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ANIMAL HEALTH LABORATORY

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Nutritional and metabolic profile testing of dairy cows

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Metabolic profile testing (MPT) refers to the use of a battery of tests for the diagnosis of subclinical nutritional and metabolic disease in dairy cows on a herd basis. Typically, blood samples from 5-7 animals per production group are tested for various analytes.

Automated laboratory testing and the ease of taking blood samples have made herd MPT popular. In practice however, there are a number of limitations, such as selection of animals, the type of biochemical tests, the homeostatic mechanisms of cows, and the difficulty in the interpretation of results. Widespread use of metabolic profiles for all farms and all cows is not warranted and will result in poor predictive values. Profiles have more value when used appropriately in the diagnostic process or as part of a specific objective in herd monitoring programs for metabolic disease. Profile testing should not be used in place of other more appropriate procedures, such as ration evaluation and physical examinations.

MPT is most useful in the diagnosis and management of periparturient disease. Specific nutrient imbalances, either deficiency or excess, in the diet of late-gestation cows have been related to increased prevalence of milk fever, hypomagnesemia, retained placentas, downer cow syndrome, mastitis, udder edema, ketosis, hepatic lipidosis, and displaced abomasum (Table 1).

Table 1. Prepartum dietary nutrient imbalances (deficiency or excess) and their associated predisposition to periparturient metabolic and reproductive disorders.

Potential disease process	**Nutrient status**		**Associated disease**
	Deficiency of:	*Excess of:*	
Dystocia	Energy, protein	Energy	MF, FCS
Milk fever	Ca, Mg, protein	Ca, P, Na, K, Vitamin D, energy (?)	DYST, RP, KET, MAST, LDA (?)
Hypomagnesemic tetany	Mg	K, protein	MF (?)
Downer cow syndrome	P, K(?)	Protein, K	MF, FCS
Retained placenta	Se, vit E, vit A, Cu, I, P, protein, energy	Energy, K	FCS, MF, KET
Delayed uterine involution/ metritis	Ca, Co, vit D, Se, Vitamin E (?)	Energy	RP, FCS, LDA(?)
Mastitis	Se, vit E, vit A		MF, LDA
Udder edema	Protein, Mg	Na, K, energy(?)	MAST (?)
Ketosis	Protein, energy	Energy (?)	MF, RP, LDA, FCS
Displaced abomasum	Ca (?), fiber (forage). energy	Energy (grain)	MET, MAST, MF, KET

DYST = dystocia, FCS = fat cow syndrome, KET = ketosis, LDA = left-displaced abomasum, MAST = mastitis, MET= delayed uterine involution/metritis, MF = milk fever, RP = retained placenta

Animal selection

Samples from sick animals may be of value in the diagnosis of problems in specific individual animals, and perhaps the problems in the herd. However, if average metabolite values are to be determined for the herd, values from sick animals should not be included. The cows should be grouped according to production (far-off dry, close-up dry, early lactation, late lactation). Ideally, a minimum of 12 animals per group would be tested. At the very least, 5 to 7 cows in each group should be sampled, depending upon the particular problem, but sampling may have to be repeated to confirm initial findings.

Blood collection

Sample collection and handling are important if one is to expect useful diagnostic information. Samples should be taken with feeding management in mind. Several metabolites are influenced by feeding and have significant diurnal variation. It is important therefore to sample animals on individual farms at approximately the same time of day, preferably 2-5 hours post first feeding of the day. Measures should be taken to prevent hemolysis. The serum should be spun and separated within 2-3 hours and refrigerated. Other information pertinent for interpretation should be included.

Test selection

The AHL routinely runs bovine metabolic profiles, which include calcium, phosphorus, magnesium, electrolytes, total protein, glucose, urea, non-esterified fatty acids (NEFA), β-hydroxybutyrate (BHBA), γglutamyl transpeptidase (GGT), aspartate aminotransferase (AST), and haptoglobin. The panel of tests may change as more information is gained about bovine biochemistry. This complete profile is often more economical to run than individual tests. However, practitioners are encouraged to have specific tests in mind for evaluation and assessment rather than just blindly running a complete profile. The probability of generating an abnormal result from a normal animal increases with each additional test that is conducted in a profile. Thus, it is important to have a diagnostic hypothesis or a monitoring objective in mind prior to submitting samples.

Energy status

Blood glucose is an insensitive measure of energy status because it is subject to tight homeostatic regulation.

Non-esterified fatty acids are the blood metabolites most directly associated with energy balance. NEFA is most valuable in the late (close-up) dry period, particularly within a week of calving.

Beta-hydroxybutyrate is the ketone body of choice for routine measurement because of its stability in serum or plasma. Blood ketone bodies are elevated in association with poor carbohydrate status only when concurrently associated with negative energy balance. BHBA is most useful within the first month post-calving, particularly in the first 2 weeks postpartum. Recent research suggests that elevated BHBA (above 700 umol/L) in the last week precalving may be useful to predict increased risk of early lactation culling and suboptimal milk yield.

Protein status

Blood urea levels can be used as an indirect measure of rumen ammonia in ruminants with normal kidney function. Although no specific disease state is associated with abnormal herd urea levels, valuable information concerning dietary protein content and utilization can be detected from herd urea levels – high blood urea levels are consistent with excessive protein intake.

Mineral and vitamin status

Most nutrients are homeostatically regulated, therefore their value in profile testing for monitoring and assessment of nutritional status is limited. However, sampling cows when they are metabolically stressed, e.g., just prior to and following calving, could potentially result in identifying cows that are more prone to metabolic disease problems. Liver trace minerals are better indicators of dietary adequacy, but serum levels may be of value in chronic dietary problems. Fat-soluble vitamins can be easily assessed in serum or liver samples. Gestational micro-mineral and vitamin losses may significantly affect the cow's reserves and thus her metabolic function. Mineral and vitamin supplementation may have been reduced during the dry period. Deficiencies in micro-minerals, such as copper, manganese, zinc and selenium, as well as fat-soluble vitamins, may lead to a compromised immune system.

A **trace element screen** (Co, Cu, Fe, Mn, Mo, Se & Zn), as well as vitamin E, can be added to the MPT, as needed.

Summary and interpretation

MPT is most useful as a diagnostic aid in difficult herd situations where other, more direct, diagnostic techniques have failed to uncover the problem. In most cases, MPT will help to further define the problem and direct additional diagnostic efforts. MPT may also be useful as a tool to support a diagnostic hypothesis with the farmer. It will seldom lead directly to a solution. However, blood metabolite analysis can reveal some useful information when properly interpreted in conjunction with animal and ration evaluation.

Dairy herds used for reference intervals

The samples were taken from 47 Holstein cows in Ontario dairy herds, on total mixed rations, during January to April, that were judged to be clinically normal (Table 2). Their production is above the Ontario average. All analyses were conducted using routine chemistry tests on a Cobas 6000 automated chemistry analyzer. Data were divided into cows that were in the close-up period (within 4 weeks of freshening), fresh cows (30 – 100 days in milk), and mid-lactation cows (>100 days in milk). Many factors, such as breed, parity, stage of lactation, feed type, feeding frequency, season, etc., can influence these values. Reference intervals are different from cut-points, which are usually set based on subsequent disease risk or production loss.

Table 2. Reference intervals for stages of lactation, derived from Holstein dairy herds in Ontario

	Close-up (n=45)	**Fresh** (n=47)	**Mid-lactation** (n=45)
Calcium (mmol/L)	2.2 – 2.8	1.9 – 2.7	2.2 – 2.8
Phosphorus (mmol/L)	1.6 – 2.4	1.4 – 2.5	1.6 – 2.6
Magnesium (mmol/L)	0.8 – 1.2	0.6 – 1.0	0.8 – 1.2
Sodium (mmol/L)	136 - 150	135 – 148	133 – 145
Potassium (mmol/L)	3.8 – 5.3	3.8 – 5.3	3.8 – 5.4
Chloride (mmol/L)	95 - 105	88 – 105	93 - 109
Total protein (g/L)	60 – 81	60 – 82	66 – 82
Albumin (g/L)	32 – 41	25 – 38	31 – 42
Globulin (g/L)	25 – 50	28 – 45	30 – 46
Urea (mmol/L)	3.0 – 6.5	3.0 – 7.2	3.0 – 7.2
Creatinine (µmol/L)	32 – 130	50 – 95	30 - 87
Glucose (mmol/L)	3.0 – 4.0	2.5 – 3.5	3.0 – 4.0
GGT (U/L)	10 – 35	10 – 37	12 – 49
AST (U/L)	30 – 110	34 – 132	37 – 150
GLDH (U/L)	0 – 30	0 – 50	0 – 40
BHBA (µmol/L)	200 – 820	300 – 1250	350 – 1220
NEFA (mEq/L)	0 – 0.5	0 – 0.8	0 – 0.4
Haptoglobin (g/L)	0 – 0.4	0 – 0.5	0 – 0.4

1. Herdt TH. Variability characteristics and test selection in herd-level nutritional and metabolic profile testing. Vet Clin North Am, Food Anim Pract 2000;16:387-403.
2. Herdt TH, Hoff B. The use of blood analysis to evaluate trace mineral status in ruminant livestock. Vet Clin Food Anim 2011;27:255-283.