Pricing Feed Ingredients on the Basis of their Nutritional Value

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▪ Take Home Message

In many instances, nutritionists, feed manufacturers, dairy producers and their advisor need an estimate of what a feed is worth on a nutritional basis to facilitate the formulation of balanced diets and the purchase of appropriate and price competitive feedstuffs. Up until now, all methods used shared common flaws. We derived a maximum likelihood method that uses composition and prices of all feedstuffs traded in a given market to estimate unit costs of nutrients and break-even prices of feedstuffs. The method was programmed as a Windows 95-98 application named ***SESAME.***

▪ Introduction

A variety of methods have been proposed to estimate unit costs of nutrients and, implicitly or explicitly, the break-even price of feedstuffs. All methods fall into one of two general categories: equation-based (**EBM**) and inequation-based methods (**IBM**). For EBM, a set of equations developed from the nutritional composition of referee feeds is solved using their market prices. The best known method among this group is the Petersen Method (**PM**) in which the energy and protein compositions of corn grain and soybean meal are equated to their respective prices, setting a set of two equations with two unknowns. The method dates back to 1932 (Petersen, 1932) and is presented and discussed at length by Morrison (1956). Although widely used, the method is fundamentally flawed in that it assumes efficient markets in commodity trading and implies economically incoherent behavioral patterns by buyers and sellers of commodities.

The second series of methods, IBM, are basically constrained optimization models solved using mathematical programming techniques (Beneke and Winterboer, 1973; Cornell-Penn-Miner Dairy). Linear programming (**LP**) is the best known member of this group and became widely used in animal nutrition with the discovery of an efficient algorithm (Dantzig, 1960) and the advent of high-speed computers. Within an LP model, a cost function is minimized subject to a series of inequations forcing the solution to meet the nutritional requirements of the animal for which the diet is being optimized. Linear programs suffer from being case specific, and they deliver little information on the unit costs of nutrients. Nutrients with non-binding constraints have an implicit unit cost of zero. Shadow costs of binding nutrients provide information on unit costs that are valid only at the margin. Additionally, the information delivered has a very narrow inference range because it provides estimates that are sound only for one group of animals in a given herd. Consequently, LP is limited in providing estimates of aggregate unit costs of nutrients within a given market. To circumvent these problems, we developed a new procedure that provides estimates of aggregate unit costs of nutrients and break-even prices of feedstuffs based on the trading of all feed commodities in a given market (St-Pierre and Glamocic, 2000).

The method is based on maximum likelihood estimation of nutrient costs. The objective of the paper is to describe briefly the computer software that we wrote to make our procedure available to the industry.

▪ Assumptions

The method sets a series of m equations (m is the number of feedstuffs) with n unknowns (n is the number of nutrients). An error term Σ is added to each equation. Maximum likelihood estimates of unit costs of nutrients are those that minimize the sum of squares of Σs. Maximum likelihood properties are obtained under the following assumptions:

- Buyers and sellers of commodities act rationally, that is, a buyer would not keep buying an overpriced commodity and a seller would not keep selling commodities at discount prices.
- The value of a feedstuff is equal to the sum of the values of its nutrients. Feedstuffs are used exclusively as sources of nutrients. Feedstuffs with valuable characteristics other than nutrient content (e.g., free-flow agents) are not evaluated properly by our method.
- The errors Σ are independently and manually distributed. In our software, we insure that this assumption is met by eliminating any outlier feedstuffs.

▪ SESAME™ Release 1.1

SESAME is a Windows 95-98 based program. Figure 1 shows the opening screen with the main menu items.

Figure 1. Opening screen showing the main menu options.

Feedstuffs is used for viewing and editing the nutritional composition of feedstuffs.

The **Solver** section is used to select feedstuffs nutrients and prices, and to get estimates of nutrients costs and break-even prices of feedstuffs.

In **Price list**, the user can set different price series to reflect, for example, regional differences.

Backup is used to produce a backup copy of the database, or to recover a previously saved copy.

DB Check verifies the integrity of databases and makes necessary repairs when needed.

Configuration provides access to the underlying structure of the nutrient definition table.

Help opens a context sensitive help system.

About prints a disclaimer and provides information on how to contact the authors.

Nutrient Composition: The Feedstuffs Menu

By default, *SESAME* contains three protected feedstuffs databases and two unprotected user libraries. Protected databases are: commercial feedstuffs, CPM library, and NRC (1989) library (Figure 2). Feedstuffs in those protected libraries can be used in setting up problems, but they cannot be edited. The user can customize the nutritional composition of a feedstuffs by first copying it to a user library. The copied feed can be edited once it resides in a user library (Figure 3).

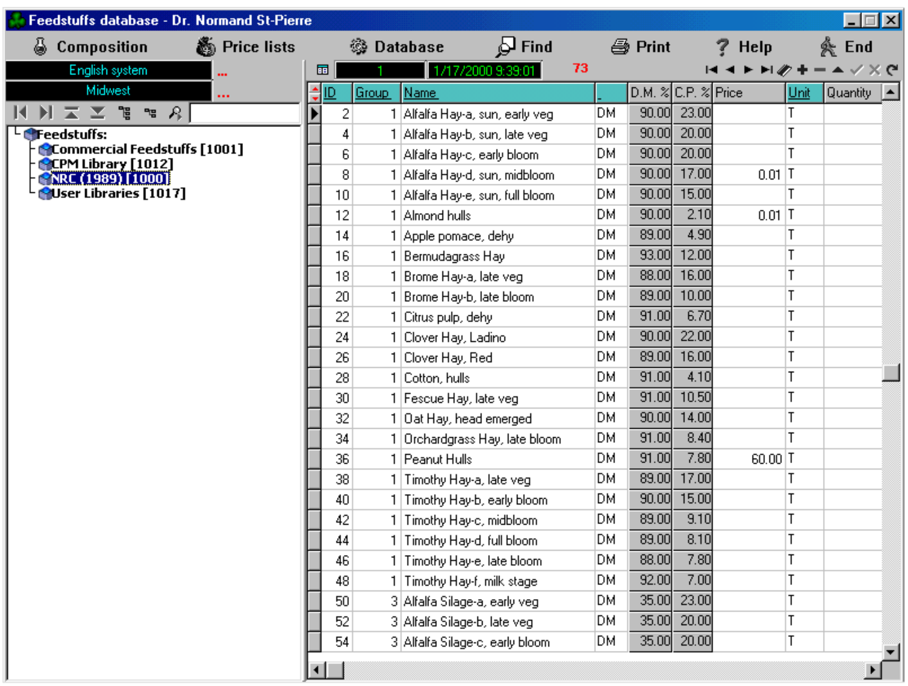

Figure 2. Feedstuffs section showing the three protected libraries [Commerical Feedstuffs, Cornell-Penn-Minor (CPM) Dairy (1998) Library, and NRC (1989)] and the unprotected (User) library. Menu items appear at the top.

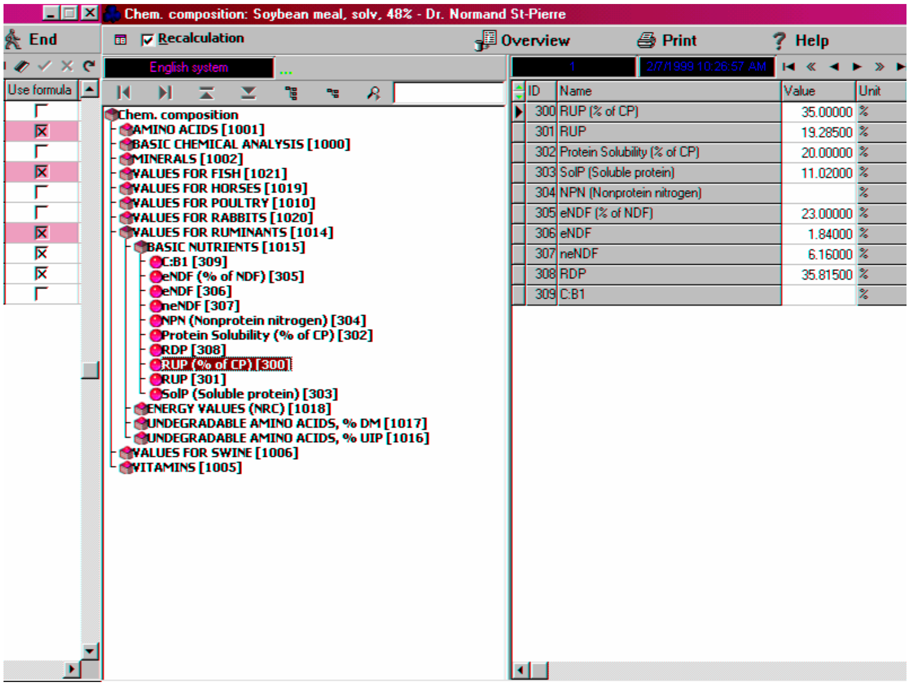

Figure 3. Chemical composition section showing the grouping of nutrients. Values in the right-hand side window are the defaults for soybean meal, solvent extracted, 48% CP.

Nutrient Definition: The Configuration Menu

Over 140 nutrients are defined in *SESAME* to cover applications in a multitude of species (Figure 4). Nutrients can be defined as direct entries (e.g. crude protein), or as calculated nutrients (e.g. NFC). Calculated nutrients are defined using equations inserted in the **Formula** section of the program.

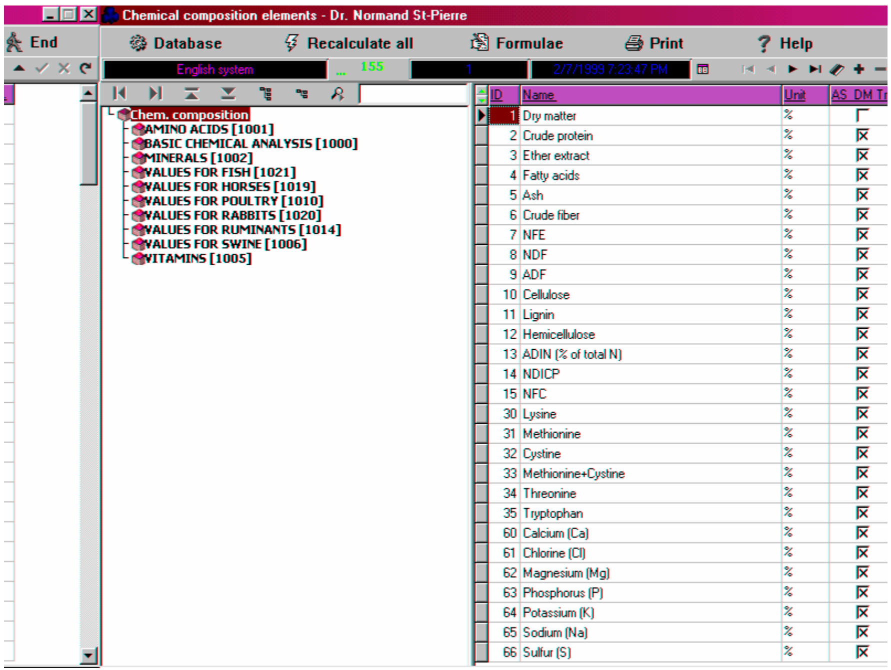

Figure 4. Chemical composition elements section showing a partial list of the more than 140 default nutrients part of the standard *SESAME*. Additional nutrients can be added using the **Formulae** section.

Market Prices of Feedstuffs: The Price List Menu

Various price lists can be set to reflect different prices across space (markets)or time (Figure 5). Feedstuffs can be added to a price list using a convenient drag-and-drop feature. There are no limits to the number of price lists.

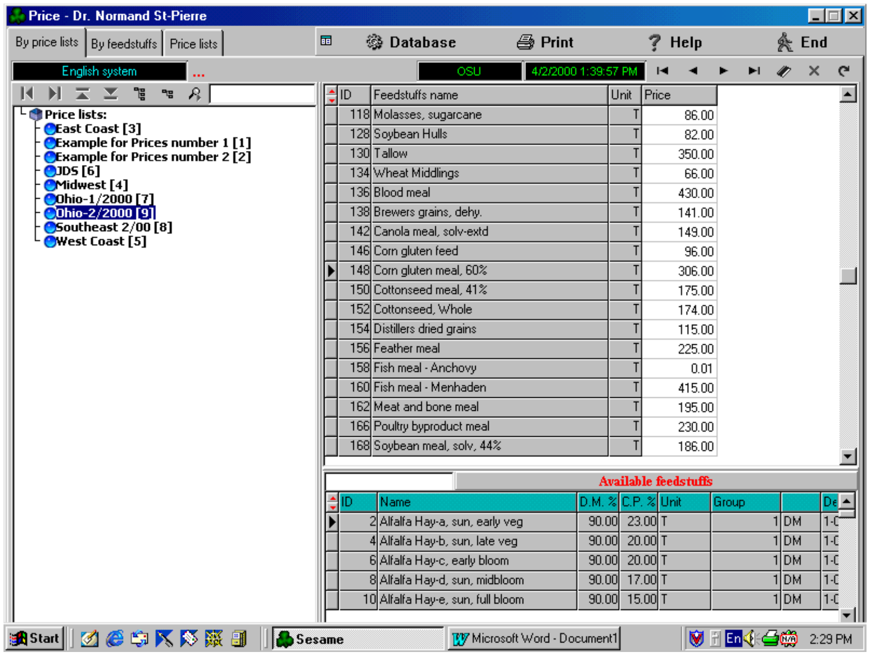

Figure 5. **Price lists** section showing the different price lists created and feedstuffs prices for the Ohio-2/2000 price list.

Setting up a Problem and Finding Break-Even Prices: The Solver Menu

The core engine resides within the **Solver** section of the program (Figure 6). To create a problem, the user must indicate what feedstuffs, nutrients and prices are part of a problem. The calibration set (Figure 6) contains all feedstuffs traded in a given market. Feedstuffs are added or deleted from this set through a simple drag-and-drop function. Alternatively, the user can identify in the appraisal set those feedstuffs for which he has no current price but for which estimated break-even prices are desired.

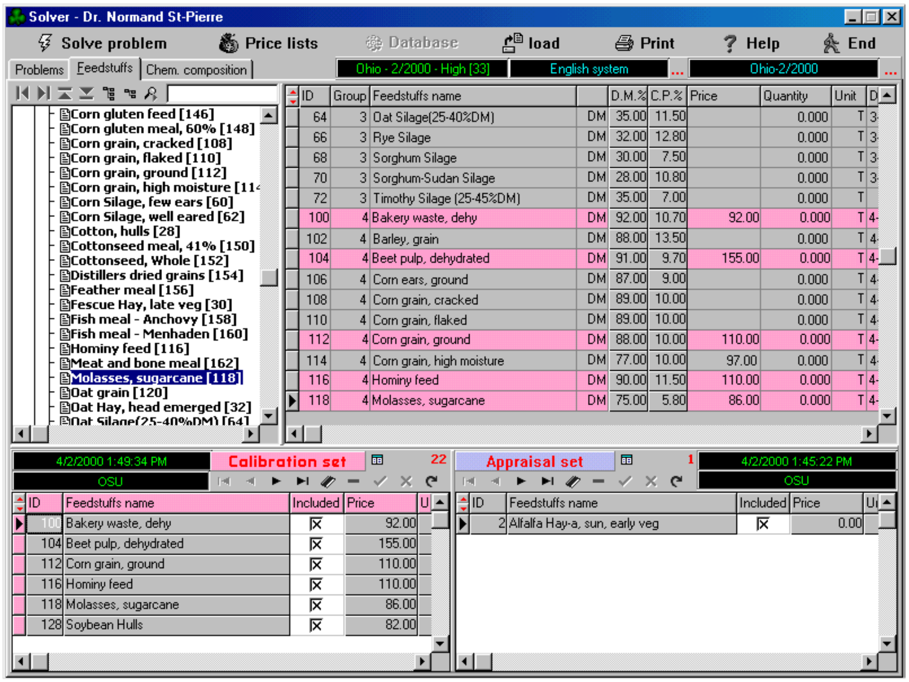

Figure 6. Solver section showing available feedstuffs, **Calibration** set of feedstuffs, and **Appraisal** set of feedstuffs. Tabs and buttons allow the user to select feedstuffs, nutrients, and prices part of a problem. A solution is found by pressing the “Solve problem” button.

The **chemical composition** tab allows the selection of nutrients where values are to be estimated. Active prices of feedstuffs are selected using the price list button.

▪ An Example

We used December 2000 Western Plain prices and standard nutritional composition of 22 feedstuffs to estimate their break-even prices when used with high producing dairy cows (Table 1), F.O.B. Minneapolis plus $30 U.S. per ton for handling and transportation. We selected the following nutrients for our evaluation: rumen undegradable protein (**RUP**), effective NDF (**eNDF**), non-effective NDF (**neNDF**), rumen degradable protein (**RDP**), rumen undegradable Methionine (**U-Met)**, rumen undegradable Lysine (**U-Lys**), and Net Energy

Table 1. Nutrient composition and market prices of 22 feedstuffs, Ohio, February 14, 2000. Composition values are on an as-fed basis.[1,2]

	RUP (%)	eNDF (%)	neNDF (%)	RDP (%)	U-Methionine (%)	U-Lysine (%)	NE_L (Mcal/kg)	Price (US$/MT)
Bakery waste, dehyrated	2.412	0.002	16.558	7.432	0.043	0.076	1.896	109.00
Barley grain	3.929	5.685	11.035	7.951	0.032	0.121	1.705	115.00
Beet pulp, dehydrated	5.064	16.216	32.924	3.763	0.033	0.152	1.630	142.00
Corn grain, ground	4.869	0.000	7.920	3.931	0.055	0.080	1.727	101.00
Hominy feed	5.435	4.455	45.045	4.915	0.060	0.174	1.810	137.00
Molasses, sugarcane	0.000	0.000	0.000	4.350	0.000	0.000	1.233	120 .00
Soybean hulls	4.625	1.219	59.751	6.386	0.022	0.210	1.608	102.00
Tallow	0.000	0.000	0.000	0.000	0.000	0.000	5.842	283.00
Wheat middlings	3.742	0.659	32.271	12.634	0.038	0.141	1.616	98.00
Blood meal	66.387	0.000	0.828	14.573	0.710	6.201	1.377	493.00
Brewers grains, dehydrated	15.395	7.618	34.702	7.973	0.194	0.331	1.377	132.00
Canola meal, solv-extd	11.878	5.693	19.059	25.068	0.166	0.792	1.429	170.00
Corn gluten feed	5.760	14.580	25.920	17.280	0.097	0.086	1.722	140.00
Corn gluten meal, 60% CP	35.683	4.536	8.064	24.797	0.746	0.442	1.854	372.00
Cottonseed meal, 41% CP	17.843	8.518	15.142	23.653	0.112	0.687	1.585	245.00
Cottonseed, whole	6.441	40.480	0.000	14.719	0.041	0.248	2.053	240.00
Distillers dried grains	12.650	1.619	38.861	10.350	0.152	0.261	1.873	124.00
Feather meal	56.036	0.429	1.437	24.015	0.275	1.440	1.488	344.00
Fish meal, menhaden	36.818	0.184	1.656	24.546	1.046	2.625	1.535	550.00
Meat and bone meal	24.653	0.000	3.720	25.660	0.330	1.247	1.506	278.00
Soybean meal, solv, 44% CP	15.544	3.050	10.211	28.867	0.157	0.833	1.725	223.00
Soybean meal, solv, 48% CP	17.357	1.656	5.544	32.234	0.144	1.055	1.810	231.00
Linseed meal	12.478	4.500	18.000	21.992	0.243	0.538	1.458	168.00
Sunflower meal	7.338	3.240	32.760	15.972	0.158	0.315	1.171	126.00

[1]*SESAME*: Chemical composition expressed on an as fed basis.
[2]RUP = Rumen undegradable protein, eNDF = effective NDF, neNDF = non-effective NDF, RDP = rumen degradable protein, U-Methionine = rumen undegradable methionine, U-Lysine = rumen undegradable lysine, and NE_L = net energy for lactation.

Lactation (**NE_L**). Nutritional composition values were those reported in Table 1. Prices used were those reported by Feedstuffs magazine for the week of December 18, 2000 for the Minneapolis market with an additional $30 U.S. /ton added to cover handling, margins and transportation charges. In a few instances, Chicago prices had to be used for which a $40/ton gross margin was added. All prices are expressed in U.S. dollars per metric ton.

Results as reported by *SESAME* are shown in Figure 7. The numbers in the column labeled "Estimate" in the Estimate of Nutrient Unit Costs table are the calculated values per unit (per kg for all nutrients except NE_l which is per Mcal) of nutrient. Thus, a kg of RUP has an estimated worth of $0.317. This estimate would appear low except that it represents the value of one kg of RUP which is free of both Methionine and Lysine because the value of those nutrients are already factored in the evaluation. In fact, markets are valuing U-Methionine at $13.58/kg and U-Lysine at $1.58/kg. Effective NDF is valued at $0.21/kg whereas neNDF is valued at -$0.05/kg, indicating that the markets are currently discounting feedstuffs for their neNDF content. Markets are valuing RDP at $0.17/kg and NE_l at $0.048/Mcal).

The break-even prices of feedstuffs (Predicted value) are reported in the two tables labeled "Calibration Set" and "Appraisal Set". Additionally, the Calibration set contains the lower and upper 75% confidence limits of break-even prices. Using these results, a user would determine that under present western plains conditions, cottonseed meal is relatively over-priced whereas canola meal is relatively under-priced. Results are also shown graphically (Figure 7). In this figure, feedstuffs appearing above the middle horizontal line are relatively well-priced whereas those appearing under the line are relatively over-priced.

During the solution process, *SESAME* concluded that fishmeal is currently so over-priced that it appears to be an outlier. Automatically, *SESAME* moved this feedstuffs from the Calibration set to the Appraisal set (Figure 8).

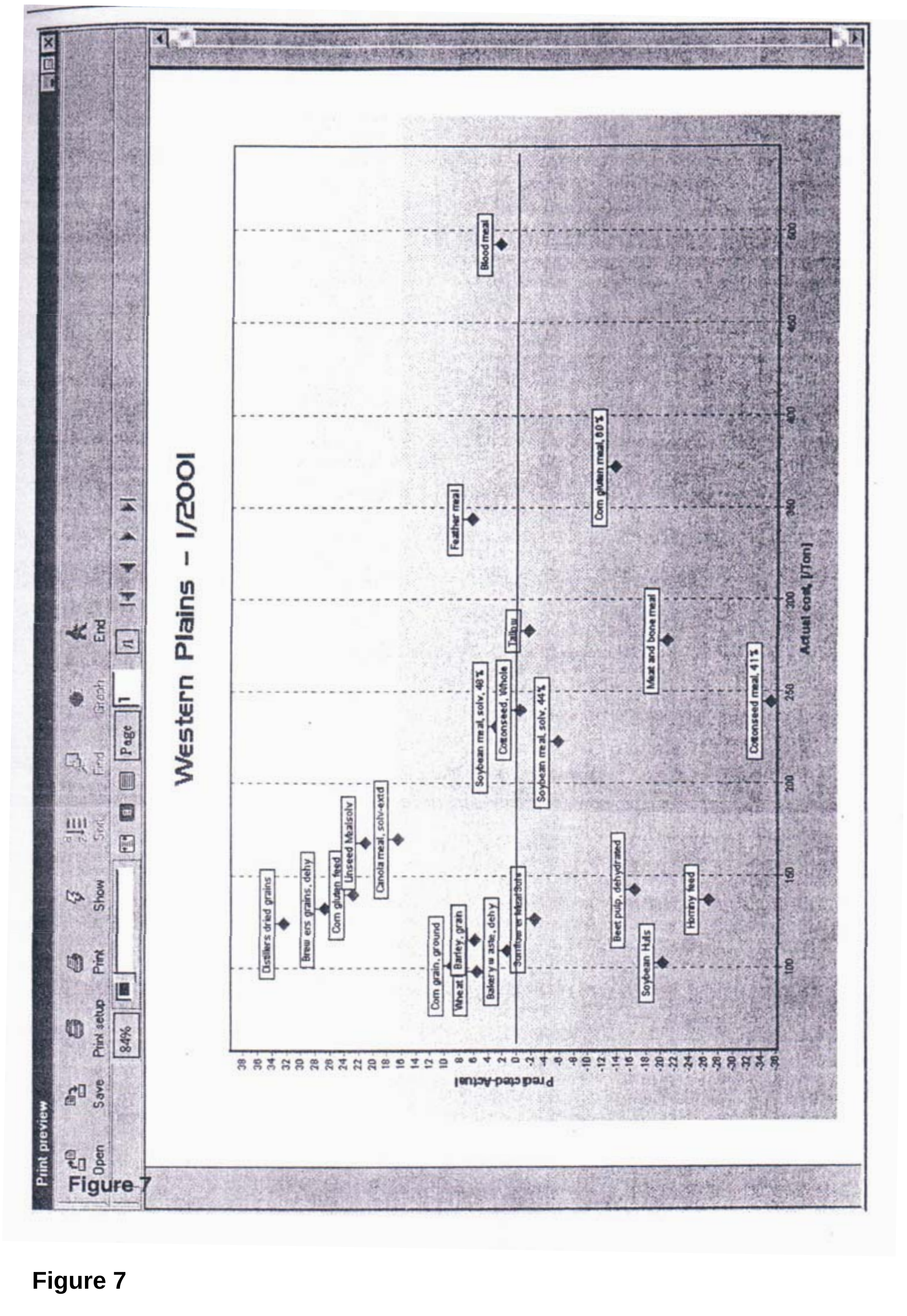
Print preview
Figure 7
Western Plains - 1/2001
Predicted-Actual
Actual cost, [/Ton]
Distillers dried grains
Brewers grains, dehy
Corn gluten feed
Linseed Meal solv
Canola meal, solv-extd
Corn grain, ground
Wheat
Barley, grain
Bakery waste, dehy
Soybean meal, solv, 48%
Cottonseed, Whole
Soybean meal, solv, 44%
Tallow
Feather meal
Blood meal
Corn gluten meal, 60%
Meat and bone meal
Cottonseed meal, 41%
Beet pulp, dehydrated
Soybean Hulls
Hominy feed

Figure 7

Western Plains - 1/2001

1/2/01 1:53:06 PM

Price Prediction Reliability	20.879

Estimate of Nutrient Unit Costs

Nutrient name	Estimate	
RUP	0.317210	**
eNDF	0.211973	**
neNDF	-0.050538	*
RDP	0.169637	**
U-Methionine	13.577591	**
U-Lysine	1.579244	*
NEI	0.048142	**

- A blank means that the nutrient unit cost is likely equal to zero
- ~ means that the nutrient unit cost may be close to zero
- * means that the nutrient unit cost is unlikely to be equal to zero
- ** means that the nutrient unit cost is most likely not equal to zero

Calibration set

Name	Actual [/T]	Predicted [/T]	Lower limit	Upper limit
Bakery waste, dehy	109.000	110.158	103.936	116.380
Barley, grain	115.000	120.753	115.777	125.728
Beet pulp, dehydrated	142.000	125.513	114.411	136.614
Corn grain, ground	101.000	109.925	104.221	115.629
Hominy feed	137.000	110.347	99.726	120.969
Soybean Hulls	102.000	81.547	67.093	96.002
Tallow	283.000	281.257	257.825	304.688
Wheat Middlings	98.000	103.586	95.473	111.699
Blood meal	493.000	495.562	470.749	520.374
Brewers grains, dehy	132.000	158.836	149.030	168.642
Canola meal, solv-extd	170.000	186.531	176.800	196.263
Corn gluten feed	140.000	162.802	154.262	171.342
Corn gluten meal, 60%	372.000	358.318	335.049	381.588
Cottonseed meal, 41%	245.000	209.554	200.650	218.459
Cottonseed, Whole	240.000	239.490	217.144	261.835
Distillers dried grains	124.000	156.379	147.201	165.557
Feather meal	344.000	350.340	326.388	374.292
Meat and bone meal	278.000	256.914	247.333	266.495
Soybean meal, solv, 44%	223.000	217.090	205.817	228.364
Soybean meal, solv, 48%	231.000	233.824	219.859	247.789
Linseed Mealsolv	168.000	189.069	180.579	197.559
Sunflower MealSolv	126.000	123.433	115.016	131.850

Appraisal set

Name	Actual [/T]	Predicted [/T]
Molasses, sugarcane	0.000	66.738
Fish meal - Menhaden	0.000	415.313

Calculation log

Action	Reason

SESAME: Regression results (Dr. Normand St-Pierre)

Figure 8

Conclusion

Our maximum likelihood method uses the prices of all feedstuffs traded in a given market to estimate the implicit costs of nutrients. Because it is a statistically-based method, it provides measures of dispersion of estimated nutrient costs and break-even prices. Also, because it does not use referee feeds (e.g., corn and soybean meal), each feedstuffs used in the estimation can potentially have a break-even price above or below its market price. The method has been programmed into a Windows application available from the author or from Church and Dwight Company who is acting as a distributor.

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