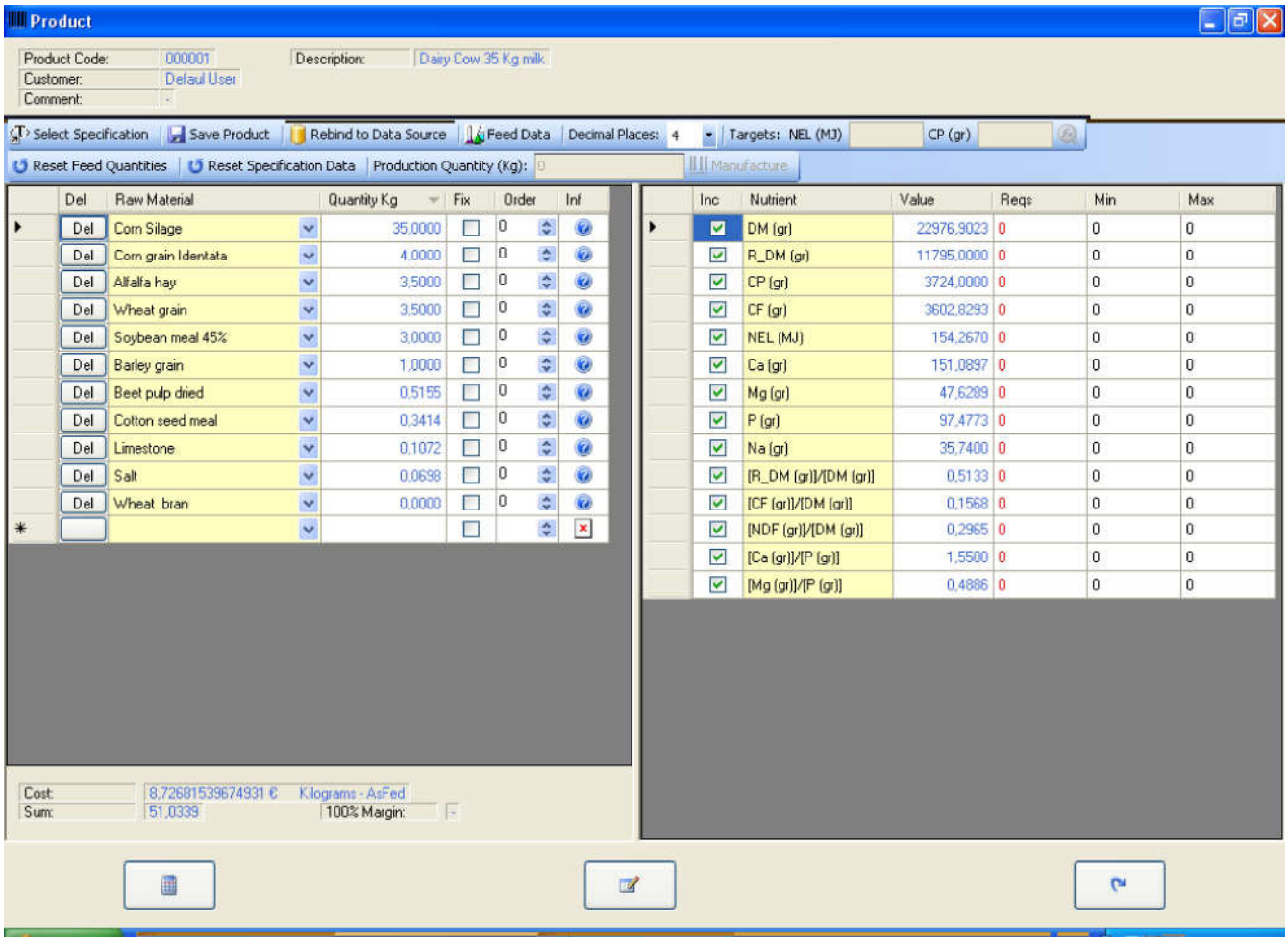


Figure 12. *Product editing window*.

Specifications can be used in order to validate a product. To call a certain specification the user has to click the "*Select Specification*" menu button in the tool bar. If the user doesn't want the selected specification data to appear in reports, he can reset the respective columns by clicking the "*Reset Specification Data*" menu button. The user can also define which nutrients and/or nutrient ratios should appear in reports too. In order to select or unselect a nutrient or a nutrient ratio just check or uncheck the respective check box in the nutrient analysis table.

If the product is an as fed mix then the user can manufacture it. He or she must declare a production quantity (PQ in kilograms) and then press the "*Manufacture*" menu button. This production quantity is stored in the product's file.

4.2 Save a product's composition as a raw material

Often times a ration is formulated only to serve as a raw material in another ration. In this case we treat it as a compound feedstuff. For that feedstuff, however, a new entry has to be made and its nutrient composition has to be entered. This could prove to be an unnecessary waste of time, therefore, in NutriSolver the aforementioned procedure is automated. The only thing the user needs to perform is to select the product which will be saved as a new feed and click "*Save as Raw Material*" in the "*Operations*" menu options.

In the dialog window that will appear we have to declare whether we wish to add it as a new raw material or revise the composition of an existing raw material. In the first case we have to give a new code and a new name. In the second case we must choose from a drop down list the raw material whose composition we want to revise. Dummy - nutrient composition can also be updated.

4.3 Changing a product's type

In NutriSolver rations can either be dry or as fed. This means that raw material quantities are either dry matter quantities or as fed quantities. In any case it would be a mistake to simply change the declaration of a product's type in the table of products, by switching the selected option in the type's column drop down list. This won't result in the equivalent ration of the opposite type. In order to achieve that we must select the product and then click "*Type Conversion*" in the "*Operations*" menu option.

4.4 Make mix - premix

There are times that we need to select a subset of a ration's raw materials and transform them into a mix or a premix. In NutriSolver this can be done by selecting the desired product and clicking "*Make Mix - PreMix*" in the "*Operations*" menu option.

In the dialog window that will appear we need to declare those raw materials that will be included in the mix, give a new code and a description for the product and click the "*OK*" button. If the kind of the initial product is "Kg", the total quantity of the newly generated mix-product that must be included in the feeding scheme, will show up in the "*Consumption Quantity*" column.

4.5 Other operations

As in formulas also in products we can duplicate their composition (copy) and we can edit their raw materials' prices, available stocks and nutrient content.

5. Specifications

Specifications are nothing more than predefined nutrient constraints. Their editing form is simpler than that of formulas because we don't need to declare any raw materials (figure 13). Yet a requirements column is included for both nutrients and nutrient ratios, because sometimes requirements and minimums do not coincide.

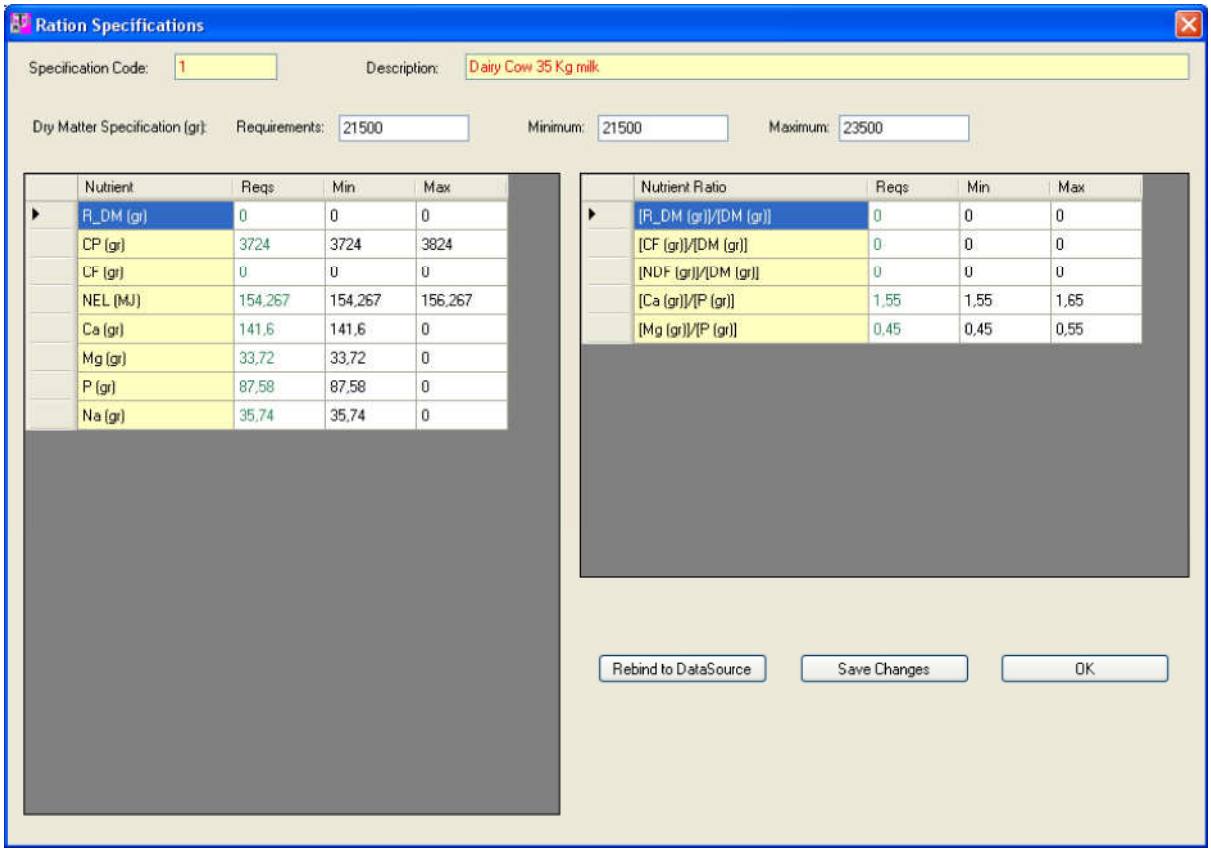
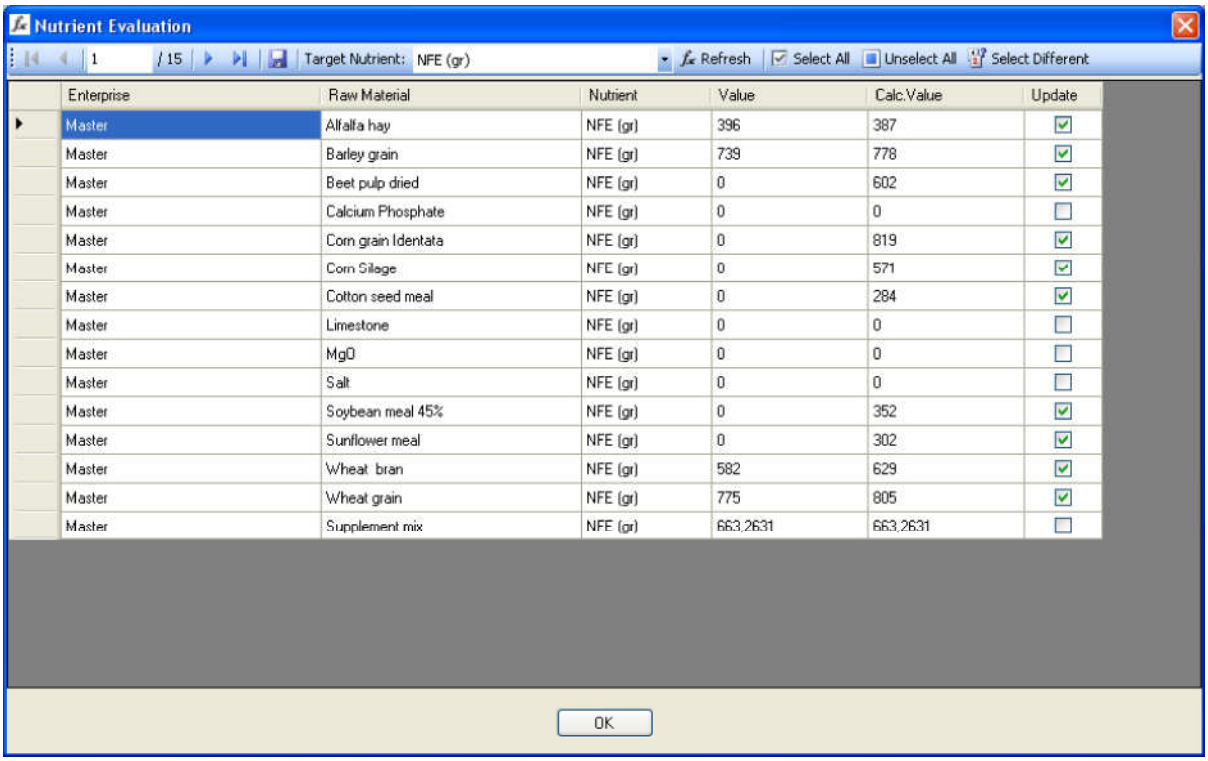


Figure 13. *Specification editing window*.

6. Nutrient Evaluation

The calculation results of equations are presented in the nutrient evaluation form (figure 14). In order for this window to appear the user has to select "*MAIN*" > "*Operations*" > "*Nutrient Evaluation*". The calculation results and the stored values of nutrient composition are presented side by side.



Enterprise	Raw Material	Nutrient	Value	Calc.Value	Update
Master	Alfalfa hay	NFE (gr)	396	387	☑
Master	Barley grain	NFE (gr)	739	778	☑
Master	Beet pulp dried	NFE (gr)	0	602	☑
Master	Calcium Phosphate	NFE (gr)	0	0	☐
Master	Corn grain Identata	NFE (gr)	0	819	☑
Master	Corn Silage	NFE (gr)	0	571	☑
Master	Cotton seed meal	NFE (gr)	0	284	☑
Master	Limestone	NFE (gr)	0	0	☐
Master	MgO	NFE (gr)	0	0	☐
Master	Salt	NFE (gr)	0	0	☐
Master	Soybean meal 45%	NFE (gr)	0	352	☑
Master	Sunflower meal	NFE (gr)	0	302	☑
Master	Wheat bran	NFE (gr)	582	629	☑
Master	Wheat grain	NFE (gr)	775	805	☑
Master	Supplement mix	NFE (gr)	663.2631	663.2631	☐

Figure 14. *Nutrient evaluation window*.

The user selects the target nutrient from a drop down list in the tool bar. If the calculated value is different than the one already stored in the database, the feedstuff is selected for update. Target nutrient values are updated by clicking the save icon in the tool bar. The user can select all feeds, unselect all feeds or select only those in which the two values are different. Recalculation is performed with the "*Refresh*" menu button.

7. Unit modification

Equations are ideal to update nutrient values. They are also ideal to generate data. For instance, with equations it is trivial to define a TDN nutrient (total digestible nutrients) and use this energy level to generate NEL values (net energy of lactation). We can also generate nutrient value data expressed in different measurement units. Provided that in our database NEL is expressed in Mcal, we can define a new NEL nutrient expressed in MJ and generate the appropriate values using the equation's module. This will work fine if we want two distinct NEL nutrients in our database. Somehow it won't work if we want to revise the measurement unit of a nutrient without defining a new one.

In that last scenario it's not just the raw material's nutrient values that need to be updated. Nutrient and nutrient ratio constraint bounds in formulas and specifications must be updated as well. This is where the unit modification option comes in handy. The unit modification window appears when we select "*MAIN*" > "*Operations*" > "*Unit Modification*". In this form we have to select the original nutrient, enter the unit conversion coefficient and provide a revised description for the nutrient. We can also define the accuracy of the calculation result. After all these steps we click the "*OK*" button and the changes will affect all files where the original nutrient was used and not just the the raw materials nutrient composition file.

8. Lists

NutriSolver generates list reports for formulas, products, specifications, customers and raw materials. Customer reports include all available enterprise information that the user enters in the customer definition form. In order to locate a customer in the list the user can use the tree guide on the right of the report. By clicking on the name of an enterprise the report scrolls to its location.

9. Raw material composition

Raw material composition report is generated in a form of a matrix. First, the user has to specify which information will be included into the report. This is done by selecting "*Reports*" > "*Raw material composition*" menu option. Right after that the parameter selection form appears (figure 15).

The user has to specify the kind of the nutrients, the digital accuracy, the source of the data (Master File or a producer), the basis of nutrient composition (as fed or dry matter) and the raw materials and the nutrients (or dummy nutrients) that will be included in the report. By pressing "*OK*" the report is generated.

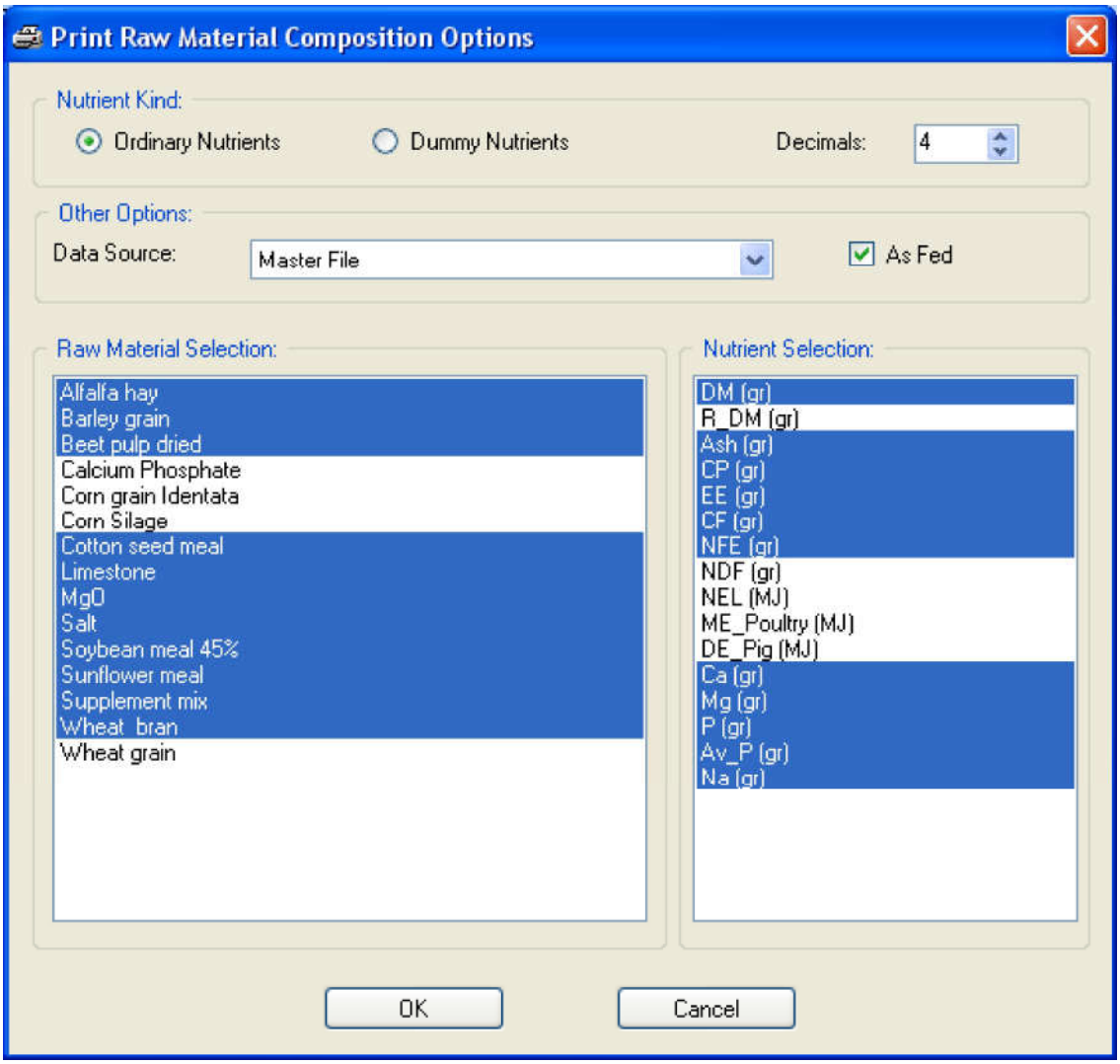


Figure 15. *Parameter selection for raw material nutrient composition report generation.*

10. Ration reports

These reports include ration description and analysis for formulas and products.

11.1 Currency

In the currency file ("*Parameters*" > "*Currency*") the user can specify as many national currency units as he or she wishes, but only one can be selected at a time.

11.2 Customer data

Customer information fields are customizable by the user. The relative form appears from the menu "*Parameters*" > "*Customer Data*".

11.3 Language settings

At the moment only two languages are supported; English and Greek.

11.4 Other settings

Other settings' form appears when the user selects the menu option "*Parameters*" > "*Other Options*". The description of those settings is as follows:

- Auto suggest alternative ration: When selected, the constraint relaxation procedure is activated automatically if the initial linear programming problem is infeasible. Otherwise, the linear programming algorithm exits with no suggestion.
- Enable scaling: Option that affects the linear programming algorithm. The user should not change the default value.
- Eps: Option that affects the linear programming algorithm. The user should not change the default value.
- Maximum LP problem iterations: Option that affects the linear programming algorithm. The user should not change the default value.
- Maximum alternative LP problems: The default value is 200. If no alternative ration can be proposed within that limit it is because either the relaxation procedure failed (error message) or because excessive nutrient allowances have to be implemented to produce an alternative. In that case, the proposed ration would be useless.
- User Information: The information that will appear in the reports in the user field.
- Equation result round digits: The result of an equation calculation will be rounded to the number of digits set in this field.

12.1 Raw material composition data

In NutriSolver the user can import raw material composition data from a text file. These can be either nutrient or dummy nutrient composition data. The import form appears when we select "*MAIN*" > "*Operations*" > "*Import*" > "*Feed Data (*.txt)*" and it is shown in figure 16.

For successful imports the user has to specify the delimiting character (default value ';') and the decimal symbol ('.' or ','). Next we click the "*Import Data...*" button and in the dialog form we declare the kind of nutrients (regular or dummy). Then we select the source data file and click "*Open*". If the operation is successful the raw material composition will show up in the corresponding table (nutrient or dummy nutrient composition).

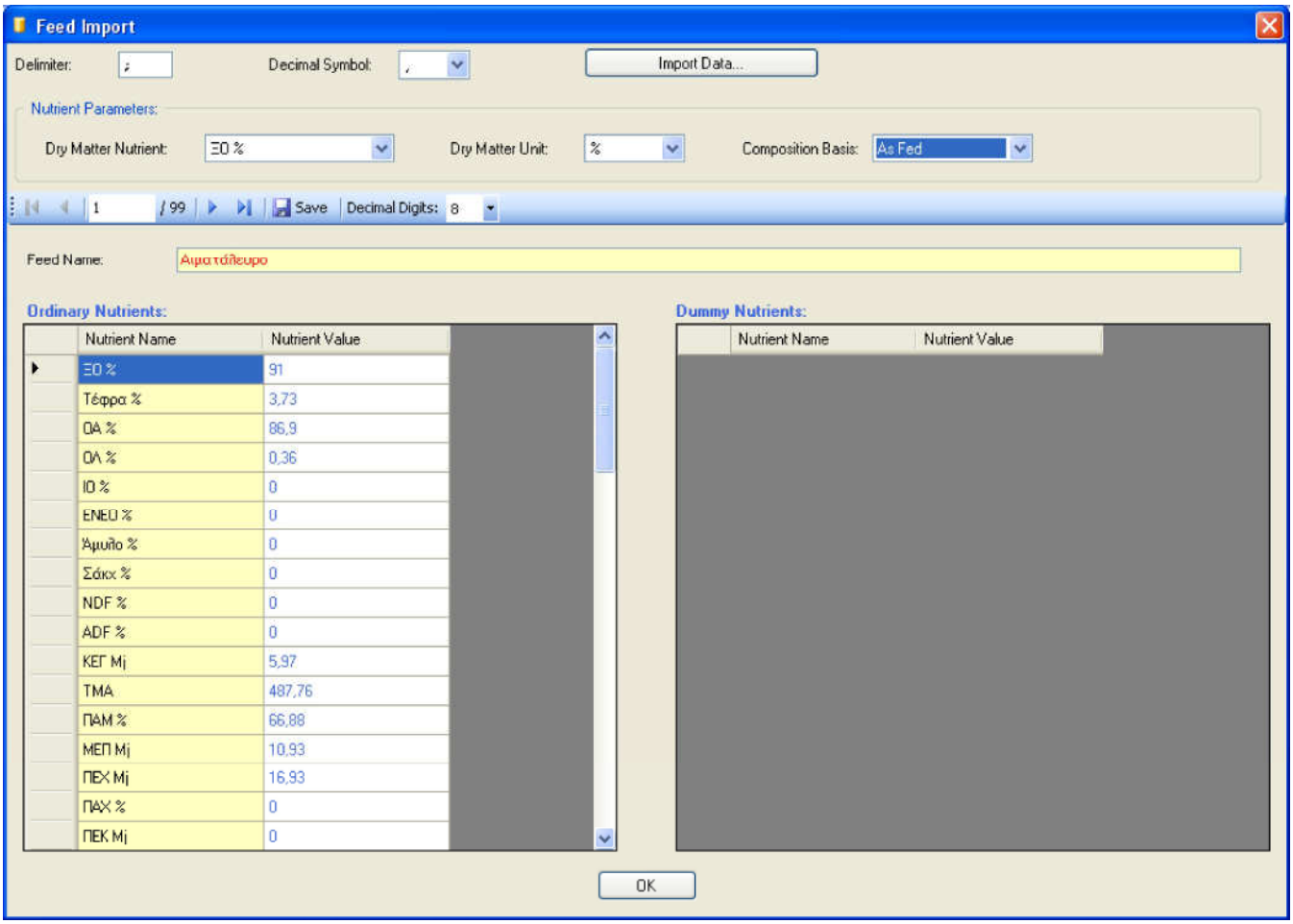


Figure 16. *Raw material composition data import.*

The data source file format must have the following structure (if the delimiting character is equal to ';'):

Feed name;Nutrient$_1$;Nutrient$_2$;...;Nutrient$_n$

Feed(1);a_{11};a_{12};...;a_{1n}

Feed(2);a_{21};a_{22};...;a_{2n}

:

:

Feed(m);a_{m1};a_{m2};...;a_{mn}

In the case of regular nutrients we have to specify the dry matter nutrient, the dry matter unit (Kg, gr, %) and the composition basis (As Fed or Dry Matter). This way the application will have all the required information to complete the import operation and we can save the data to the database. In the case of dummy nutrients those parameters don't need to be specified. However, before saving, we can examine the validity of the imported composition data by navigating through the imported raw material records. If the composition basis is as fed, then it will be transformed to dry matter. The digital accuracy with which the outcome will be saved is set in the "*Decimal Digits*" drop down list.

Now, a few words about the import mechanism. During the saving process the application first examines the nutrient (or dummy nutrient) names. Then it inserts those nutrients that are not already present in the database. The raw materials are examined based on their names too. For those **not** present, a new code is automatically assigned and then they are created in the database. Those already present have their nutrient composition values updated for

the common nutrients.

If we wish to import both nutrient and dummy nutrient composition for the same set of raw materials, we have to create two data source files and repeat the import process twice; once for the regular nutrients and a second time for the dummy nutrients.

12.2 Import data from NUTX Ver. 1.00

NUTX Ver. 1.00 is the predecessor application of NutriSolver. This concerns only Greek users since NUTX was exclusively in Greek. Therefore, more information is given in the Greek version of this manual.

13.1 Back Up

Back up operation is fully automated. We select "*MAIN*" > "*Database*" > "*Back up*" and the "*browse folder*" window appears. Then we select the directory in which our back up will be stored and click "*OK*". If a previous back up file exists in the same folder it will be overwritten.

13.2 Restore

Restore is the reverse operation of back up. In this case, in the browser folder window we select the directory in which an existing back up file resides. When the selection is completed, we click "*OK*" and the back up file becomes our current database file.

Attention!! Back up and restore should not be performed through simple file copy - paste operations. SQL Server© and SQL Server Express© are **service** based and **not** file based database systems (like MS Access©). If for any reason the user decides to move the database files to another machine or another SQL Server© instance, with different credentials, this operation should be performed by a technician.

13.3 Maintenance

Although back up and restore are maintenance operations, in this case the "*Maintenance*" option includes procedures that are not meant to be invoked by the ordinary user. Those procedures are diagnostics (not that dangerous) and connection string setting (very dangerous!!).

Diagnostic procedures include integrity check and defragmentation. If an integrity check reports problems, possible causes are database file corruption, disk failure, malware infection etc. To identify the exact reason most of the times the user should consult with a technician. But whatever the cause may be, perhaps the only way to restore the damage is through the most recent back up. Therefore, you should back up as often as possible.

Defragmentation results in file size reduction and data access optimization regarding read and write operations. However, these improvements will be observable if the database's size is quite large.

Finally, the connection string is a database attribute that must never be altered by the user, unless the physical location of the database's files has to change or the database will be attached to a different SQL Server© instance. In such a case the user should always test if connectivity with the database is possible before saving the new connection string. Initially, the default connection string that is set during the application's installation is not encrypted. With every subsequent change, the new connection string value is encrypted.

Note: NutriSolver application is designed to run locally by one user, in SQL Server Express© with no credentials. However, no one can stop users from running the application in a network. In this case, database maintenance (including back up and restore operations) should be performed by the technician supervising the network, SQL Server© installation and user credentials. Moreover, since it is a single user application, no user accounts are supported. This means that in a multiuser environment anybody will be able to see and modify every one else's work (raw material composition and prices, customers, formulas, products, specifications etc.). This kind of mess is definitely not a desirable situation. In addition, when some of the work has to be carried out off line (users running NutriSolver in a laptop computer, locally), there is no application option (other than back up and restore) to synchronize data between the local database and the network database. All those matters should concern potential network users prior to network installation.