ANALYTICAL PROCEDURES IN ANIMAL NUTRITION AND FEED TECHNOLOGY

There are number of methods for each measurement reported in literature and it poses some difficulty in selecting a suitable method particularly for those who have newly entered the research field. Compilation of appropriate methods for a wide range of measurements employed in biological research is often helpful to researchers and technicians and the present book is an attempt in that direction. The book entitled "Analytical Procedures in Animal Nutrition and Feed Technology" authored by "Vinod Kumar, Muneendra Kumar and Raju Kushwaha" has been designed to meet the needs of the research students, teachers, scientist of department of animal nutrition and personnel of feed industry involved in feed analysis and quality control. The main purpose of this compilation is to make available a wide range of analytical and biochemical techniques evolved out of actual experience of research workers. Content of this book will be helpful in understanding the general principles and methodology behind preparation of standard solution, preparation, processing and preservation of samples, analysis of proximate principles, fibre fraction determination, mineral and vitamin estimation, fatty acid and amino acid analysis, estimation of energy content, in vivo, in sacco and in vitro methods of feed evaluation, rumen liquor analysis and tests for evaluation of quality of silage. This book is designed to give rapid and easy access to the recent test and techniques used in evaluation of feedstuffs, enteric methane measurement, rumen study, detection of adulteration in feed, determination of harmful constituents and pesticide residues in feeds and fodders. The text will also helpful in better understanding about recent techniques like atomic absorption and inductively coupled plasma spectrophotometer, chromatography, near-infrared-spectroscopy, calorimetry, sulphur hexafluoride tracer technique etc. Each section of book provides a structured approach to learning by covering the topics in a uniform and systematic format.

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SATISH SERIAL PUBLISHING HOUSE
403, Express Tower, Commercial Complex, Azadpur, Delhi - 110033 (India)
Phone : 011-27672852, Fax : 91-11-27672046
E-mail : info@satishserial.com, hkjain1975@yahoo.com
Website : www.satishserial.com

Rs. : 750.00

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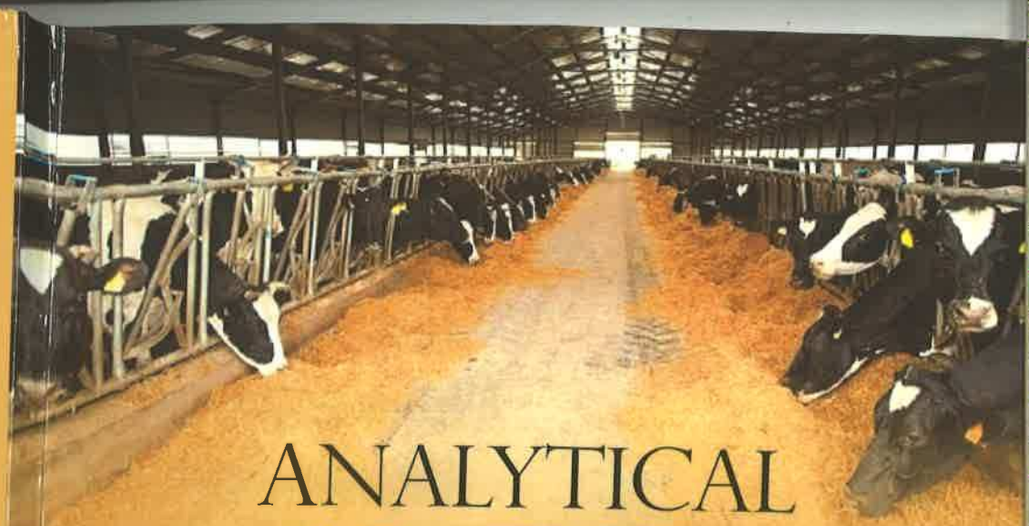

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Analytical Procedures in Animal Nutrition and Feed Technology

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Published by :

SATISH SERIAL PUBLISHING HOUSE

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ISBN 978-93-86200-59-4

Composed, Designed & Printed in India

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Dr. Vinod Kumar was born in village Pawti in Hapur district of Uttar Pradesh on 3th July 1976. He completed his graduation in Veterinary Science and Animal Husbandry (B.V.Sc. & A.H.) in 2001 from G.B. Pant University of Agriculture & Technology, Pantnagar, Uttrakhand. He completed his M.V.Sc. (Animal Nutrition) from IVRI, Izatnagar, Uttar Pradesh, in 2003 and Ph.D. (Animal Nutrition) from NDRI, Karnal, Haryana in year 2009. He started his carrier as Assistant Professor in 2007 in the Animal Nutrition division, F.V.Sc. & A.H., SKUAST-Jammu and subsequently at the Animal Nutrition department College of Veterinary Science and Animal Husbandry, DUVASU, Mathura from January, 2009. In June 2014, Dr. Kumar selected as Associate Professor in the same department. Since 2010, he is the officer Incharge of Department of Animal Nutrition. His work on the practical aspects of animal nutrition received considerable acclaim especially on mineral nutrition and unconventional feed sources. He involved himself in conducting research in area of trace element research, non conventional feed resources, and precision nutrition. He has guided four M.V.Sc and two Ph.D students. He formulated area specific mineral mixture (DUMIN-AS) for Braj region. He is lifetime member of Animal Nutrition Society of India, Animal Nutrition Association, Indian, Academy of Veterinary Nutrition and Animal Welfare, Indian Poultry Science Association and Indian Science Congress Association. Dr. Kumar has been executive committee member of Animal Nutrition Society of India and IPSA, India. He has published about 30 research articles in international and national journals, 5 laboratory manuals and contributed 3 chapters in books, delivered invited lectures and lead papers in various seminar/trainings/workshop etc. Dr Kumar has many prestigious award in various seminar and symposia like best paper presentation as oral and poster. He was recently given research excellence award by ETT-CRS. Dr Kumar is involved in various project of national importance like gokul gram mission and experiential learning.

Dr. Muneendra Kumar born in village Bhawan Khera, Hardoi district of Uttar Pradesh on 5th July, 1982 did his B.V.Sc. & A.H. in 2007 from U.P. Pandit Deen Dayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidyalaya Evam Go-Anusandhan Sansthan (DUVASU), Mathura. He qualified ICAR- Junior Research Fellowship for Masters degree programme and completed his M.V.Sc.

(Animal Nutrition) from ICAR-NDRI, Karnal, Haryana in 2009. Dr. Kumar awarded Institutional Fellowship and pursued his doctoral programme (Animal Nutrition) in the same institution. He became Assistant Professor in Department of Animal Nutrition on 19th October, 2011 at College of Veterinary Science, DUVASU, Mathura. Dr. Kumar had a deep involvement in teaching, research and extension on various facets of animal nutrition. His work on the micronutrient nutrition received considerable acclaim. Dr. Kumar awarded the prestigious VLIR-UOS Scholarship in 2014 for International Training Programme in Animal Nutrition organized by Gent University, Belgium. Dr. Kumar was recipient of K. Pradhan and VIFRA Young Scientist Award (2015) and many awards in category of oral and poster presentation. He is lifetime member of Animal Nutrition Society of India, Animal Nutrition Association, Indian Academy of Veterinary Nutrition and Animal Welfare, Society for Conservation of Domestic Animal Biodiversity, Indian Poultry Science Association, International Society for Environmental Information Sciences, The Indian Science Congress Association, Associated member of the be-troplive, the Belgian Platform on Tropical Animal Health and Production. He is executive (CEC) member of Animal Nutrition Society of India and Animal Nutrition Association. Dr. Kumar attended two international conferences at Belgium and several national conferences. He has published 13 research articles in international journals, 25 research articles in national journals, 4 laboratory manuals and contributed 2 chapters in books.

Dr Raju Kushwaha born on September 15, 1979 in Kanpur Nagar of U.P. graduated in Veterinary Science and Animal Husbandry from DUVASU, Mathura (2007). Dr. Kushwaha qualified ICAR- Junior Research Fellowship for Masters degree programme and completed his M.V.Sc. (Animal Nutrition) from ICAR-NDRI, Karnal, Haryana in 2009. He joined as Assistant Professor in Department of Animal Nutrition, College of Veterinary Science and Animal Husbandry, DUVASU, Mathura (U.P.) in June, 2014. Dr. Kushwaha involved in teaching, research and extension activities regarding to animal nutrition. He involved himself in conducting research in area of antinutritional factors. He is lifetime member of Animal Nutrition Society of India, Animal Nutrition Association and The Indian Science Congress Association. He has published 11 research articles and 2 laboratory manuals.

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Date: October 31, 2017

FOREWORD

I am very glad to know that Drs. Vinod Kumar, Muneendra Kumar and Raju Kushwaha have authored the book titled "Analytical Procedures in Animal Nutrition and Feed Technology" keeping in view the requirements of students, scientists, teachers and others involved in the field of animal nutrition. This book will be very useful in understanding the basic principles and methodologies involved in preparation of different standard solutions, proximate analysis, fiber-fraction determination, estimation of minerals, vitamins, fatty acids and amino acids etc.

This book has been designed to give rapid and easy access to the recent and well-validated tests and techniques used in evaluation of feedstuffs, rumen fermentation studies including methane estimation, detection of adulterants, harmful constituents, and determination of pesticides residues in feedstuffs and animal products.

I am sure this book will enhance the practical knowledge and analytical skills of students, scientists and technicians involved in academics especially those who are involved in quality control in the feed-industry.

I heartily congratulate all the authors of this book and wish all success in their future endeavors and academic pursuits.

(Satish K. Garg)

Preface

Every sector of the livestock industry, the associated services and the wellbeing of both animals and humans are influenced by animal feeding. Proper animal feeding is the supply of a diet balanced in all nutrients and free from deleterious components. The availability of accurate, reliable and reproducible analytical data regarding nutrients composition is imperative for proper feed formulation. Also only reliable data can lead to the generation of sound scientific data. Therefore, better understanding of analytical procedures and laboratory techniques used in animal nutrition is required. The text in book represents an attempt to summarize and consolidate a considerable amount of information relative to principles, methodology and experimental techniques that are commonly used in animal nutrition studies. Basically, the text is an outline of the author's laboratory manuals with attempts made to expand and reference where possible. This book is designed to give rapid and easy access to the recent test and techniques used. The content can be divided into various sections including preparation of standard solution, proximate analysis, mineral and vitamin estimation, analysis of energy content, fatty acid and amino acid, enteric methane measurement, rumen liquor analysis, determination of quality of silage, detection of adulterants and harmful constituents in animal feedstuffs. The authors hopes that this book will also serve as useful reference to understand recent techniques like atomic absorption spectrometry, inductively coupled plasma-atomic emission spectrophotometer, gas and liquid chromatography, thin layer chromatography, high performance liquid chromatography and near-infrared-spectroscopy etc. Each section of book provides a structured approach to learning by covering the topics in a uniform and systematic format. The methods and techniques are detailed in a straight forward and lucid manner. This book will be useful for research students, teachers, scientists and laboratory analysts involved in feed analysis and quality control.

Our thanks to Dr. Debashis Roy, Dr. Shalini Vaswani and Dr. Avinash Kumar for the important contribution made in the preparation of this book. I appreciate the contribution of staff of animal nutrition department for providing us conducive environment for designing of this superior manuscript.

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Preparation and Expression of Standard Solution

1.1. Standard solution

A solution of known concentration is called the standard solution. A primary standard is a reagent that is extremely pure and stable; it not a hydrate/it has no water of hydration, and it has a high molecular weight. A secondary standard is a standard that is prepared in the laboratory for a specific analysis. It is usually standardized against a primary standard. The term secondary standard can also be applied to a substance whose active agent contents have been found by comparison against a primary standard.

1.2. Expressing concentration of standard solution

The concentration of a solution can be expressed in the following ways.

i) Molarity (M)

It is defined as the number of gram moles of solute dissolved in one litre of the solution.

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Appendices

APPENDIX I

LIST OF ABBREVIATIONS

%	Percentage	IU	International unit
°C	Degree celsius	IVGPT	*In vitro* gas production technique
µg	Micro gram	kg	Kilo gram
µl	Micro litre	l	Litre
AAS	Atomic absorption spectrophotometry	L-BAPA	Benzoyl-L-arginine-p-nitroanilide
ADF	Acid detergent fibre	M	Molarity
ADFCP	Acid detergent fibre crude protein	m	Molality
ADIN	Acid detergent insoluble nitrogen	MBP	Microbial biomass production
ADL	Acid detergent lignin	Mcal	Mega calorie
ADS	Acid detergents solution	ME	Metabolizable energy
AIA	Acid insoluble ash	mg	Milligram
ANFs	Anti-nutritional factors	mm	Millimeter
AOAC	Association of Official Analytical Chemists	mol	Mole
BCAA	Branched chain amino acids	Mol. wt.	Molecular weight

BCPI	Bromocresol purple index	N	Normality
BIS	Bureau of Indian Standard	NDF	Neutral detergent fibre
BSA	Bovine serum albumin	NDS	Neutral detergent solution
cc	Cubic centimeters	NFE	Nitrogen free extract
CF	Crude fibre	ng	Nano gram
CH_4	Methane	NH_3-N	Ammonia nitrogen
CP	Crude protein	NIR	Near-infrared
DC	Digestibility coefficient	NPN	Non protein nitrogen
DE	Digestible energy	OM	Organic matter
DM	Dry matter	pg	Pico gram
EE	Ether extract	ppb	Parts per billion
ECD	Electron capture detector	ppm	Parts per million
ELISA	Enzyme-linked immunosorbent assays	RUSITEC	Rumen simulation technique
Eq. wt.	Equivalent weight	SAA	Sulphur amino acids
FAAS	Flame atomic absorption spectrophotometry	SF_6	Sulphur hexafluoride
FAMEs	Fatty acid methyl esters	TCA	Trichloroacetic acid
g	Gram	TDDM	True degradability of dry matter
G	Gauge	TDN	Total digestible nutrients
GC	Gas chromatography	TDOM	True degradability of organic matter
GE	Gross energy	TIA	Trypsin inhibitor activity
GFAAS	Graphite furnace atomic absorption spectrometry	TLC	Thin layer chromatography
GHG	Green house gas	TMR	Total mixed ration
GLC	Gas liquid chromatography	v/v	Volume/volume

HPLC	High performance liquid chromatography	VFA	Volatile fatty acid
hr(s)	Hour(s)	w/v	Weight/volume
ICP-AES	Inductively coupled plasma-atomic emission spectrometry	w/w	Weight/weight
ISO	International Standard Organization		

APPENDIX II

NUTRIENT COMPOSITION OF COMMON FEEDSTUFFS

Ingredient	ME (Kcal/ kg)	Crude protein (%)	Crude fiber (%)	Ether extract (%)	Lysine (%)	Methio-nine (%)	Calcium (%)	Phosp-horus (%)
Cereals								
Maize	3309	9.2	3.0	3.8	0.18	0.15	0.25	0.40
Bajra	2950	12.7	4.0	3.0	0.43	0.20	0.13	0.72
Wheat	3045	10.3	3.0	2.5	0.47	0.21	0.19	1.12
Rice	2345	7.9	8.0	2.5	0.33	0.17	0.11	0.48
Barely	2618	12.0			0.60	0.20	0.29	0.64
Cereal by product								
Rice polish	2837	12.7	12.0	16.0	0.55	0.24	0.27	1.37
De-oiled rice polish	2135	14.1	14.0	1.0	0.44	0.31	0.37	1.80
Wheat bran	1286	17.2	10.9	3.0	0.53	0.09	0.19	1.12
Vegetable protein								
Soybean meal	2300	45.0	6.0	1.0	2.57	0.76	0.36	0.90
Full fat soybean	3275	36.5	5.5	18.0	2.35	0.53	0.25	0.58
Groundnut cake	2700	38.0	9.0	8.0	1.6	0.42	0.16	0.16
Groundnut ext.	2128	40-42	11.2	1.0	1.47	0.68	0.31	0.67
Sunflower cake	1600	28.0	26.0	1.0	1.00	0.60	0.37	0.30

Mustard cake	2373	35.1	9.6	8.0	1.14	0.42	0.89	1.78
De-oiled mustard cake	1672	31.7	11.6	2.3	1.37	0.51	0.58	0.82
Cotton seed meal	1556	25.9	21.3	0.9	1.07	0.41	0.52	0.86
Guar meal	1821	37.1	10.5	6.7	2.58	0.39	0.41	0.50
Maize gluten meal	3300	60.0	2.0	2.5	1.02	1.28	0.22	0.19
Brewer's dried grains	2732	28.2	-	-	0.98	0.43	0.29	0.54
Animal proteins								
Fish meal	1834	43.1	2.5	6.0	2.5	1.08	7.16	2.5
Meat meal	2300	56.2	2.6	6.8	4.00	0.84	2.68	2.06
Meat cum bone meal	2100	48.0	-	8.0	3.72	0.75	11.25	5.39
Mineral source								
DCP	-	-	-	-	-	-	23	18
Limestone	-	-	-	-	-	-	35.0	-
Oyster shell	-	-	-	-	-	-	38.0	-

UNITS AND CONVERSION

Unit	Description	Conversion	Remarks
Pressure			
Pa	Pascal	Standard unit	Pascal = Newton/ m^2
atm	Atmosphere (physical)	101,325 Pa	Pressure in gases
atm	Atmosphere (technical)	98,066.5 Pa	One atmosphere =1 kp/cm^2
bar	Bar	100,000 Pa	Pressure in gas and liquid
psi	Pounds per Square Inch	6,894.757293168 Pa	1 psi equivalent 14.5 bar
mbar	Millibar	100 Pa	Equivalent one hector pascal(hPa)
mmHg	Millimeter-mercury column	133.32 Pa	
Energy			
Unit	**Description**	**Conversion**	
J	Joule	Standard unit	
BTU	British Thermal Unit	1055.058138 J	
cal	calorie	4.186794846 J	
HPh	Horsepower hour	2684517.413 J	
Wh	Watt hour	3599.9982 J	
Area			
m^2	Square meter	Standard unit	
ha	Hectare	10,000 m^2	
ft^2	Square foot	0.0929 m^2	
km^2	Square kilometer	1,000,000 m^2	
mi^2	Square mile	2,589,988.11 m^2	
Volume			
l	Liter	Standard unit	
bl, bbl	Barrel	159 l	
gal	Gallon (UK)	4.55 l	
gal	Gallon (US)	3.7862 l	
pt	Pint	0.4733 l	
qt	Quart	0.9466 l	
Speed			

m/s	meters per second	Standard unit
km/h	kilometers per hour	0.278 m/s
mi/h	miles per hour	0.447 m/s
Power		
N	Newton	Standard unit
W	Watt	Standard unit
hp	horsepower	745.701 W
Length		
m	meter	Standard unit
ft	foot	0.3048 m
In	Inch	0.0254 m
mi	mile	1609.344 m
yd	yard	0.9144 m
Mass		
kg	kilogram	Standard unit
lb	pound	0.4536 kg
t	ton	1000 kg
oz	ounce	0.02834 kg
Temperature		
K	Kelvin	Standard unit
°C	Degree Celsius	K = °C+273.15
°F	Degree Fahrenheit	°F = 1.8×(K-273.15)+32
		$°C = \frac{(°F - 32)}{1.8}$
		°F = (°C×1.8)+32
Time		
s	second	Standard unit
m, min	minute	60 s
h	hour	3600 s
d	day	86400 s

FREQUENTLY USED STANDARDS OF CONCENTRATION

Measurement	Notation	Generic formula	Typical units
Mass percentage	wt% or w/w%	g solute x 100/ g solution	%
Mass-volume percentage	m/v%	g solute x100/ ml solution	% though strictly % g/ml
Volume-volume percentage	vol% or v/v%	ml solute x 100/ ml solution	%
Molarity	M	moles solute/ liter solution	mol/l (or M or mol/ dm^3
Molinity	-	moles solute/ kg solution	mol/kg
Molality	m	moles solute/ kg solvent	mol/kg (or m)
Molar fraction	(chi)	moles solute/ moles solution	(decimal)
Formal	F	moles undissolved solute/liter solution	mol/l (or F)
Normality	N	gram equivalents/ liters solution	N
Parts per hundred	%(or pph)	Dekagrams solute/ kilograms solution	dg/kg
Parts per thousand	%(or ppt)	grams solute/ kilograms solution	g/kg
Parts per million	ppm	mg solute/kg solution	mg/kg
Parts per billion	ppb	µg solute/kg solution	µg/kg
Parts per trillion	ppt	ng solute/kg solution	ng/kg

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