WHEY AND LACTOSE PROCESSING

Edited by

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For Sue

FOREWORD

It would be difficult to imagine a more appropriate means of marking the Jubilee of the Dairy Research Laboratory, Division of Food Processing, CSIRO, than a publication on whey and lactose processing. The genesis of the Laboratory in 1939 was when the Australian dairy industry was very largely based on the supply of cream from farms to numerous butter factories, the skim milk being fed to pigs. By the mid-1940s, when Geoffrey Loftus-Hills was appointed in charge of the fledgling Dairy Research Section, the main objective of the Section—the full utilization of the constituents of milk for human food—had been firmly established. Over the next two decades progress towards this objective was exemplified by the scientific and technological contributions made in specialized milk powders for use in recombining and in the manufacture of casein and cheese. Meanwhile farming practices changed from cream production to the supply of refrigerated whole milk to the factories.

By the late 1960s the increasing production of cheese and casein had resulted in almost 2 million tonnes of whey per annum. This represented not only a waste disposal problem, but also under-utilization of over 100000 t of milk solids. The Laboratory had now grown to a staff of around 70, so it was possible to allocate some resources to this extra challenge.

This challenge was by no means unique to Australia and the subject of whey utilization was so large as to be beyond the resources of any one laboratory. Loftus-Hills and his colleagues had, over the years, established close contacts, and, indeed, friendships, with many eminent dairy scientists in different countries. Perhaps there was scope for collaborative efforts to examine the many facets of this research field.

The first major event in the international collaboration was a feasibility

study in Australia in which I was very pleased to collaborate with Professor Walter L. Dunkley, University of California, Davis. This study helped to define the extent of the problem and highlighted some opportunities. Subsequently these opportunities, particularly through application of ultrafiltration to whey, were explored on pilot- and semi-commercial scale equipment with excellent support and collaboration from several dairy companies. The Gilbert Chandler Institute of Dairy Technology (now Food Research Institute), Werribee, Victoria, joined in the collaborative effort.

Meanwhile plans were being made in the United States, New Zealand and Australia to establish collaboration more firmly. Submissions to the National Science Foundation in the United States and the Department of Science in Australia led to the first Whey Protein Collaborative Research Group Workshop held in 1975 at the Ohio State University, Columbus, Ohio. Representatives from the New Zealand Dairy Research Institute, the two Australian institutes as well as the CSIRO Division of Chemical Engineering, joined with those from five universities in the United States, one in Canada and from industry in the United States. This first Workshop was followed at two-yearly intervals by further meetings in Australia, New Zealand and the United States which established not only extensive collaborative efforts in research, but also enduring friendships. Opportunities were created for exchange visits by some of the eminent scientists. Professor W. James Harper, Ohio State University, spent some time at the Dairy Research Laboratory (DRL), CSIRO, as did Professor Michael Mangino from the same university, and the late Professor Thomas Nickerson, University of California, Davis. Professor Harper also worked for an extended period at the New Zealand Dairy Research Institute. Dr John Pearce of DRL spent some time at the Ohio State University, and Dr Greig Zadow of DRL spent some months at the University of Wisconsin-Madison.

Recent developments have seen the formation by the International Dairy Federation (IDF) of a Group of Experts to study measurement of the functional properties of milk protein products, a study vital to the development and marketing of whey protein products. Several of the members of that IDF Group have played a leading role in the collaborative effort over the years.

Almost every one of the authors of this treatise on whey and lactose processing have joined in phases of the collaboration over the years. So in writing this foreword I consider it as a greeting and thanks to many friends.

It is with this background that I consider the publication such a fitting means of marking the Jubilee of the Laboratory in which I spent some 28 rewarding years.

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PREFACE

This publication marks the Jubilee of the CSIRO Dairy Research Laboratory. It is the work of distinguished experts in dairy and food research, drawn from research centres throughout the world. I thank all of the contributors for their efforts, and for their patience during the final preparation of the manuscript.

The CSIRO Dairy Research Laboratory has had a proud record of success in dairy research, and has many luminaries in the field. Over the past few years, changes in the funding and structure of the Laboratory have had a major impact on the direction of the Laboratory's work and its interface with industry, moving its activities more towards the development of value added products. These changes will determine to a large extent the continued success of CSIRO's dairy research activities.

Events such as the Jubilee of the founding of organizations are prone to pass without notice—it is rare indeed for any member to be with an organization for fifty years to remember its founding! However, these events are worthy occasions, and deserve to be marked and celebrated. They give an opportunity for reflection on the successes of the organizations and its people, on the changes that have occurred and their impact on output and effectiveness, and a timely opportunity to consider the future.

The approaching Jubilee was first recognized by the CSIRO Dairy Research Librarian, Mrs Susan Zadow (my wife), who also suggested the publication of this book to mark the event. She was also responsible for much of the selection of the authors, and the editing of the work. This book is for her.

J. G. Zadow

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Chapter 1

SOURCES AND COMPOSITION OF WHEY AND PERMEATE

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1 INTRODUCTION

Whey, a by-product from cheese or casein manufacture, originates from mammal's milk, as do its permeates. (The clear yellowish liquid resulting from making soybean curd or soy cheese is sometimes called whey, which should not be confused with whey from mammal milk.) Milks differ depending on origin of specie but all varieties will contain similar gross components but in different amounts.

Most whey products of commerce are generated from processing cow, sheep, and goat milks. These milks, from the three different species, are important to most people in the world. However, it is interesting to look at milk from across a wide array of mammals to compare variations in composition between the different species and think about how different or similar whey or permeates might be when produced from different milk supplies (see Table 1).

Not only are there species differences, but we know that we can expect some seasonal differences in milk, as shown in Tables 2, 3, 4 and 5, which contain cow, sheep and goat milk data at different times of the year.

Compositional differences in mammalian milk can be critical when related to growth rates of young for whom nature provides nutrients. Data in Table 6 shows that man needs 180 days for its offspring to double its weight while rabbits need but 6 days. Webb *et al.* (1974) were quick to note that the one indisputable fact regarding variations in the composition of milk appears to be 'variation'.

One author, Dr Ernst J. Mann, who writes about dairy science, depicted growth and maturity of the dairy industry by its technology and marketing of dairy products as a tree. At first the tree was mostly a trunk and had but a few leaves identified as milk, cream, butter and powder.

Table 1
Average Composition (Per Cent) of Milks of Various Mammals

Species	*In milk*							*In total solids*				
	Water	*Fat*	*Protein*	*Lactose*	*Ash*	*Non-fat solids*	*Total solids*	*Fat*	*Protein*	*Lactose*	*Ash*	*Non-fat solids*
Woman	87·43	3·75	1·63	6·98	0·21	8·82	12·57	29·83	12·97	55·53	1·67	70·17
Cow	87·2	3·7	3·5	4·9	0·7	9·1	12·8	28·9	27·34	38·28	5·47	71·1
Cow	86·61	4·14	3·58	4·96	0·71	9·25	13·39	30·91	26·76	37·04	5·30	69·09
Goat	87·00	4·25	3·52	4·27	0·86	8·75	13·00	32·69	27·08	32·85	6·62	67·31
Ewe	80·71	7·90	5·23	4·81	0·90	11·39	19·29	40·96	27·11	24·94	4·67	59·05
Egyptian buffalo	82·09	7·96	4·16	4·86	0·78	9·95	17·91	44·44	23·23	27·14	4·36	55·56
Chinese buffalo	76·80	12·60	6·04	3·70	0·86	10·60	23·20	54·31	26·03	15·94	3·71	45·69
Philippine carabao	78·46	10·35	5·88	4·32	0·84	11·19	21·54	48·05	27·30	20·06	3·90	51·95
Indian buffalo	82·76	7·38	3·60	5·48	0·78	9·86	17·24	42·81	20·88	31·78	4·52	57·19
Camel	87·61	5·38	2·98	3·26	0·70	7·01	12·39	43·42	24·05	26·31	5·65	56·58
Mare	89·04	1·59	2·69	6·14	0·51	9·37	10·96	14·51	24·54	56·02	4·65	85·49
Ass	89·03	2·53	2·01	6·07	0·41	8·44	10·97	23·06	18·32	55·33	3·74	76·94
Reindeer	63·30	22·46	10·30	2·50	1·44	14·24	36·70	61·20	28·06	6·81	3·92	38·80
Llama	86·55	3·15	3·90	5·60	0·80	10·30	13·45	23·42	29·00	41·63	5·95	76·58

(Webb *et al.*, 1974).

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