ANIMAL BY-PRODUCT PROCESSING & UTILIZATION

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To Frances J. Ockerman and Joyce D. Hansen

PREFACE

THE animal by-product segment of the food-processing industry has been a remarkable economic achievement and public health phenomena. Nevertheless, published information in the area of animal by-product processing and utilization is limited. The forerunner of this book, *Animal By-Product Processing,* published in 1988 (translated into Spanish in 1994), is the most quoted book on the topic, but it has been out of print for several years. Prior to this publication, a 1927 book was the standard reference source. The most recent book, *The Original Recyclers* (1996) by Don Franco and Winfield Swanson, covers primarily rendering. The scientific journal literature, too, is limited, although material on this topic increasingly can be found on the Internet. Clearly, changes in the industry, the lack of up-to-date information, and the scattered nature of sources make a new, comprehensive treatment of the subject appropriate at this time.

A unique feature of the current book is that it brings together, in one place, information on the entire field of animal by-product processing and utilization. We have incorporated new and updated information—both published and unpublished—made available since 1988 throughout this book. Chapter sections have been revised with information of current importance. Particular attention has been paid to concerns over new animal diseases that might be transferred by feeding low-temperature rendered products and to new precautions for the rendering industry.

The book will be useful for anyone interested in by-product processes or by-product utilization, individuals interested in recycling, people interested in a classic example of reutilization of valuable material, and those involved in the health area who are interested in disease prevention.

The increased economic squeeze on animal processors, increased emphasis on pollution, the energy crisis, and competition from man-made items will challenge the by-products industry in the foreseeable future. However, considering the track record already established, it is reasonable to expect that innovation will continue. Any industry that turns waste into valuable products and reduces pollution ought to be applauded.

Trade association and industry personnel were extremely helpful in sharing information with the authors (see references listed). Dr. Vern R. Cahill of the Ohio State University and Dr. Divakaran of the Oceanic Institute, Waimanald, Hawaii, were also helpful consultants and proofreaders. The authors would appreciate additional information about this varied industry for their files and in case a revision of this text is undertaken in the future.

HERBERT OCKERMAN
CONLY HANSEN

CHAPTER 1

Introduction and History of Processing Animal By-products

INTRODUCTION

ANIMALS are grown and slaughtered to provide nutritious meat for humans, and without this utilization, few of what we consider "meat" animals would be allowed by Homo sapiens to exist except as examples of species in zoos. As the economic stature of a country or race increases, there is usually a shift in its diet and nutrition to include a greater percentage of tasty, well-balanced protein from animal sources. With this consumption of more well-balanced protein from meat, peoples' size (particularly height) usually tends to increase.

With all of the natural advantages of animal food products, there still remains a great quantity, often in excess of 40%, of animal by-products that sometimes have rather unusual physical and chemical characteristics that are not part of the normally consumed steaks and roasts. The efficient and economical utilization of these edible or inedible products is the subject of this book.

The quantity of animal by-products available for utilization can be estimated by subtracting the dressing percentage (see Table 1.1) from 100. This large quantity of material can then be increased by the quantity of fat and bone that traditionally remains with the carcass at the slaughter stage; therefore, it is obvious that tremendous tonnage (estimated at 30 million tons; Franco and Swanson, 1996) of this material is involved and, if not utilized, is a tremendous pollution and health problem.

The economics of the world's meat industry insist that animal by-products be utilized so that the livestock industry can stay economically competitive with vegetable protein sources. If animal by-products are not effectively utilized, of course, a valuable source

Table 1.1. Dressing Percentage (carcass weight/live weight x 100), When Subtracted from 100%, Will Give an Estimate of the Quantity of Noncarcass By-Products.

U.S. Grades	Dressing Percentages	
	Range	Average
Cattle		
Prime	62–67	64
Choice	59–65	62
Good or select	58–62	60
Standard	55–60	57
Commercial	54–62	57
Utility	49–57	53
Cutter	45–54	49
Canner	40–48	45
Calves and veal (hide off)		
Prime	59–65	62
Choice	56–60	58
Good	52–57	55
Standard	47–54	51
Utility	40–48	46
Lambs (wooled)		
Prime	47–55	51
Choice	45–52	49
Good	43–49	47
Utility	41–47	45
Cull	40–45	42
Sheep (excludes yearlings)		
Choice	49–54	52
Good	47–52	49
Utility	44–48	46
Cull	40–46	43
Barrow and gilt (ham facings, leaf fat, kidneys, and head removed)		
U.S. No. 1	68–72	70
U.S. No. 2	69–73	71
U.S. No. 3	70–74	72
U.S. No. 4	71–75	73
Utility	67–71	69

Table 1.1. (continued)

U.S. Grades	Dressing Percentages	
	Range	Average
Poultry		
Chicken, broilers	—	70
Chicken, capon	—	68
Turkey, broiler	—	77
Duck, Peking	—	58
Pheasant	—	78
Channel catfish	—	60

USDA Market News (1973), Mountney (1966), Hedrick et al. (1994).

of potential revenue is lost, and the added and increasing cost of disposal of these products is incurred by the industry. Today the cost of the live animal often exceeds the selling price of its carcass; therefore, the value of the by-products must pay the expense of slaughter and generate the profit for the meat-slaughtering operation. In 1984 Bengtsson and Holmqvist (1984) suggested that 7–12% of slaughterhouse income could come from by-products. Later, Bowater and Gustafson (1988) gave a figure of 15% and reported that some plants were as high as 32.5%. Over the last several years, the value of animal by-products relative to the value of the live animal has declined (Hedrick et al., 1994) because of technological progress in producing competitive products from nonanimal sources such as synthetic materials to replace leather, synthetic fibers to replace wool, vegetable oils to replace animal fat, and synthetic detergents to replace soap made from animal fat.

In addition to the economics involved, the meat industry has the obligation to eliminate waste by salvaging as much of the animal as possible, because this is a valuable natural resource and responsible individuals are expected to be effective stewards of the resources placed at their disposal. Because much of the world's vegetation can only be harvested by animals and it takes energy to organize these chemical animal by-product structures, it would behoove mankind to utilize these by-products, when possible, in an organized form and not allow them to be wasted or converted to a lower energy state.

Nonutilization of animal by-products would, of course, create a major aesthetic and catastrophic public health problem. The effective utilization of animal by-products and water and sewage treatment plants undoubtedly have had major influences in upgrading public health in the last century.

The modern livestock industry has been an effective user of by-products. It has often been quoted that "all of the pig is used except the squeal and the curl in the tail." But despite this, a great deal more can be done, because more than 2% of the carcass (more than the shrinkage) is often unaccounted for and is usually lost to the server. Also, to achieve utilization, many of the products are sometimes downgraded in value.

A flowchart showing the interrelationships between land, water, animals, and animal by-products is illustrated in Figure 1.1. Another flowchart showing a few examples of the tremendous variety of animal by-products that may be involved can be found in Figure 1.2.

Some products, such as hides, are easy to classify as "animal by-products," and steaks can easily be excluded from such a classification. Other products, however, such as lard or liver, are more difficult to categorize. The U.S. meat industry considers everything produced by or from the animal, except dressed meat, as a by-product (offal). Therefore, animal by-products in the United States fall into two categories, i.e., "edible" and "inedible."

In U.S. terminology "offal" refers to meat slaughter by-products and includes all of the animal that is not a part of the carcass. "Variety meats" are the wholesale edible by-products that are segregated, chilled, and processed under sanitary conditions and are inspected for sanitation and wholesomeness by the U.S. Meat Inspection Service. These include liver, heart, tongue, oxtail, kidney, brain, sweetbreads (thymus and/or pancreas gland depending on the animal's age), tripe (stomach), chitlings and natural casings (intestines), and fries (lamb or calf testicles). In some areas of the world and to different degrees, blood is also utilized as an edible product for humans. In the United States, meat trimmings from the head are described as "edible offal" or "edible by-product items," and "edible fats" are fats obtained during slaughter, such as "caul fat" surrounding the rumen and/or stomach, and "cutting fat," which is "back fat" or pork "leaf fat" (kidney fat) or "rumen fat."

A partial, but certainly not all-encompassing, list (American Meat Institute, 1958; Levie, 1976) of animal by-products includes the following:

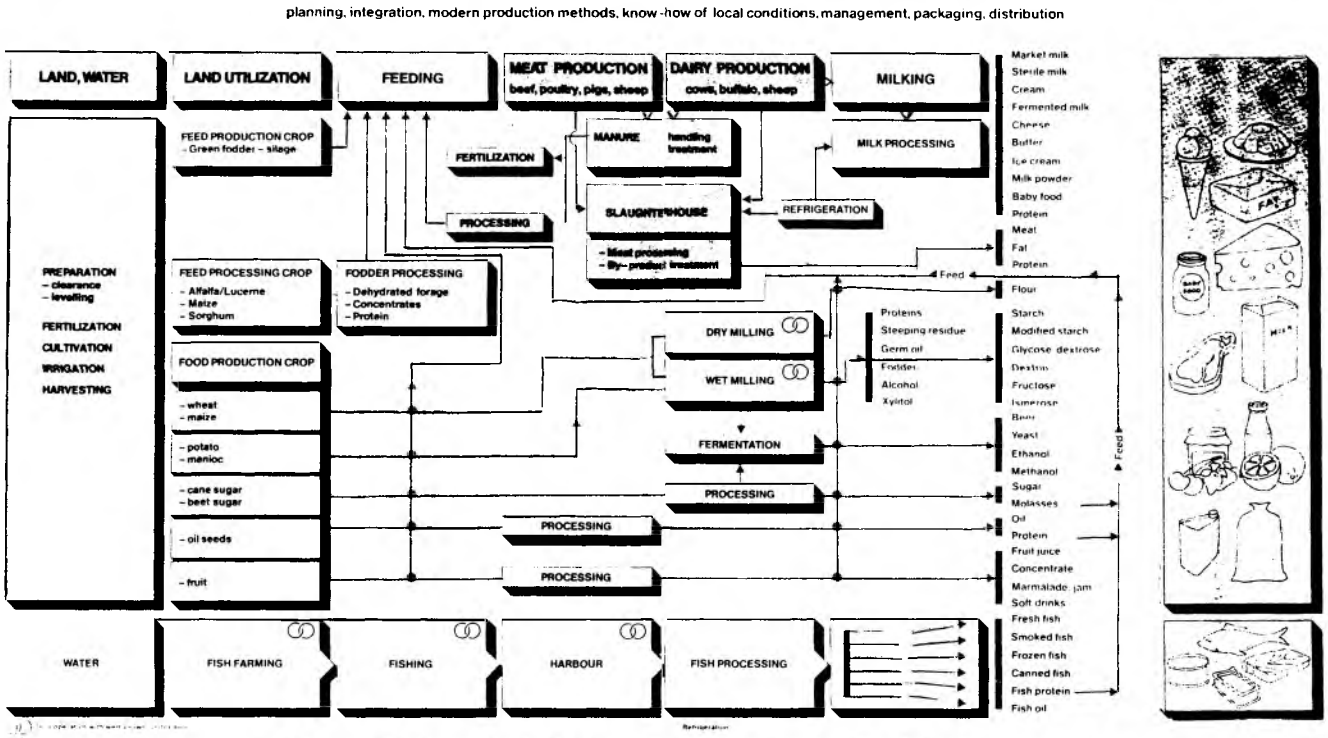

Figure 1.1. *From Virgin Land to Green Pastures and Food Products.*

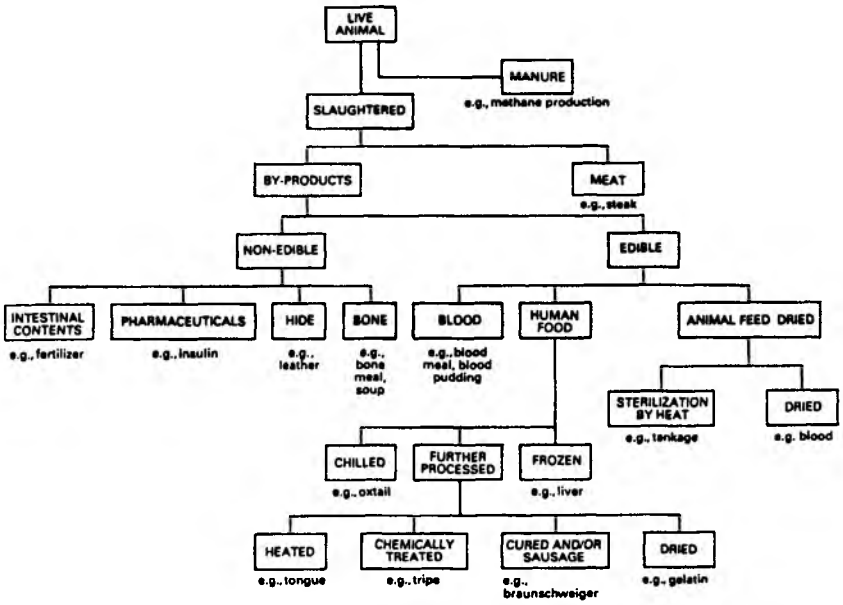

Figure 1.2. Flow Diagram of a Few of the Meat Industry By-products.

(*1*) Variety (edible by-products including organs) meat for human consumption.

(*2*) Edible fats for shortening, margarine, sweets, and chewing gum.

(*3*) Bone utilized in the mechanical deboning process to produce soft tissue or bones used in soup for human food, or bones used for buttons, knife handles, bone meal, mixed with pottery clay or used in refining sugar.

(*4*) Blood for human consumption and for blood meal, adhesives, and fertilizer.

(*5*) Glycerin for hundreds of industrial uses, such as nitroglycerin, ointment bases, solvents, vehicles for medicine, preservatives for food, plasticizers, or humectants.

(*6*) Intestines for sausage casings, musical strings, and surgical ligatures.

(*7*) Gelatin for confectionery items, ice cream, and jellied food products.

(*8*) Rennin used in cheese making.

(*9*) Pharmaceuticals, such as adrenocorticotropic hormone, albumin, bilirubin, epinephrine, insulin, liver extract, pepsin, pituitrin, testosterone, thromboplastin, thymocrescin, and thyroxin.

(*10*) Organ parts for implantation into humans, such as heart valves, skin, and bones, and, experimentally, even whole hearts.

(*11*) Livestock feed (usually high in protein or fat or minerals) manufactured from by-products.

(*12*) Pet food and feed for aquatic farming.

(*13*) Hides and skins for use as fur, leather, or leather goods.

(*14*) Wool for clothing, furniture, and lanolin extraction.

(*15*) Inedible fats used for many industrial products, such as tires, lubricants, insecticides, and germicides.

(*16*) Hair for brushes, felt, rugs, upholstery, plaster binding, insulation, and athletic equipment.

(*17*) Feathers for insulation, decorative items, pillows, sporting goods, and animal feed.

(*18*) Glue used in carpentry, for sizing, sandpaper, emery cloth, and making boxes and plywood.

(*19*) Neat's foot oil used in the leather industry and as a lubricant.

(*20*) Fertilizer applied to soil is manufactured from animal by-products.

(*21*) Animal manure used as fertilizer, animal feed, and/or methane production.

The division of cattle (Figure 1.3) and sheep (Figure 1.4) into various product categories are illustrated in pie charts.

In English commercial slaughterhouse practice (Gerrard, 1972), the offal is divided into red [head, heart, liver, lungs, melt (spleen), sweetbreads, tail, thick skirt (diaphragm), and tongue] and white [fats, manyplies (third stomach), set of guts and bladder, set of tripe (weasand, first, second, and fourth stomach), and rectum] and four feet and trimmings. Blood, hides, and pharmaceuticals are usually considered as a separate category. The English Food Standards Committee (Food Standards Committee of the Ministry of Agriculture, Fisheries and Food, 1972) separated offal into two categories. List A, items that may be used in cooked or uncooked products from mammalian species, contains tissue, such as diaphragm (skirt, cattle only), head meat (ox cheek, cattle only; bath chip, pig only), heart,

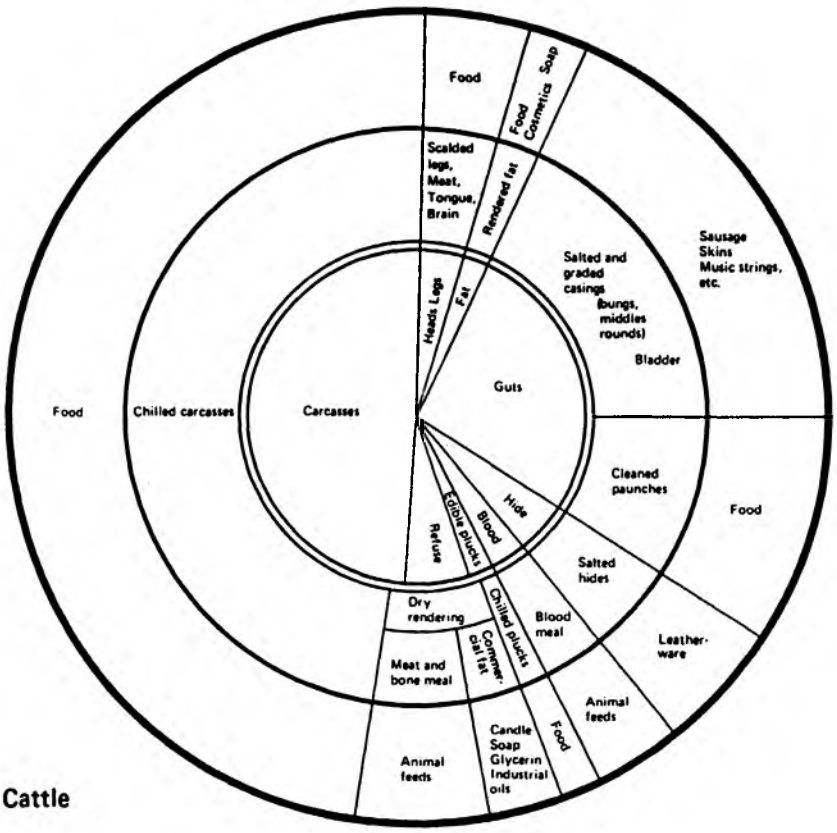

Figure 1.3. *Division of Cattle into Various Product Categories [from Filstrup (1976)].*

kidney, liver, pancreas (sweetbreads), tail meat (oxtail, skinned, cattle only), thymus (sweetbreads, cattle and sheep only), and tongue and avian parts, such as heart and liver (giblets, when gizzard and neck of list B are included). List B, items that may not be used in uncooked products, contains portions of the mammalian species, such as blood, blood plasma, brains, feet (cow heel, cattle only; sheep trotters, sheep only; pig trotters, pig only), large intestines (chitlings, pigs only), small intestines, lungs (lites), esophagus meat, rectum, spinal cord, stomach (nonruminant), first stomach (tripe, after cooking), second stomach (tripe, after cooking), fourth stomach, testicles (lamb fries, lamb only), udder, and parts of avian

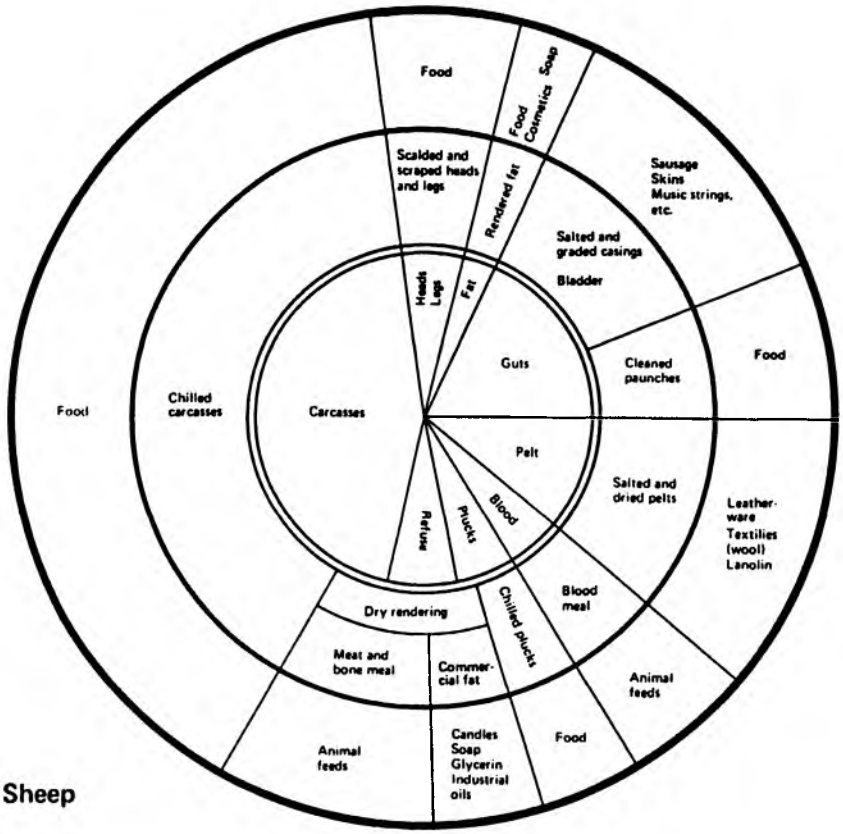

Figure 1.4. *Division of Sheep into Various Product Categories [from Filstrup (1976)].*

species, such as gizzard (giblets, when the heart and liver are also included) and neck.

The percentages of by-products from different species, divided into major categories by different countries, may be found in Table 1.2.

Several requirements (Clemen, 1927) are necessary for animal by-products to be effectively utilized as follows:

(*1*) There must be a practical commercial process for converting the animal by-products into a usable commodity.

(*2*) There must be an actual or potential market for the commodity that has been produced.

Table 1.2. Percentage of Live Weight of By-products from Various Species Reported in Different Categories in Different Countries.

	Cattle					Sheep		Pigs			
Country	Denmark[a]	England[b]	Sweden[c]	United States[d]	United States[e]	Denmark[a]	United States[d]	Denmark[a]	Sweden[c]	United States[d]	United States[f]
Carcass and other edible products	62–64					61–64		75–80			
Carcass, meat, and bone			50		54–58				69	56	56
Retail cuts (bone in)				42			35				
Retail cuts (boneless)		41									
Organs			16	4	3.4–3.6		2		7	4	2.4
Red offal		6									
Bone		8									
Bone (dried weight)					1.5						
Edible fats	3–4	10	4	11		4–6	9		3	16	16
Edible fat rendered weight					1.5–2.3						
Cracklings											2.7
White offal		10									

Table 1.2. (continued)

Country	Cattle					Sheep		Pigs			
	Denmark[a]	England[b]	Sweden[c]	United States[d]	United States[e]	Denmark[a]	United States[d]	Denmark[a]	Sweden[c]	United States[d]	United States[f]
Blood	3–4	3	3	4		3.5–4.5	4		3	4	3
Inedible raw material	8–10		5	17		6–8	22		6	8	15
Tankage (dried weight)						1.5					
Hide and/or hair	7		6	8		11–15	15		6		1
Hide (cured weight)		6			6.3–6.6						
Waste		20	16	14					11	6	12 4
Paunch and manure	8					5.5–9.5					
Shrinkage	2–10		25-30			0.5–1.5					

[a] Filstrup (1976).

[b] Gerrard (1977).

[c] Bengtsson and Holmqvist (1984).

[d] Forrest et al. (1975).

[e] American Meat Institute Committee on Textbooks (1958).

[f] Romans et al. (1985).

(*3*) There must be a large enough volume of economically priced animal by-product material in one location for processing.

(*4*) There must be some method of storing the perishable product before processing and to store the manufactured product after processing.

(*5*) There is often a critical need for highly technically trained operatives.

Getting all of these requirements together at one time in one place is not always an easy task. For reasons including these, animal by-products are often underutilized.

HISTORY

Archaeological evidence suggests that some animal by-product utilization was well established prior to recorded history. Use of organ tissue for food, utilization of animal skins for clothing and housing, making of tools from bones, use of dried manure as fuel, use of intestinal parts for food containers, and utilization of fish for fertilizer in planted crops are just a few known examples.

The books *Rendering, the Invisible Industry* (Burnham, 1978), *Darling-Delaware Centenary* (Dainty, 1981), and *The Original Recyclers* (Franco and Swanson, 1996) describe the early recorded history of animal by-product utilization and a summary of some of the milestones found in these references are as follows.

Plinius Secundus (Pliny the Elder), a Roman scholar in the first century A.D., recorded man's first written record of animal fat utilization. He described a cleaning compound (soap) made from goat's tallow and wood ashes, but it was uncertain if the Romans got the idea for making soap from the wandering Bedouins or from the Celts who are known to have made "saipo." Later descriptions of soap making and "saponarius" can be found in the works of a Greek physician (A.D. 130–200), the authors Theodorus Priscianus (A.D. 385) and Jabir Ibn Hayyan (approximately A.D. 800). It was not until 1823, however, that the French chemist Chevreul described saponification as the process of splitting fat (triglycerides) with an alkali into an alkali salt of a fatty acid (soap) and glycerin.

It is unclear historically whether an open saucer containing oil and a fibrous wick (later developed into a lamp) or a candle with

a wick encased in solid fat (usually cattle and/or sheep fat) was developed first. It is recorded that candle dipping goes back to the days of the Romans and that the English used reeds stripped of the pith and plugged with grease or oil as a common method of lighting. Molding of better candles was developed in the fifteenth century in France.

In the early history of California, meat was in abundant supply, and cattle were used primarily to produce by-products of hides and tallow, whereas in the Great Plains, soon after the white man came, buffalos were used for this same purpose. Much of the tallow was converted into soap. But as America grew, beef became the primary product, and William Pynchon of Boston started the first meatpacking operation as early as 1662. By 1865, the Chicago stockyards had become the nation's livestock market and was often described as "the busiest square mile of territory in all the world." In the 1850s, the railroads pushed west, and the great cattle drives moved animals to the railheads. After the American Civil War, Swift began using refrigerated freight cars and fresh beef carcasses, rather than live animals, could be transported.

H. W. Heath established the first rendering company in the United States in Manchester, New Hampshire, in the late 1800s. From there, the American industry expanded. Air-dried tankage was soon available as an animal protein feed substance, and cracklings supplied fat and protein to animal rations. The early to middle 1900s saw the animal by-products industry grow to tremendous proportions. The meat and by-products industry also moved further west to the source of the animals, and now centers, such as Kansas City, Omaha, and St. Louis, became important to the meat and rendering industries.

Today, the U.S. meat industry generates some 30 billion pounds of inedible waste material each year for recycling into usable products by the by-products industry.

In the United States, the animal by-products industry can be credited with the development, in this country, of commercial fertilizer, the use of by-products in animal feed, illustrating the importance of protein in the diet, salvaging of leather and wool for clothing and industrial use, the manufacture of soap and candles, the development of glue and gelatin, and the collection of pharmaceutical raw materials, just to mention a few.

Today, however, synthetic substitutes (i.e., imitation leather, detergents, shortenings, electrical illumination, soybean-based protein products) for many animal by-products are challenging the value of this industry and the industry itself to develop new products, new uses for old products, and to develop new markets.

QUANTITIES OF BY-PRODUCTS

An estimate (Filstrup, 1976; Simpson and Farris, 1982) of the world's supply of pigs is 500 million; cattle, 1,200 million; and sheep, 1 billion; the combined beef and pig population is distributed as follows:

34% Asia (20% in India but only 20% of the population eats meat)

30% North and South America

25% Europe and USSR

8% Africa

3% Oceania (contains the world's largest concentration of sheep slaughtering)

The cattle and buffalo populations in 1992 were divided according to countries as shown in Table 1.3, and meat production in different countries is categorized in Table 1.4. U.S. by-products raw material can be found in Table 1.5.

The total production of by-products can be estimated from the animals slaughtered and their dressing percentages. To separate the quantity salvaged from the amount wasted is much more difficult. Comparing the animals slaughtered, and, consequently, the by-products available, with the amount of by-products salvaged can clarify this relationship. The quantity and current value (1983–95) of by-products in the United States (see Table 1.6) and the quantity of by-products produced in the United States (see Table 1.7) and in England (see Table 1.8) can give some insight into the relationship in the developed countries between the availability of these by-products and those that are utilized.

Table 1.3. World Cattle Inventory in 1992.

Region	Head of Cattle (not buffalo) (thousands)	Percentage of World Cattle	Beef and Veal Meat Production[a] (thousand metric tons)	Percentage of World Beef and Veal Meat
Africa	187,523	15	3,439	7
North and Central America, other than United States	63,257	5	3,112	6
United States	99,559	8	10,607	21
South America	277,503	22	7,746	15
Asia	391,886	31	5,623	11
Europe	114,017	9	10,528	21
Oceania	32,647	3	2,327	5
Former USSR	119,936	9	7,454	15
Russia Federation	54,677	4	2,326	5
Total[b]	1,284,188	100	50,835	100
Developed world	389,526	30	33,172	65
Developing world	894,663	70	17,663	35

[a] Indigenous production only, does not include imported animals.

[b] Totals contain an estimate for missing countries.

[c] Include part of developed and developing world.

FAO *Production Yearbook* (1979, 1992), Simpson and Farris (1982).

Table 1.4. Meat Production in Selected Countries.[1]

Country	Beef and Veal (1,000 metric trons[4])		Pork[3] (1,000 (metric trons[4])		Mutton, Lamb, and Goat Meat (1,000 metric trons[4])		Poultry (1,000 metric trons[4])	
	1993	1994[2]	1993	1994[2]	1993	1994[2]	1993	1994[2]
Argentina	2,550	2,600	0	0	80	82	630	675
Australia	1,806	1,839	328	344	646	580	467	498
Belgium	375	358	988	1,008	5	5	196[5]	219[5]
Brazil	4,545	4,475	1,250	1,300	0	0	3,211	3,491
Bulgaria	123	95	265	267	64	61	614[7]	—
Canada	860	903	1,192	1,234	0	0	741	829
China	2,337	3,300	28,544	32,048	1,373	1,609	5,736	7,550
Colombia	563	566	126	126	0	0	497	514
Costa Rica	93	94	0	0	0	0	106[7]	—
Denmark	200	190	1,527	1,537	2	2	162	172
Egypt	364	392	0	0	85	83	275	315
Ireland	484	445	213	215	98	93	88	97
El Salvador	25	27	0	0	0	0	77[7]	—
France	1,704	1,592	2,034	2,126	163	154	1,875	1,961
Germany	1,575	1,447	3,180	3,030	41	41	615[6]	641[6]
Greece	50	83	150	144	129	130	173	175
Guatemala	53	48	14	14	0	0	85	95
Hong Kong	0	0	9	10	0	0	20	16
Honduras	44	45	0	0	0	0	39	40
Hungary	95	83	500	494	4	4	307	320
India	945	1,050	0	0	610	615	3,899[7]	—
Israel	37[7]	—	7[7]	—	6[7]	—	224	241
Italy	1,190	1,170	1,371	1,369	81	79	1,061	1,084
Japan	593	602	1,433	1,390	0	0	1,368	1,302
Korea, Rep	176	200	773	786	0	0	366	378
Kazakhstan, Rep	590	575	0	0	240	200	1,510[7]	—
Kuwait	2[7]	—	—	—	3[8]	—	18	18
Mexico	1,710	1,810	870	900	138	142	1,090	1,240
Netherlands	611	603	1,750	1,673	18	18	565	594
New Zealand	575	572	45	45	520	513	1,226[7]	—
Poland	462	435	1,537	1,350	23	14	300	345
Portugal	116	122	284	344	32	32	238	248
Romania	172	170	373	565	57	69	160	135
Philippines	133	135	690	715	0	0	1,204[7]	—

Table 1.4. (continued)

Country	Beef and Veal (1,000 metric trons[4])		Pork[3] (1,000 (metric trons[4])		Mutton, Lamb, and Goat Meat (1,000 metric trons[4])		Poultry (1,000 metric trons[4])	
	1993	1994[2]	1993	1994[2]	1993	1994[2]	1993	1994[2]
Russian Federation	3,360	3,100	2,560	2,260	340	310	1,277	1,170
Saudi Arabia	29	30	0	0	194	197	285	286
South Africa, Rep	691	581	0	0	177	134	663	679
Singapore	0	0	85	87	0	0	62	57
Spain	488	478	2,088	2,107	241	240	840	880
Sweden	140	141	291	307	0	0	478[7]	—
Switzerland	155	142	260	246	0	0	476[7]	—
Turkey	292	286	0	0	378	372	16	18
Taiwan	5	5	1,135	1,204	0	0	585	604
Thailand	192[7]	—	342[7]	—	2[7]	—	685	730
United Arab Emirates	2[7]	—	—	—	24[7]	—	16	18
United Kingdom	863	918	1,025	1,053	348	352	1,244	1,289
Ukraine	1,379	1,421	1,013	910	27	40	450	400
United States	10,584	11,194	7,751	8,027	153	140	12,885	13,206
Uruguay	309	368	0	0	0	0	485[7]	—
Venezuela	377	370	110	110	0	0	350	365
Total meat, includes 1992 data	44,054	45,293	66,113	69,696	6.391	6,435	49,785	53,282

[1] Carcass weight basis: excludes offals, rabbit, and poultry meat.

[2] Preliminary.

[3] Includes edible pork fat but excludes lard and inedible greases (except United States).

[4] Metric ton = 2,200 lbs.

—, No data available.

[5] Includes Luxembourg.

[6] Includes former West Germany.

[7] 1992 data.

[8] Lamb only, 1992 data.

FAS, Dairy, Livestock and Poultry Division. Prepared or estimated on the basis of official statistics of foreign governments, other foreign source materials, reports of U.S. Agricultural Counselors, Attaches, and Foreign Service Officers, results of office research, and related information.

USDA, National Agriculture Statistical Service (1995–96), USDA, Dairy and Poultry Statistics (1995), FAO Yearbook Production (1992).

Table 1.5. United States By-product Raw Materials Available in 1990.

	Cattle	Calves	Lambs and Sheep	Hogs
Number of animals slaughtered, million	33.4	1.8	5.7	85.4
Live weight, billion kg	17.3	0.23	0.33	9.7
Total by-products, packers and retailers, percent of live weight	55	49	57	48

Little, Arthur D., Inc. (1969), American Meat Institute (1991).

Table 1.6. United States By-product Trading.

	Million dollars		Million lb[a]		
	Import	Exports	Production	Export	Domestic Use
Variety meat	4.4	260.6			
Tallow, grease, and lard	3.8	587.2	559	137	422
Lard			1,513	295	557
Tallow					
Inedible tallow and grease	0.6	697.1	6,366	2,666	3,259[b]
Meat meal and other protein			6,043	552	5,491
Other inedible products			1,855		
Total			16,336	3,650	9,729
Casing	52.7	19.0			
			1,000 Pieces		
			Production	Export	Domestic Use
Hides and skins	66.1	777.3			
Cattle hides			37,500	20,500	12,608
Calf hides			3,020		
Leather	318	275	16,500		
Wool and mohair	175.4	53.3			

[a] lb = 453.59 g.

[b] 2,186 million lb feed products, 634 million lb fatty acids, 301 million lb soap, 128 million lb lubricants and other products.

American Meat Institute (1984), USDA (1980, 1982, 1983, 1984), U.S. Hide, Skin and Leather Association (1983a,b), Bureau of the Census (1995).

Table 1.7. Yield of Items Obtained from Meat Animals.

Item	Cattle	Lamb	Hogs
Grade	Choice	Choice	U.S. No. 1
Live weight, kg	455	45	100
Dressed carcass, kg	273	23	70
Retail cuts, kg	190	16	56
By-products, kg			
Hide or pelt	36	7	—
Edible fats	50	4	16
Variety meats	17	1	4
Blood	18	2	4
Inedible fats, bone, and meat scrap	80	10	8
Unaccounted items (stomach contents, shrink, etc.)	64	5	12

Hedrick et al. (1993).

Table 1.8. English Production of Animal Slaughter By-products.

Items	Production (thousand tons)
Blood (all animals)	100
Esophagus	2
Head meat (deboned)	147
Tongues	18
Spleen	.6
Stomach	64
Lungs	26
Intestines	123
Mesentery fat	69

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CHAPTER 2

Edible Meat By-products

INTRODUCTION

THE yield of edible by-products varies widely depending on species, sex, live weight, and methods of recovery. Total by-products ranges from 10 to 30% (sometimes higher for fat animals) of the live weight for beef, pork, and lamb and from 5 to 6% of the live weight for chickens (Table 2.1); therefore, more attention should be given to edible by-products. In general, the yield of edible blood and organs from cattle is 12%, for sheep 14%, and when pork rinds are included the yield is 14% for hogs (Fornias, 1996).

Biologically, most noncarcass material is edible, with appropriate cleaning, handling, or processing. Red viscera (the most frequently used edible by-products) is a term that is often applied to liver, heart, kidney, tongue, and neck sweetbread (thymus), and these products are also marked as "fancy meat." Because of custom, religion, palatability, and reputation of the product, however, variety meat is normally limited to the fancy meats plus other sweetbreads, brain, tripe, and sausage casings, although there are additional items salvaged and/or used in many cultures. Edible may have many interpretations, and what is considered acceptable in a given region may be considered inedible in another. Even though the number of animals slaughtered over the last 40 years has increased, the acceptance of by-products for human consumption has declined (Fornias, 1966).

This noncarcass material is usually separated into categories of decreasing value, such as main ingredient (e.g., "fancy meat"), sausage material (e.g., cheeks, head trimmings, pork rinds), pet food, animal feed (often used in this category are blood, lungs, spinal cord, breast fat, bones, and several of the stomachs), and fertilizer.

Table 2.1. By-product Yield Based on Live Weight.

	Percentage of Live Weight			
	Beef	Hog (pig)	Lamb	Chicken [1.4–2.3 kg (3–5 lb)]
Blood	2.4–6	2–6	4–9	
Blood, dried	0.7			
Brain	0.08–0.12	0.08–0.1	0.26	0.2–0.3
Breast fat	0.07			
Cheeks	0.03–0.32			
Chitlings	0.06			
Cracklings	3.0	2.2		
Ears	0.02			
Edible kill fat	1–7	1.3–3.5	12	
Feet	1.9–2.1	1.5–2.2	2.0	
Gizzard			1.9–2.3	
Gullet	0.03	0.1		
Hanging tender	0.19			
Head		5.2	6.7	
Head and cheek meat	0.32–0.4	0.54.6		
Head trimmings	0.03			
Heart	0.3–0.5	0.15–0.35	0.3–1.1	0.3–0.8
Intestines		1.8	3.3	
Jowl		2.7		
Kidney	0.07–0.24	0.2–0.4	0.3–0.6	
Large blood vessels	0.07			
Lips	0.1–0.24			
Liver	1.0–4.5	1.1–2.4	0.9–2.2	1.6–2.3
Lungs	0.4–0.8	0.4–0.85	0.7–2.2	0.7
Omasum	0.38			
Maw (Abomasum)	0.48			
Pancreas	0.06	0.1	0.2	
Pizzle	0.18			
Rennet	0.23			
Skirt	0.15–0.3	0.4–0.5	0.5	
Spinal cord	0.03			
Spleen	0.1–0.27	0.1–0.16	0.1–0.4	0.15
Stick trimmings	0.48	0.21		
Stomach		0.7		

Gerrard and Mallion (1977), Ockerman (1975), Romans et al. (1985).

The area or category into which a meat processor places a specific product depends not only on the possible utilization of that product but also on the availability of a potential market. Many edible by-products are downgraded because of the lack of a profitable market. Because the demand for variety meat is less than that for other cuts of meat, it is usually an economical buy. Because of this lack of demand in many producing countries and the fact that edible by-products are an economical source of high-quality protein, there is a sizable international trade in these products. An example of this may be found in Table 2.2, which shows the import and the export figures for U.S. variety meat. When the products are not salvaged or downgraded, as is often the case in developing countries, they pose a tremendous environmental pollution problem.

Fortunately, many cooks and ethnic groups have the ability to prepare a variety of interesting variations of delicious variety meats and are usually large consumers of this type of product. Variety meats are often different in structure, proximate composition, functional and sensory properties, but many have excellent nutritional properties, as shown by the protein, fat, mineral, and vitamin contents tabulated in Table 2.3, amino acid content shown later in Tables 2.15, 2.16, 2.17, fatty acid contents shown in Table 2.4, and a few problems, as listed in the cholesterol-content figures shown in Table 2.5. In general, sausages containing by-products are often considered nutritionally superior to their all-meat counterparts.

Edible by-products, in general, because of their higher glycogen content and lesser fat covering, are more perishable than the carcass; therefore, they must be chilled quickly, handled with a high degree of sanitation, and cooked and served as soon after slaughter as possible. The organs should be removed within 30 minutes of bleeding the animal, but they usually remain with the carcass until after governmental inspection, which is normally longer than 30 minutes. The kidneys often remain with the carcass until it is cut. Reduction of temperature retards bacterial growth tremendously, and Bijker (1981) illustrated a drastic increase in the bacterial growth curve when products were stored at 4°C (39°F) compared with similar products stored at 2°C (36°F). Even at 2°C (36°F), bacterial numbers were altered during 5 days' storage of beef, pork, and lamb organs, as reported by Hanna et al. (1982). The change in bacterial numbers during this storage period expressed in $\log_{10}$/

Table 2.2. U.S. Variety Meat, Imports and Exports.

	Imports		Exports	
	($ million)	(metric tons)	($ million)	(metric tonnes)
U.S. imports and exports in 1994				
Variety meat	53.0		567.6 (6%[a])	
Tallow, grease, and lard	25.0		1,024.9 (10%[a])	
Casings	61.3		43.5	
Hides, skin and leather	1,086.0		2,203.6 (22%[a])	
Wool and mohair	133.7		35.9	
Beef (1995)				
Australia (head meat and tongue)		1,853		
(edible organs)		138		
Canada (head meat and tongue)		3,182		
(edible organs)		2,499		
Costa Rica (head meat and tongue)		13		
(edible organs)		43		
Honduras (edible organs)		11		
Mexico (edible organs)		29		
New Zealand (head meat and tongue)		613		
(edible organs)		11		
Nigaragua (head meat and tongue)		27		
(edible organs)		87		
Pork (1995)				
Canada (edible organs)		10		
Mutton, lamb, and goats (1995)				
Australia (edible organs)		9		
Iceland (edible organs)		5		
New Zealand		630		
U.S. exports, 1984 to				
Denmark			1.0	391
United Kingdom			15.2	18,926
The Netherlands			8.9	9,705

Table 2.2. (continued)

	Imports		Exports	
	($ million)	(metric tons)	($ million)	(metric tonnes)
Belgium-Luxembourg			10.8	8,352
France			46.1	39,330
West Germany			1.4	1,387
Italy			0.016	20
Greece			0.007	5
Total EEC			83.8	78,116
			Export	
			($ million)	Thousand whole hides
Cattle hides (whole) in 1994				
South Korea			539.1	9,142
Japan			216.1	3,520
Taiwan			166.0	2,714
Mexico			89.4	1,584

[a] Share of total livestock export value in 1994.

American Meat Institute, (1984), Bischoff (1985), Boyle (1995), USDA (1997).

cm^2 ranged from 0.12 to 0.57 increase for livers, from –0.07 to 0.62 change for kidneys and from –0.28 to 1.18 change for hearts. The removal of the mucous membrane also reduced (approximately 10-fold) the bacterial load, and this reduction seemed to be maintained during reasonable storage (Bijker, 1981). The addition of carbon dioxide snow (dry ice) to accelerate chilling of by-products on the slaughter floor greatly reduces microbiological growth in these products. Freezing is known to cause sublethal injury and death to many microorganisms in food; however, freezing [–20°C (–4°F) for 4 days] of liver, kidney, and heart did not significantly decrease the bacterial numbers on these products (Hanna et al., 1982). Freezing can be expected to arrest bacterial growth (R. Strange, personal communication) as long as the product remains frozen. Vacuum packaging of liver and kidneys for 7 days' storage at 2°C (36°F)

Table 2.3. Range of Composition of Variety Meat/100 g Raw Edible Portion.

	Protein (g)	Fat (g)	Ca (mg)	P (mg)	Fe (mg)	Na (mg)	K (mg)	Thiamin (mg)	Riboflavin (mg)	Niacin (mg)	Vit. B_6 (mg)	Pantothenic Acid (mg)	Biotin (g)	Folacin (g)	Vit. B_{12} (mg)	Vit. A (IU)	Ascorbic Acid (mg)
Beef																	
Brain	10.4–11.5	8.6	10	312	2.1–2.4	125	219	0.07–0.23	0.22–0.26	3.0–4.7	0.10–0.26	2.5	2.0–6.1	4–12	4.7–10.9	Nil	16.6–23.0
Heart	14.9–28.5	3.6–20.0	5	195–230	4.0–4.9	86–95	193–320	0.19–0.68	0.80–1.02	6.3–9.5	0.23–0.43	1.2–2.3	2.0–7.3	2–110	8.0–13.7	Trace–3.0	2.0–7.6
Kidney	15.3–24.7	2.6–6.7	10–11	219–230	5.7–7.4	176–180	225–230	0.28–0.38	1.90–2.55	5.4–7.9	0.32–0.44	3.4	24.0–92.0	41–77	8.5–31.0	264–880	8.9–15.0
Liver	19.0–22.9	3.8–7.8	6–8	352–360	6.5–7.0	81–136	281–320	0.23–0.28	2.78–3.30	12.8–21.0	0.74–0.94	5.5–8.3	33.0–100.0	81–330	65.0–110.0	12709–105032	2.6–31.0
Pancreas	17.6–27.1	7.3	8	216–330	2.8–8.4	67	276	0.14	0.34–0.55	3.1–5.8	0.20	3.8	14.0	—	4.8–5.0	Nil	13.7–14.0
Tongue	15.3–22.2	10.4–14.6	6–8	170–182	2.1–2.9	73	197–250	0.12–0.17	0.28–0.49	3.9–4.9	0.13–0.31	2.0	1.0–3.3	4–7	3.79–7.0	Nil	3.1–7.0
Veal Liver	19.2–21.5	4.7–7.3	7–8	333–360	8.0–8.8	73–93	281–330	0.20–0.52	2.70–3.30	11.4–16.5	0.30–0.54	6.0	39.0–75.0	46–240	100.0	13530–22500	18.0–36.0
Pork																	
Brain	10.3–12.2	8.6–9.2	10	312	1.6–2.4	125	219	0.16–0.23	0.26–0.28	4.3–4.4	0.19	2.8	—	6.0	2.2–2.8	Nil	13.5–18.0
Heart	16.8–23.5	2.7–4.4	3–6	131–220	3.3–4.8	54–80	106–300	0.31–0.61	0.81–1.24	6.6–9.6	0.29–0.39	2.5	4.0–18.0	2–4	2.4–8.0	Trace–106	3.0–5.3

Table 2.3. (continued)

	Protein (g)	Fat (g)	Ca (mg)	P (mg)	Fe (mg)	Na (mg)	K (mg)	Thiamin (mg)	Riboflavin (mg)	Niacin (mg)	Vit. B_6	Pantothenic Acid (mg)	Biotin (g)	Folacin (g)	Vit. B_{12} (mg)	Vit. A (IU)	Ascorbic Acid (mg)
Kidney	15.4–25.4	2.7–3.6	8–11	218–270	5.0–6.7	115–190	178–290	0.26–0.58	1.70–1.90	7.5–9.8	0.55	3.1	32.0–130.0	42	6.6–14.0	130–230	14.0–14.2
Liver	18.9–21.6	2.4–6.8	6–10	356–370	19.2–21.0	73–87	261–320	0.28–0.31	3.00	14.8–16.4	0.68–0.69	0.9	27.0	110–212	25.0–26.0	Nil–10900	13.0–25.3
Pancreas	28.5	4.0–15.0	—	—	18.9	—	—	0.11	0.46	3.5	—	4.6	—	—	6.5–7.0	Nil	15.0–15.3
Lamb																	
Brain	10.3–12.7	7.6–8.6	10–12	312–340	1.6–2.4	125–140	219–270	0.07–0.23	0.24–0.28	3.0–4.4	0.10–0.29	2.6	2	3–6	7.3–11.0	Trace	16.3–23.0
Heart	16.8–21.7	5.6–9.6	11	249	4.0	—	—	0.28–0.48	0.74–0.94	4.6–6.9	0.30–0.39	3.0	4	2	5.2–10.2	Trace–70	4.9–7.3
Kidney	16.8–23.1	2.7–3.3	10–13	218–260	5.8–7.6	200–220	230–270	0.38–0.70	1.80–2.40	6.8–8.3	0.22–0.30	4.3	37	31–35	26.0–55.0	279–690	7.0–15.0
Liver	21.0–23.7	3.9–4.2	10	349	7.5–10.9	52	202	0.27–0.40	3.30–3.90	12.0–16.6	0.37–0.90	8.1	41–130	220–230	35.0–93.5	21324–76756	10.0–33.0
Pancreas	14.7–23.3	7.8–19.9	8–11	282–400	1.0–2.5	44–75	217–420	0.13	0.50	3.9	—	3.5	—	—	19.0	Nil	17.5–18.0

Anon (1976), Kiernat et al. (1964), Ockerman (1983, 1996), Paul and Southgate (1978), USDA (1963), U.S. Meat Export Federation (2nd Ed.), Hedrick et al. (1989), Fornias (1996).

Table 2.4. Percentage of Fatty Acids in Organ Fats.

	Liver		Heart		Kidney		Brains		Spleen	
Fatty Acid	Beef	Pork	Beef	Pork	Beef	Pork	Beef	Pork	Beef	Pork
C10:0	—	—	0.1	0.3	0.1	0.1	—	—	—	Tr.
C12:0	Tr.	—	0.1	0.2	0.1	0.1	—	—	Tr.	Tr.
C13:0	Tr.	0.1	—	—	—	0.1	—	—	—	—
C13:1	Tr.	—	—	—	—	—	—	—	Tr,	—
C14:R	—	—	0.2	—	0.1	0.1	0.2	Tr.	—	0.1
C14:0	0.8	0.8	1.3	1.9	2.0	1.1	1.1	0.3	1.3	0.9
C14:1	0.7	0.2	0.2	—	0.4	0.1	—	—	—	Tr.
C15:R	0.5	—	0.2	—	0.7	—	0.2	—	—	—
C15:0	0.7	0.5	0.3	—	0.8	0.1	2.1	0.1	0.4	0.1
C15:1	1.7	—	0.3	—	0.4	0.4	—	1.2	0.7	Tr.
C16:R	—	0.7	0.6	0.3	—	—	0.2	—	—	—
C16:0	15.0	16.2	16.2	20.0	22.4	21.4	16.4	16.0	24.2	21.6
C16:1	4.1	1.3	4.3	2.5	3.5	2.2	2.0	2.0	2.9	2.8
C16:2	—	—	—	—	—	—	0.8	—	0.8	—
C17:0	1.0	0.7	0.9	0.6	0.9	0.4	0.7	0.5	1.5	1.5
C17:1	3.7	1.7	2.3	0.1	0.9	0.3	2.8	1.1	1.0	2.3
C18:0	14.7	17.7	21.2	13.5	25.0	19.0	22.3	27.1	15.0	20.2
C18:1	19.8	27.9	29.4	39.7	29.2	39.6	30.2	34.5	31.5	29.0
C18:2	10.1	12.4	7.0	9.1	5.0	8.1	2.3	1.5	6.9	7.9
C18:3	3.2	1.1	2.0	4.5	1.5	1.7	3.9	2.9	1.6	2.2
C19:0	0.3	0.7	0.6	1.5	1.7	0.6	0.6	1.1	1.4	3.0
C20:0	4.3	1.1	1.7	1.9	0.4	0.1	1.7	0.4	2.2	0.8
C20:1	—	—	—	—	—	—	—	2.2	—	0.9
C20:2	4.2	2.2	1.9	0.8	—	0.4	—	—	—	1.5
C20:3	—	2.6	0.8	1.4	—	0.7	0.6	0.7	—	—
C20:4	8.3	9.7	1.5	0.9	2.6	2.6	8.0	7.8	5.2	2.4
C20:5	6.9	2.6	4.3	0.1	—	0.4	—	—	—	0.4
C21:0	—	—	—	—	0.7	—	1.5	—	—	0.3
C21:3	—	—	—	—	—	—	—	—	2.3	—
C22:0	—	—	1.5	0.7	0.6	0.4	1.4	0.6	—	2.1
C22:4	—	—	—	—	—	—	1.0	—	1.1	—
Saturated	37.3	38.3	46.0	40.9	56.5	43.8	48.4	46.1	46.8	50.6
Unsaturated	62.7	61.7	54.0	59.1	43.5	56.2	51.6	53.9	53.2	49.4

Tr. = trace.

Renon et al. (1980).

Table 2.5. Cholesterol Content.

Variety Meat	Treatment	Cholesterol (mg/100 g meat)
Brain	Raw	>2,000
Heart, beef	Cooked	270
Kidney	Raw	375
Kidney	Cooked	800
Lard	Rendered	95–240
Liver	Raw	300
Liver, beef	Cooked	435
Liver, calf	Cooked	435
Liver, lamb	Cooked	435
Liver, pork	Cooked	435
Sweetbreads	Raw	260
Tongue	Raw	180
Tripe	Raw	95
Muscle		
Beef, Pork, Lamb	Raw	59–79

Ockerman (1983, 1996), USDA (1963).

resulted in bacterial levels of the vacuum packages that did not increase as much as the nonvacuum packaged product. This difference in bacterial levels between vacuum and nonvacuum packaged products was greater after 14 days, and in many cases, vacuum packaging doubled the refrigerated shelf life of these stored organs (R. Strange, personal communication). In vacuum packaging, lactic acid bacteria (homofermentative and heterofermentative lactobacilli, streptococci, *Leuconostoc* spp.) became the dominant types. With organs packaged in polyvinylchloride (nonvacuum packaged), gram-negative bacteria (i.e., *Pseudomonas* spp.) frequently became dominant (Hanna et al., 1982). In addition to being utilized fresh and frozen, a few of these items are cured and/or smoked and/or pickled and/or canned.

The characteristics, storage and preparation, types and sizes, and cooking methods of variety meat, together with a buying guide, may be located in Table 2.6.

Although variety meat utilization is reasonably uniform between species and between countries, there are a few differences. Despite

Table 2.6. Preparing Variety Meat.

Kind	Characteristics	Buying Guide: Average Weight (lb)	Buying Guide: Servings	Storage and Preparation
Liver (beef, veal, pork, lamb)	Veal, lamb, pork livers more tender than beef. Veal and lamb livers milder in flavor than pork and beef.	1 beef-10 1 veal-2.5 1 pork-3 1 lamb-1	3/4–1 lb for four	Frozen, thaw in refrigerator. Fresh, refrigerate, use in 24 h. Grind, for loaves or patties.
Kidney (beef, veal, pork, lamb)	Veal, lamb, and pork kidneys more tender than beef, also milder in flavor. Veal and lamb kidney sometimes cut with chops.	1 beef-1 1 veal-3/4 1 pork-1/4 1 lamb-1/8	4–6 3–4 1–2 0.5–1	Fresh, refrigerate, use in 24 h.
Heart (beef, veal, pork, lamb)	Beef heart is least tender, but all hearts must be made	1 beef-4 1 veal-1/2 1 pork-1/2	10–12 2–3 2–3	Frozen, thaw in refrigerator.

Table 2.6. (continued)

Kind	Type and Size	Fry	Cooking		
			Broiled	Braised	Cooked in Liquid
Liver	Beef				
(beef, veal,	3- to 4-lb				
pork, lamb)	piece,			2–2.5 h[a]	
	sliced	20 min		20–25 min[a]	
	Veal (calf)				
	sliced	20 min	8–10 min		
	Pork				
	3–3.5 lb				
	whole,			1.5–2 h[a]	
	sliced	20 min		20–25 min[a]	
	Lamb				
	sliced	20 min	8–10 min		
Kidney	Beef			1.5–2 h[a]	1–1.5 h
(beef, veal,	Veal (calf)		10–12 min	1–1.5 h[a]	3/4–1 h
pork, lamb)	Pork		10–12 min	1–1.5 h[a]	3/4–1 h
	Lamb		10–12 min	3/4–1 h[a]	3/4–1 h
Heart	Beef				
(beef, veal,	Whole			3–4 h	3–4 h
pork, lamb)	Sliced			1.5–2 h	

(continued)

Table 2.6. (continued)

Kind	Characteristics	Buying Guide: Average Weight (lb)	Buying Guide: Servings	Storage and Preparation
Heart	tender by proper cooking.	1 lamb-1/4	1	Fresh, refrigerate, use in 24 h.
Tongue (beef, veal, pork, lamb)	May be purchased fresh, pickled, corned or smoked. Must be made tender by proper cooking. Pork and lamb usually purchased ready to serve.	1 beef-3.75 1 veal-1.5 1 pork-3/4 1 lamb-1/2	12–16 3–6 2–4 2–3	Fresh, refrigerate, use in 24 h. Smoked, refrigerate, use in 3 days. Pickled, refrigerate, use in 7 days.
Tripe (beef)	Plain and honeycomb, latter preferred. Purchased fresh, pickled, or canned.	Plain-7	3/4–1 lb for four	Fresh, refrigerate, use in 24 h; usually cooked

Table 2.6. (continued)

Kind	Type and Size	Fry	Cooking		
			Broiled	Braised	Cooked in Liquid
Heart	Veal (calf)				
	Whole			2.5–3 h	2.5–3 h
	Pork			2.5–3 h	2.5–3 h
	Lamb			2.5–3 h	2.5–3 h
Tongue (beef, veal, pork, lamb)	Beef				3–4 h
	Veal (calf)				2–3 h
	Pork Usually sold ready to serve				
	Lamb				
Tripe (beef)	Beef	10–15 min	10–15 min		1–1.5 h
Sweetbreads (beef, veal, lamb)	All types	Deep fat 10 min[b]	10–15 min[b]	20–25 min	15–20 min

(continued)

Table 2.6. (continued)

Kind	Characteristics	Buying Guide: Average Weight (lb)	Buying Guide: Servings	Storage and Preparation
Tripe	Often purchased precooked; requires further cooking.	Honeycomb-1.5		but requires more cooking. Pickled, soak before use. Canned, heat and serve.
Sweetbreads (beef, veal, lamb)	Divided into two parts: heart and throat sweetbreads. Tender and delicate in flavor.	Veal Neck and heart pair-1 Pieces-3/4 oz Beef Neck only Lamb-2 oz	3/4–1 lb for four	Frozen, thaw in hot water. Fresh, refrigerate, use in 24 h.
Brains (beef, veal, pork, lamb)	Very tender and delicate in flavor; veal most popular.	Beef-3/4 Lamb-1/4 Pork-1/4	3/4-1 lb for four	Frozen, thaw in hot water. Fresh, refrigerate, use in 24 h.

Table 2.6. (continued)

Kind	Type and Size	Fry	Cooking		
			Broiled	Braised	Cooked in Liquid
Brains (beef, veal, pork, lamb)	All types	10–15	20–25 min min[b]		15–20 min
Oxtail (beef)	Beef				Simmer 2 h or until tender.
Giblets (poultry)		Chicken liver-10 min			Simmer until tender. Liver 10–15 min. Gizzard and heart: young chicken 30 min; old chicken 1 h; turkey 1.5–2 h.

(continued)