Metabolic Profile Studies in the Bovine Animal

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Editor's Note: This paper was prepared at the request of the Editor and should be of special interest to practitioners engaged in dairy or beef herd health programs. The paper is published in the style presented by the author.

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Undoubtedly one of the most useful weapons which has been added to the bovine practitioners' armoury in the fight against metabolic diseases in the last few years is the metabolic profile study. Based as it is on the detailed analyses of the animal's blood, the technique is not a new one, what is new is our ability to analyse large numbers of bloods in detail, quickly and accurately. These analyses, when processed through a suitably programmed computer, and when compared with norms, can give a detailed and easily readable picture of the nutritional and physiological processes within that animal or group of animals.

Today, the advantages of such analyses are even more worthwhile, due to the trend in all countries for animals to be kept in larger and larger groups. Therefore, what was in the past of clinical significance to perhaps only one or two animals, now becomes not only of clinical significance to a group of animals, but also of very real economic significance to the owner or breeder. The progress towards greater attention being paid in veterinary medicine to details of economics rather than pure disease or health factors, means that the veterinarian with the metabolic profile study at his disposal can advise more accurately on the general husbandry and in particular, plan the nutrition of the animals in question.

In addition, various other facets and rewards are opened up. For instance, recent work shows that certain genetic lines of animals are able to resist conditions of poor nutrition more adequately than certain other genetic types. The fact that some animals can produce more efficiently, and that this characteristic is an inheritable one is of very real significance to every farmer who breeds dairy or beef cattle. This aspect has not been used to any extent, to date, in selective breeding programmes, but undoubtedly it will be one of the factors which the farmer and breeder will refer to in the future.

History

Metabolic profile studies have been used for detailed analyses of bloods to obtain a picture of the animal's nutritional status, in particular, since the mid 1960's. Dr. J. Payne and his co-workers at the Agricultural Research Council Field Station at Compton in Berkshire, England, evolved the technique of programming and listing the details of multiple analyses for a wide variety of blood levels, thereby getting an overall picture of some thirteen or so factors in the blood of cattle in any one herd. Initially, analyses were done on every animal in the herd, and this was useful for obtaining a large number of animals' blood pictures, useful for statistical analyses, and in establishing norms. When applied commercially in the field this was of course a factor which detracted from the viability of the check test in the terms of cost benefit to the farmer. It could have well been that unless the present technique of taking groups of representative animals within herds was followed, the "whole-herd" technique of sampling might well have placed this valuable tool merely in the realms of research as opposed to being of value to the veterinarian in practice.

It was decided however, in an endeavour to make this system of analyses more worthwhile to each and every farmer, to sample from statistically significant groups within the herd. Initially, seven animals were sampled in each group. The grouping might well vary, but in the average dairy herd where problems were being investigated the routine is generally as follows with 21 cattle: (1) Seven samples from end of lactation "dry" cows; (2) Seven animals which have reached their peak lactation after calving; and (3) Seven animals which have been calved for some time, e.g., four months after calving, and giving average yields.

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It is also apparent that this method of assessing the nutritional status of cattle can be applied to any group where problems are being investigated. For instance, a heifer breeding problem or a high incidence of ketosis in dairy cows can be usefully investigated thereby confirming that clinical suspicions are correct or incorrect, and deficiencies or excesses regulated.

Technique

The samples are collected both in clotted and unclotted forms (in oxalate/fluoride water) aseptically from the jugular vein. These are then examined in the laboratory as soon as possible. Undoubtedly the time lapse between the collection of the blood and its analysis is important, as a degradation of many of the factors being investigated can occur if the time interval between collection and investigations is a long one. **It is preferable that the analyses are done on the same day and within a few hours of collection.** It is possible also, however, that providing the time lag is long between collection and analyses, to compute the degradation processes involved, thereby assessing the actual levels at time of collection. This, however, is obviously not as accurate as obtaining a short collection/examination time interval, and this should be aimed for on all occasions.

The auto analyser is then used to carry out the detailed examinations which are required and these will naturally vary according to circumstances. However, in the United Kingdom it has become a standard routine to carry out up to 13 or so examinations as a standard pattern which would include the following:

Blood Analyses:

1. Packed cell volume was carried out using a Hawksley micro-haematocrit centrifuge.
2. Blood haemoglobin is estimated as oxy-haemoglobin on an AutoAnalyzer (Technicon Instruments Co., Ltd.).
3. Blood-glucose, using the AutoAnalyzer method N-9a which involves dialysis to remove cells followed by a ferricyanide reduction method.
4. Serum urea, using the AutoAnalyzer method N-1c which is a colorimetric procedure involving the carbamidoliacetyl reaction.
5. Serum inorganic phosphate, using the AutoAnalyzer method N-4, which involves acid molybdate reduction.
6. Serum calcium, using the AutoAnalyzer method N-3a which is a colorimetric procedure using cresol-phthalein complexone.
7. Serum magnesium, using an atomic absorption flame spectrophotometer.
8. Serum sodium and potassium are estimated on an AutoAnalyzer flame photometer by method N-20d.
9. Serum total protein, using AutoAnalyzer method N-14c which is based on the biuret reaction.
10. Serum albumin, using AutoAnalyzer method N-15c which is a colorimetric procedure using hydroxy-azobenzoic acid.
11. Serum globulin is estimated as the arithmetical difference between the serum total protein and serum albumin values.

Table 1

Means, Standard Deviations (SD) and Coefficients of Variation (CV) for each Blood Constituent Measured in Three Control Sera

(Each Value is Calculated from the Results of at Least 40 Analyses Completed in a period of 10 weeks)

		1	2	3
Glucose, mg/100 ml				
	Mean	29.0	34.0	82.7
	SD	0.92	1.20	1.38
	CV	3.2	3.5	1.7
Urea N, mg N/100 ml	Mean	6.4	13.7	31.3
	SD	0.32	0.43	1.99
	CV	5.0	3.1	6.0
Inorganic P, mg/100 ml	Mean	2.9	6.2	8.2
	SD	0.08	0.12	0.15
	CV	2.8	1.9	1.8
Ca, mg/100 m	Mean	6.8	9.5	10.0
	SD	0.20	0.28	0.29
	CV	2.9	3.0	2.9
Mg, mg/100 ml	Mean	1.91	2.05	2.69
	SD	0.054	0.055	0.065
	CV	2.7	2.7	2.5
Na, m equiv./l	Mean	124	138	146
	SD	1.0	1.5	1.4
	CV	0.8	1.1	0.9
K, m equiv./l	Mean	4.4	4.8	7.3
	SD	0.07	0.10	0.16
	CV	1.7	2.0	2.3
Protein, g/100 ml				
	Mean	6.8	7.2	7.6
	SD	0.14	0.14	0.09
	CV	2.0	1.9	1.2
Albumin, g/100 ml				
	Mean	3.2	4.0	4.5
	SD	0.10	0.14	0.15
	CV	3.3	3.5	3.3

Reference R. Manston and G. J. Rowlands. Journal of Dairy Research (1973) 40, p. 87.

Another important aspect in setting up an autoanalysing unit is in the careful standardisation of the various tests. In the United Kingdom, laboratories which are carrying out these tests regularly interchange a sample in order that there is no variation in analyses. This is particularly

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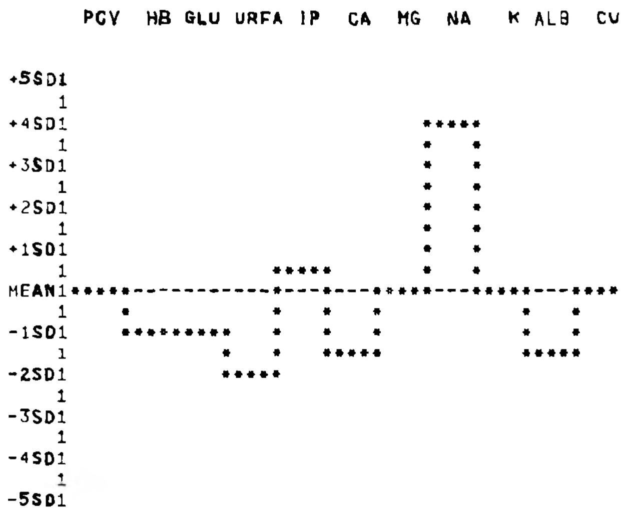
important with some of the metabolites and nutrients being assayed, due to their low concentrations in the bovine plasma, on the technical difficulties inherent in certain assay techniques. Known standard deviations are allowed for in the finalising of the results from herd or group samples.

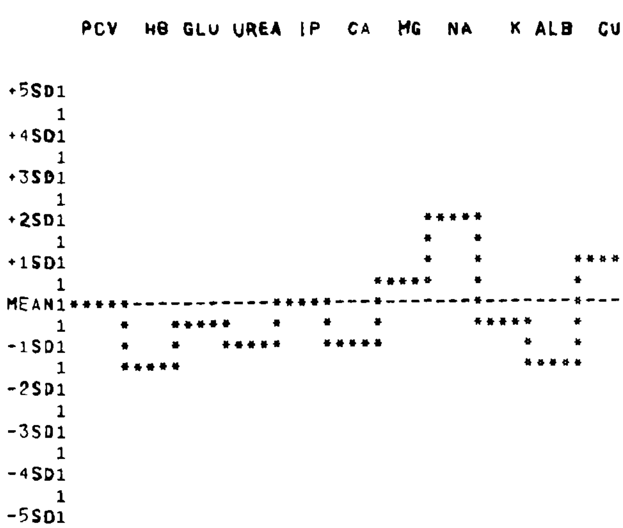
The following diagrams plot the metabolic values for individual cows against their daily milk yields.

The middle dotted line represents the normal standard. The outer two represent the upper and lower 2SD (Approx. 95% confidence limits).

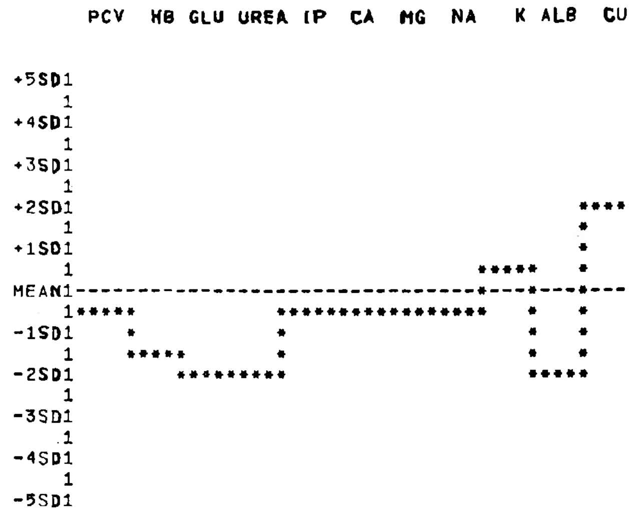
For a normal profile the majority of points should lie within these lines.



GROUP 1



GROUP 2



GROUP 3

These figures, when fed into a suitably programmed computer and printed out, can give the results of the samples from each individual group of animals in the herd not only as individual figures but processed so as to present a histogram which can then be compared with a histogram of the normal levels previously established.

It is therefore obvious that any variation can be readily seen and in due course corrected by adjusting the nutrition of the group or groups of animals whose nutrition is at fault. The advantages of the histogram are obvious when discussing the problem and the alleviation of the problem with the farmer. It is also advantageous to be able to discuss with the farmer or the herd owner the supportive evidence of clinical impressions and findings, expressed in terms of detailed analyses. Today it is very evident in the United Kingdom that with more highly educated farmers and breeders, the ability to put clinical findings and general advice into practice as a result of detailed scientific findings rather than pure clinical impressions is very much easier. Also, when using a metabolic profile study as a series, the advantages are even more apparent: a check test being done after a suitable interval after the correction of the systems of management and feeding have been carried out, in order to ascertain that the recommendations were (a) sound and (b) that they are actually being carried out.

In order that a comprehensive picture is built up of the herd's nutritional pattern, herd group samples should be taken in the early winter period and then again about six weeks after turning to pasture in the spring or early summer—these periods are minimal and can be adjusted to foreign customs and climate.

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These points are particularly important in large groups of animals where the unit manager may not be able to closely regularise the day to day feed mixing and feeding processes and where human error can also creep in. The monitoring of the nutritional status of the animals on different feeds, and at different times of the year, is also of great value. For instance, whilst the feeding programme during the winter months might be adequate, it may well be that the feeding programme during a part of the summer, where much of the diet is obtained from natural pasturage, which is all too open to the vagaries of climate and local conditions, then the metabolic profile will reveal any such deficiencies. When assessing the value of any change in feeding, it is important however to leave at least three to four weeks from the time of the initiation of the new feeding programme until the metabolic profile study is done. This is obviously in order that the animals' blood picture may change consistently and fully before the check test is taken rather than taking the test too early and giving indefinite or confusing results.

Undoubtedly one of the most important aids to the veterinarian in the field has proved to be in the areas of infertility due to nutritional origin and underproduction as a result of impaired nutritional states.

More recently, the application of the metabolic profile study to beef cattle has become apparent and further work is being carried out on this important aspect of the profile studies used in the areas of the feeding of stock intended for beef.

This was particularly apparent when the author visited feedlots in the U.S.A. in **February** 1973—that metabolic profile studies carried out at suitable intervals would obviously have very real financial rewards inasmuch as underfeeding of one or several factors can produce quite marked effects on growth. Where several thousands of animals are involed, then it is vital that every calorie is used efficiently and none are wasted from overfeeding and that no time is wasted in expensive feedlot systems by sub-clinical underfeeding. Whilst it is well known that certain nutrients are required by the bovine animal and vary in fairly precisely defined rates, it is not possible to allow for stress factors such as cold, damp and excessive heat and irregular feeding intervals, changes in diet and human errors. It is not possible to programme all these into the ideal ration. Accordingly, periodic check tests in feedlots and in animals arriving in feedlots would be of very real economic worth. Today, the economics of the feedlot system point towards greatly increased costs of production both from the cost of the feeding stuffs used, but also in terms of labour and overheads. It is readily apparent that the more efficient use that can be made of the available feedstuffs, then the more financially successful will be that unit. No doubt, in time, we will see our laboratories equipped to carry out computerised metabolic profile studies in the feedlot areas, and probably owned by feedlot syndicates. The cost/benefit ratio should be more than advantageous. At the same time it is possible to have the ability to accurately and quickly assess the feeding programmes required and also assess the efficiency of the feeding programmes being actually carried out.

Today, the role of the veterinarian in the cattle industry is one of intelligent anticipation and prevention of problems, as well as the well established one of disease control. Unless he fulfills these roles adequately, then he will not be playing his part in helping the world to produce the much needed protein for the present economy for his fellow human beings who are living at a sub-nutritional level. Nutrition of the bovine animal has for many years been very much a "hit or miss" programme, a game of nutritional Russian roulette based on inaccurate guidelines! Today, with an intelligent use of the metabolic profile tests, the nutrition of groups of animals can be more accurately and more readily assessed as a routine procedure, thereby giving an efficient and accurate guide to the feeding programmes of the future.

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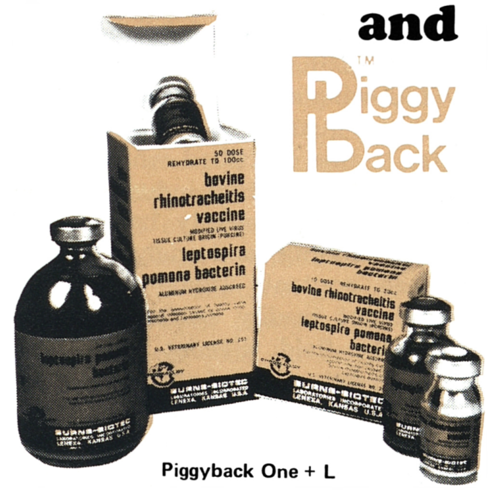

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