

CRAMPTON / HARRIS

APPLIED
ANIMAL NUTRITION

2ND EDITION

APPLIED ANIMAL NUTRITION

*The Use of Feedstuffs in the
Formulation of Livestock Rations*

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APPLIED ANIMAL NUTRITION

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FOREWORD TO SECOND EDITION

The developments that have taken place in the field of animal nutrition in the twelve years since the publication of the first edition of *Applied Animal Nutrition* have not changed our basic premises so much as they have extended their application to livestock ration formulation.

This second edition includes the first textbook use of a new system of nomenclature for products used in animal feed mixtures. It presents information on the use of the caloric system of describing biological energy, preferred by many to the total digestible nutrient (TDN) system. The concept of expressing dietary requirements as nutrient-to-calorie ratios is proposed as more rational in the light of modern nutritional knowledge than the consideration of nutrients as independent entities. The quantitative data are given in both the metric and avoirdupois systems in anticipation of the early universal adoption of the former for scientific use.

The system for naming feed products, proposed by Harris in 1963, was standardized by the National Research Council Committee on Feed Composition in 1966, and adopted for use in all NRC Tables of Feed Composition. The nomenclature features a unique name and reference number for each of the more than 5,500 animal feeds of North America: the name of a given product gives precise information about its (1) genus or parent material, and (2) its species, variety or kind; (3) the part of the parent material that constitutes the feedstuff; (4) the processes to which it has been subjected in preparation; (5) for forages, the stage of physiological maturity and (6) the cutting or crop it represents within the year of harvest; (7) its quality, grade,

and/or guarantees, and (8) its feed class code number. In tabulations, feeds are listed alphabetically, with the common area names for any given feed integrated into the listing and cross-referenced to the "official" NRC name.

An improved and systematic nomenclature for feeds has been long overdue, not only to describe the origin and nature of a product and make more meaningful the analytical data, but also to accommodate the rapidly expanding number of by-products from the processing of human foods that are or can be made edible and acceptable for livestock: for example, citrus pulp, seeds, and rind; poultry feathers; laboratory-synthesized vitamins; purified amino acids; defluorinated rock phosphate; fermentation products.

A development closely related to and facilitated by the adoption of a systematic nomenclature has been the machine retrieval and manipulation of feed compositional data, to produce least-cost feed combinations containing the amounts and proportions of the nutrients that the feeding standard indicates are needed for a particular ration. Thus we now can "balance" the rations, not only for three or four nutrients, but for all of them for which we have requirement data. This advance has brought into prominence the current paucity of data on the nutrient composition of all but a few feeds.

The so-called linear programming of rations is but an extension, albeit an important one, of the principle of flexible formulae for balanced rations dealt with in detail in the text. Each formula is based on the premise that there is no one best formulation—that the adequacy and balance of nutrients rather than those of the nutrient sources are the nutritionally critical features of a fully acceptable ration.

As the number of nutritionally important components of livestock feeds on which data are available has increased from the six of the Proximate Analysis to the eighty or more now recognized, the problem of the format of a functional working table in which to record these items has taken on new significance. The NRC's Committee on Animal Nutrition sub-committee on Feed Composition* devised the tabulation format that is used in the NRC *Encyclopedia of Feed Composition* and this format has been followed in this edition of *Applied Animal Nutrition*. It assembles systematically and consecutively all of the data currently available on a feeding stuff. There are no blank spaces in the table, yet the format lends itself to expansion and, at the same time, preserves the unity of each feed and its position in the alphabetical arrangement of the tabulation as a whole. Feedstuffs are classified according to their principal contribution to the feeding characteristics of the ration: (1) dry, (2) fresh, or (3) ensiled forages; and (4) energy, (5) protein, (6) mineral, (7) vitamin carriers, (8) additives. To identify (as in linear programming

* E. W. Crampton and Lorin E. Harris.

of rations), the class of a particular feed, its class code number has been made the first digit of its six-digit reference number.

In accordance with the trend in scientific publications, the metric system of weights and measures has been incorporated into the quantitative parts of the book. In many tables both the original units and the corresponding metric value are shown. Where the weight units are only generally descriptive, we have rounded values, using, for example, 450 kilograms (instead of 454) to describe a 1000-pound animal. This sort of approximation will, of course, disappear as the avoirdupois system falls into disuse.

The broad general objectives of the second edition do not differ from those of the first edition, since we believe them to be as relevant now as when outlined initially in 1956.

Our sincere thanks are due Dr. J. Malcolm Asplund, Utah State University, for his help with the Feed Composition Table.

E. W. Crampton
L. E. Harris

September, 1968

FOREWORD TO FIRST EDITION

The subject of animal nutrition is concerned with the application of scientific knowledge to the day-to-day feeding of livestock. Much remains to be discovered before we can construct a completely satisfactory overall pattern of nutrition. Nevertheless, we already have sufficient information to justify the belief that apparent gaps between animal husbandry, in its broadest sense, and such sciences as chemistry, physics, and physiology are not truly discontinuities, but merely voids in our information. As discoveries in the sciences have gradually filled these voids, there has been a tendency to change the grouping of subject matter for the teaching of animal nutrition, which has become, in fact, an integration of the relevant phases of all those sciences that underlie the principles of animal feeding. One of its most urgent tasks, therefore, has become the assessment of the relative significance and importance, from its peculiar viewpoint, of advances in all sciences that bear on this phase of animal husbandry.

In their concern with integrating basic scientific advances into their subject, animal nutritionists have all too often stopped short of practical application. Nutrients are considered in regard to their physiological roles; but problems of getting these nutrients to the animal day by day in accordance with the exigencies of practical livestock management tend, it would seem, to be regarded as proper to some other field.

The author feels that such a tendency is regrettable. He believes that the teaching of animal nutrition should bring closer together the theory of nutrition and the practice of animal feeding. This gap is not adequately covered by re-

capitulation of the specifications and behavior in rations of the hundreds of edible products used in feeding animals. Nor should we shirk our responsibility by discussing theories of animal nutrition, and leaving it for some phase of animal care and management to apply the theories to feeding practice. For example, the problems of ration formulation, together with those of ingredient procurement, processing, and mixing have become so broad in scope and so intricate in application that the commercial preparation of "balanced rations" and of specialized ration supplements is no longer merely a matter of convenience to the feeder.

The present book has been designed expressly to help bridge this gap between animal nutrition and livestock feeding practice; it is an attempt to extend fundamental animal nutrition into what we may call "applied animal nutrition."

Students taking this course should have as prerequisites, as far as practicable, those subjects of a college undergraduate curriculum necessary for an understanding of fundamental animal nutrition, as well as many of those that deal with animal care and management.

The subject matter of the text can partly be deduced from the paragraphs above. The author, in attempting a critical consideration of feedstuffs and their use, accepts on the one hand the facts presented and discussed in animal nutrition; and on the other, presumes that livestock feeding practice is a part of the subject of animal management. He also assumes that a catalogue of feedstuffs is an important part of the subject matter of reference books on feedstuffs rather than a desirable feature of a text dealing with problems of the assembly of nutrients into rations. But he does believe firmly, that to present a coherent and reasonably complete treatment of applied animal nutrition, he cannot be bound by traditional subject limitations.

The reader will find the subject matter treated under four main sections, plus an appendix. The first section is devoted to definition and critical appraisal of the terms and expressions used in describing feedstuffs. Section II deals with the nutritional requirements of animals, with special attention to the biological basis for feeding standard data. The nature of feeding standards and their limitations as guides in ration formulation are also considered in some detail. Section III features a classification of feeds. The discussion of the properties and functions of key feeds is intended to establish a sound basis for feed substitution in ration formulation. A classification of roughages according to available energy is a feature of this section.

The last section (IV) has to do with the problems of ration formulation. The translation of feeding standards into terms of meal mixtures, and the development of the concept of flexible formulae for meal mixtures, mineral mixtures; and mixed supplements intended as all, or as a part of the rations

of farm livestock (cattle and swine) receives careful consideration in this section. It is through such formulae that the facts of nutrition and the characteristics of feeds are eventually brought together in terms that are immediately useful in feeding practice.

Finally, pertinent comments on feed legislation and a selected table of feed composition appear as an appendix.

E. W. Crampton

April, 1956

CONTENTS

I WHAT ARE FEEDSTUFFS?

Chapter 1. Terms and Definitions for Feeds	3
<i>History and Development of the NRC Nomenclature for Feeds</i>	3
<i>NRC Nomenclature for Feeds</i>	6
<i>The Ideal Feed Name</i>	9
<i>Long Names</i>	13
<i>Format for Tables of Feed Composition</i>	13
<i>Feeding Stuffs</i>	15
<i>Basal (Energy) Feeds</i>	17
<i>Supplements</i>	17
<i>Concentrates</i>	18
<i>Forage and Roughage</i>	19
<i>Nutrients</i>	19
<i>Enzymes</i>	21
<i>Toxicity</i>	24
Chapter 2. The Proximate Analysis of Feeds	30
<i>Water</i>	31
<i>Ether Extract</i>	35
<i>Crude Fiber</i>	42
<i>Nitrogen-Free Extract</i>	45

	<i>Crude Protein</i>	48
	<i>Ash</i>	51
	<i>Another Look at the Proximate Analysis</i>	51
Chapter 3.	Schemes for Describing the Energy Value of Feeds	56
	<i>The Caloric System</i>	56
	<i>Glossary of Energy Terms</i>	60
	<i>Physiological Fuel Values</i>	70
	<i>Total Digestible Nutrients</i>	72
	<i>Starch-Equivalent Values</i>	77
	<i>Direct Determination of Caloric Value</i>	78
	<i>Significance of the Energy Determination</i>	80
	<i>Feed Efficiency</i>	81
Chapter 4.	Schemes for Describing the Protein Values of Feeds	87
	<i>Measures of Protein Quality</i>	88
	<i>Application of Protein Quality in Feeding Practice</i>	98
	<i>Supplementary Values of Protein</i>	99
Chapter 5.	Measuring the Intake and Utilization of Energy and Nutrients of Feeds	105
	<i>Technical Problems with Determining Coefficients of Apparent Digestibility with Penned Animals</i>	108
	<i>Effect of Variability</i>	116
	<i>Measuring Intake and Digestibility of Rations of Animals on Range or Pasture</i>	119
	<i>Calculating Forage Intake and Digestibility</i>	119
	<i>Obtaining Samples of Actual Forage Ingested</i>	122
	<i>Coefficients of Apparent Digestibility and the Proximate Analysis</i>	125

II NUTRITIONAL REQUIREMENTS OF ANIMALS

Chapter 6.	The Energy Requirements of Animals	137
	<i>Partition of Food Energy in Digestion and Metabolism</i>	139
	<i>The Maintenance Requirement of Adult Animals</i>	142

<i>Energy Cost of Production and Work</i>	150
<i>Energy Requirements of Growth</i>	152
<i>Conclusions: Where Do We Stand Now?</i>	161
Chapter 7. Requirements for Protein	165
<i>Fate of Dietary Protein</i>	166
<i>Protein Requirements for Growth</i>	177
<i>Protein Requirements for Lactation</i>	180
Chapter 8. Requirements for Minerals, Vitamins, and Miscellaneous Additives	181
<i>Minerals</i>	181
<i>Vitamins</i>	185
<i>Antibiotics</i>	185
Chapter 9. Feeding Standards	191
<i>The Evolution of Feeding Standards</i>	192
<i>The Significance of Balance Between Nutrients and Energy</i>	195
<i>Feeding Standards as Hypothetical Rations</i>	196
<i>The 1949 Canadian Pig Feeding Test</i>	198
<i>Margins of Safety in Feeding Standards</i>	203
<i>Description of Feeding Groups</i>	204
<i>Feeding Standards as Indispensable Guides</i>	205
<i>Modern Feeding Standards</i>	206
<i>A Broader Use of Feeding Standards</i>	207
<i>Use of Feeding Standards</i>	216

III THE NUTRITIONAL CHARACTERISTICS OF SOME COMMON FEEDS

Chapter 10. A Classification of Feeds	223
<i>Forages, Roughages, and Concentrates</i>	223
<i>Classification of Feeds Based upon Use</i>	224
<i>Variability of Feedstuffs in Chemical Make-up</i>	226
Chapter 11. Basal Feeds	233
<i>Chemical Characteristics</i>	233
<i>Nonchemical Characteristics of Basal Feeds</i>	239
<i>Quality in Basal Feeds</i>	242

Chapter 12. Protein Supplements	257
<i>Products of Plant Origin</i>	257
<i>Protein Supplements of Animal and Marine Origin</i>	265
Chapter 13. Vitamin and Mineral Supplements and Miscellaneous Additives	271
<i>Vitamins</i>	271
<i>Minerals</i>	276
<i>Miscellaneous Additives</i>	280
Chapter 14. Forages and Roughages	285
<i>General Characteristics of Forages and Roughages</i>	285
<i>Form in Which Roughage Is Fed</i>	288
<i>Hay Grading</i>	290
<i>What Constitutes Good Hay</i>	292
<i>Low-Grade Roughages</i>	293
<i>An Energy Classification of Roughages</i>	295
<i>A Nutritive Value Index for Forages</i>	297
<i>Nutritional Liabilities in Forages</i>	305
<i>Practical Aspects of Pasture as a Feed</i>	307
<i>Straw as a Feed</i>	308

IV RATION FORMULATION

Chapter 15. Translation of Feeding Standards into Meal Mixture Specifications	317
<i>Animal Feeding Categories</i>	317
<i>Swine Meal Mixture Specifications</i>	318
<i>Dairy-Cow Meal Mixture Specifications</i>	323
<i>Beef-Cattle Meal Mixture Specifications</i>	331
Chapter 16. The Preparation of Flexible Formulae for Meal Mixtures	337
<i>The Pattern Meal Mixture</i>	338
<i>Making the Pattern into a Flexible Formula</i>	341
<i>Subformulae</i>	343
<i>Using the Supplement Formulae</i>	343
<i>Precautions</i>	344

Chapter 17. The Preparation of Mixed Mineral Supplements	346
<i>Flexible Formula Mineral Supplements</i>	346
<i>Mineral Supplements for Cattle or Sheep</i>	347
<i>Requirements of Dairy Cattle for Mineral Supplements</i>	350
<i>Mixed Mineral Supplement for Swine</i>	352
Chapter 18. Flexible Formulae for Cattle Meal Mixtures	355
<i>Corn vs. Barley as the Basis of Cattle Meal Rations</i>	355
<i>Percentage of Protein in the Formula</i>	356
<i>A Protein Supplement for Use in Preparing Cattle Meal Mixtures</i>	362
<i>Flexible Formula for an 18 Per Cent Protein Dairy-Cow Meal Mixture</i>	363
<i>Suggestions for Formulation of Cattle Meal Rations</i>	364
<i>Flexible Formula for a 22 Per Cent Protein Calf Meal (Calf Starter)</i>	364
<i>The Flexible Formulae in Practice</i>	367
Chapter 19. Flexible Formulae for Swine Meal Mixtures	377
<i>Two 15 Per Cent Protein Flexible Formulae for Swine Meal Mixtures</i>	377
<i>Protein-Mineral-Vitamin Supplement for Use with Home-Grown Feeds</i>	381
Chapter 20. Linear Programming of Meal Mixtures	382
<i>Linear Programming Defined</i>	383
<i>The Specifications Necessary</i>	384
<i>Reliable Chemical Analyses Necessary</i>	385
<i>Incompatible Requirements</i>	386
<i>Actual Steps in the Linear Programming of Rations</i>	386
<i>Program Defined</i>	389

V NUTRIENT NEEDS OF ANIMALS

Chapter 21. Livestock Feeding Guides	399
<i>Daily Allowances of Feed for Animals</i>	399
<i>Guides to Dairy-Cattle Feeding</i>	400
<i>Rules of Thumb for Feeding Young Dairy Cattle</i>	404

<i>Feeding Pregnant Dairy Cows</i>	407
<i>Guides for Swine Feeding</i>	408
<i>Horse Feeding</i>	410
<i>The Proximate Analysis as an Index of Feeding Value for Meal Mixtures Whose Formulae Are Unknown</i>	412
<i>Are "Balanced" Rations Necessary?</i>	414
<i>Feeding Iodine</i>	416
<i>Annual Requirements of Meal for Livestock</i>	417
<i>The Format of Modern Feeding Standards</i>	418
Chapter 22. Feedstuffs Control and Legislation	440
<i>Canadian Legislation</i>	440
<i>Feed Legislation in the United States</i>	442
<i>Uniform State Feed Bill</i>	443

APPENDICES

Appendix 1. Tables for Metabolic Size and Numerical Conversion	459
Appendix 2. The Chemical and Biological Composition of Feedstuffs	463
Appendix 3. Table of Feed Composition	473

FIGURES

1-1. Wheat milling products and by-products.	7
1-2. Some important pathways of energy metabolism.	25
2-1. Apparatus for extraction of fat and water.	32
2-2. Partition of forage feeds.	54
3-1. Conventional biological partition of food energy.	58
3-2. True biological partition of food energy.	59
3-3. Total heat production and energy use by a lactating cow.	65
3-4. Relationships between environmental temperature and heat production.	66
3-5. An improved recording bomb calorimeter.	79
3-6. Biological partition of food energy and heat loss.	82
3-7. Gain-feed relationships.	83