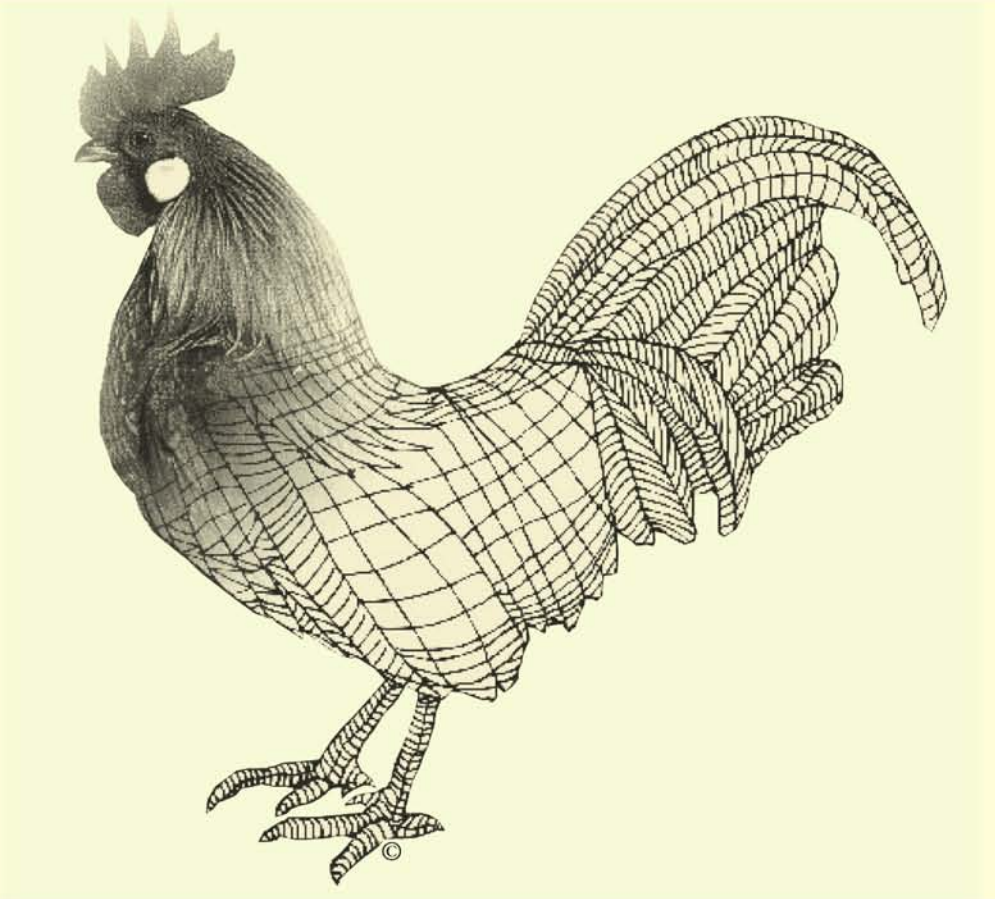
Poultry Products Processing

An Industry Guide



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To my wife Ilana

PREFACE

THIS book provides comprehensive coverage of the modern poultry processing industry for people currently working in the field and students or newcomers wishing to learn about this rapidly developing industry. The book covers all areas of modern further processing, starting with catching and hauling poultry, the operation of a primary processing plant, inspection, grading, meat processing (including chapters on equipment, formulations, preservation, and breaded products), poultry meat microbiology, sanitation, HACCP (including a detailed description of new guidelines for raw, cooked and breaded products), reviews of poultry meat color (including a trouble shooting guide), flavor, sensory, functional properties and by-products. In addition, there is a chapter on basic avian anatomy and muscle biology, to assist the reader in understanding the fundamental aspects of meat quality and processing.

The goal of this book is to provide a thorough review of the world poultry industry today. Coverage includes the major poultry meat producing species, chicken and turkey, and also duck, geese, pigeon and ratite meat. There are numerous cross-references and a list of additional reading at the end of each chapter. New trends, such as machine vision for automated grading, are discussed in order to help the reader understand the basis for past and future development.

It is hoped that this book will provide a valuable resource for personnel working in the dynamic area of further processing, including management, quality control, and sanitation personnel, food technologists, meat specialists, ingredient and equipment suppliers, as well as students and others new to the field.

I would like to thank a number of individuals who assisted me during the process of writing the book. First, to my friend and colleague, Howard Swatland, for his continuous support and encouragement to write the book. I would also like to thank the people who reviewed parts of the book and provided valuable comments: Larry Binning, Wayne Brightwell, Valerie Davidson, Ian Duncan, Chris Findlay, Carolyn Hamilton, Ed Halford, Chris Haworth, Theo Hoen, Walter Knecht, Mohan Raj, Robert Rust, John Summers, Uwe Thode, Bethany Uttaro, and Diane Wood.

I would like to make special mention of Kim Rawson whose continuous help in entering data, illustrations, revisions, and editing has contributed so much to the production of the book. I would like to thank Alex Galvez for providing the front cover artwork, Ori and Gal Barbut for illustration work and the editors at the Technomic Publishing Company for their support and guidance.

Overall, the development of the poultry processing area has been a team effort involving many talented individuals. It would be impossible to mention them all here, but one of them is my former advisor at the University of Wisconsin, the late Arthur J. Maurer, whose enthusiasm and guidance were invaluable to the development of my career.

If you have any comments/suggestions, I would appreciate hearing from you. You can contact me at my home page—http://surf.to/poultry.

Poultry Meat Processing and Product Technology

INTRODUCTION

POULTRY meat is consumed all around the world and, over the last few decades, has increased in popularity in many countries. Among the reasons for this increased consumption are the relatively low costs of production, the rapid growth rate of poultry, the high nutritional value of the meat and the introduction of many new further processed products. Overall, the poultry industry has changed dramatically over the past 50 years. In the early 1900s, most poultry in the western world was produced in small flocks mainly to supply eggs to support small farm units, and the eggs and live birds' by-product of the egg enterprise were sold live in local markets. Today, the poultry industry is highly integrated and managed by a number of large corporations. Computers are used to formulate diets (e.g., least cost feed formulations), forecast market trends, control meat processing equipment, and lately, also to operate machine vision used for automatic inspection and grading. The Internet and E-commerce are starting to play a major role in marketing. For example, in the summer of 2000, some of the major North American meat processors created on-line business-to-business marketing for poultry meat.

In the early 1900s, the same chicken breed was used for both meat and egg production, with little or no selection. Over the years, the poultry industry has grown and specialized in meat production and egg production breeds, as will be discussed later in this chapter. In addition, farmers have started to specialize in certain aspects of raising poultry and, today, it is common to find operations specializing in only one phase of the growing stage (e.g., breeding, hatching or meat production). Modern growing operations are usually fairly large and house a few hundred thousand to a few million birds at one location. Such operations require precise management control and must run efficiently in order to be profitable. Vertical integration of poultry operations has been another major change in the structure of the poultry industry. Such an integration usually starts with the hatchery, moves through to the growing operation, which includes the feed mill, and moves to the processing plant. This helps to streamline the operation and makes production more cost effective

and competitive. This book focuses on the further processing aspects and includes discussion of factors affecting meat quality such as growing conditions, catching and transportation.

The further processing segment is rapidly developing with the integration of automated equipment, advances in food science, food microbiology, engineering and marketing. Past achievements have been the contribution of many individuals, and further advances will require the cooperation of technologists, scientists and businesspeople. The industry is still facing many challenges, and the way they are handled will determine the efficiency and competitiveness of the poultry industry compared to other meat and non-meat protein sources. Such challenges include live bird catching and hauling, where reduction in the amount of bruising and improving worker conditions are critical. The use of new automated catching equipment will be discussed, as well as the monitoring and control of environmental conditions on the truck during transportation. In the processing plant, various changes are taking place today, where stunning methods are re-examined, and the use of gas stunning is starting to emerge. In the further processing area, new formulations that include gums, coating materials and sophisticated cooking equipment are constantly being developed. Today, emphasis is put on food safety and on the implementation of hazard analysis critical control point (HACCP) programs in order to meet new government regulations. Processes such as irradiation are gaining acceptance as part of the overall goal to reduce foodborne illnesses. In addition, animal welfare issues are becoming more important today on the political agenda, and public concern has promoted various groups to demand changes in the handling and processing of poultry. In places such as Europe, representatives from large supermarket chains are visiting growing and processing facilities to ensure proper handling of live birds and, in some cases, are demanding changes.

The industry has done a tremendous job increasing the popularity of poultry meat around the world. Maintaining this position will require innovations, new ideas and strategies in the ever-increasing competitive food market. These are really exciting times for the poultry industry, and the goal of this book is to assist people already in the business and newcomers in gaining an overview of the entire industry. In addition, emphasis has been placed on providing students with background material that will allow them to understand fundamental aspects, such as poultry biology, muscle structure and conversion of muscle to meat.

PRODUCTION

Poultry meat is produced all over the world. Figures 1.1 and 1.2 show the major areas of the two most commonly produced poultry species, namely chicken and turkey. Chicken production is concentrated in four major areas (Figure 1.1). In North America, about 44% of the world's production, or

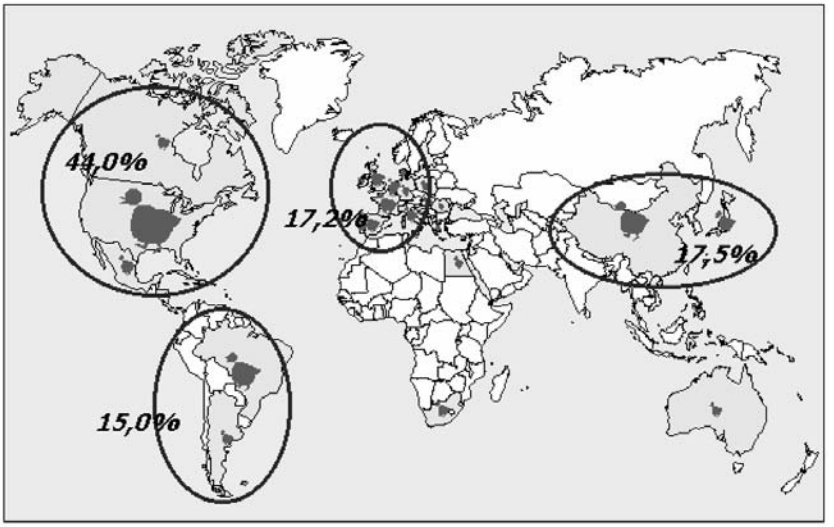

Figure 1.1. *World Chicken Production in 1996. From French Meat Industry Center (2000).*

14,000 million tons, were produced in 1996. The United States produced 12,160, Mexico 1,120 and Canada 710 million tons. Asia produced about 5,550 million tons, with China accounting for 4,400 and Japan 1,150 million tons. Western Europe produced 5,460 million tons, with France accounting for 1,150, United Kingdom 1,016, Spain 840, Italy 693. The Netherlands 580,

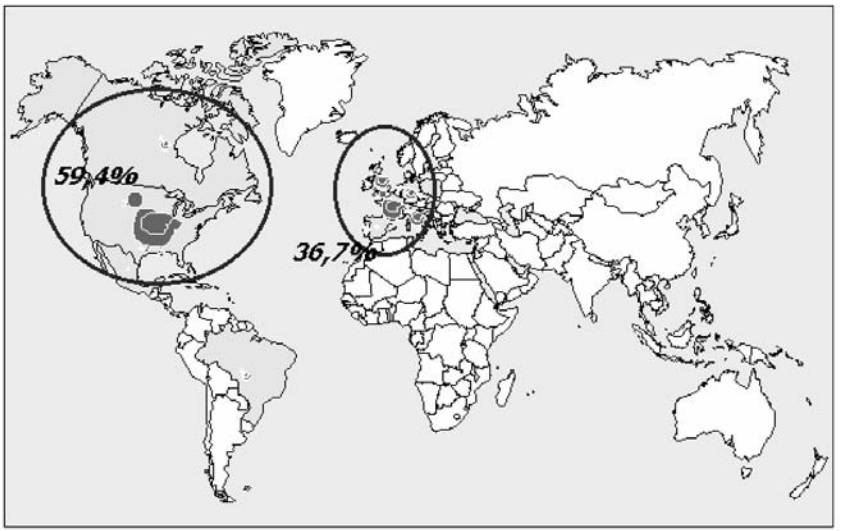

Figure 1.2. *World Turkey Production in 1996. From French Meat Industry Center (2000).*

Germany 350, Belgium 255, Portugal 200, Denmark 155, Greece 146 and Ireland 70 million tons. In South America, 4,780 million tons were produced, in Brazil 4,130 and in Argentina, 650 million tons. Other countries such as South Africa produced 647 million tons, Australia 453, Egypt 34, Hungary 218 and Poland 190 million tons.

Turkey production is concentrated in three major areas (Figure 1.2). In North America, 2,630 million tons were produced, in the United States 2,480 and in Canada 143 million. In Western Europe 1,625 million tons were produced, in France 680, Italy 310, United Kingdom 280, Germany 215, Portugal 42, Ireland 33, The Netherlands 28, Spain 17, Denmark 10 and Greece 3 million tons. Other countries were Brazil with 100, Poland 49 and Hungary 27 million tons.

Figure 1.3 shows changes in turkey production in selected countries over the period 1987 to 1997. The figure illustrates continuous growth of over 50% during that period. The highest production was in the United States, where turkey meat is very popular and represents about 18% of the total meat consumed, as will be later discussed.

Chicken is the species most commonly produced around the world, followed by turkey and, to a much lesser degree, by other species. Table 1.1 shows the common commercially available poultry along with their market age, their average carcass weight and their ready-to-cook (RTC) weight. In certain areas of the world, such as Southern Asia, duck production represents a very significant segment of total poultry production. Local species of pigeons and quail have been an important staple in the diets of people in the Middle East for many centuries. Meat production from several "exotic species" such as ostrich and rhea are becoming more popular as these species are

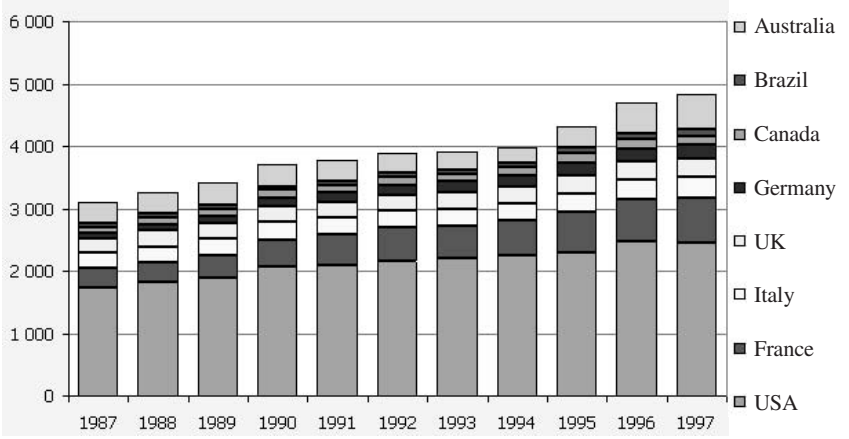

Figure 1.3. *Turkey Production (Metric Tons) in Some Major Countries. From French Meat Industry Center (2000).*

Table 1.1. Types of Commercially Available Poultry and Their Average RTC[a] Weight.

Type	Age (Weeks)	Weight RTC (kg)
Chickens		
Broiler or fryer	6–8	1.2–1.7
Roaster	8	3.0
Rock Cornish game	3–4	0.6
Hen/stewing fowl	>52	1.1
Cock or mature rooster	>30	2.2
Turkeys		
Broiler hen	10	4.2
Young hen	16	7.0
Young tom	17–18	12.5
Spent breeder	>52	11.0
Ducks		
Broiler or Fryer	7	2.5
Geese		
Mature	12–16	5
Guineas		
Mature	12	1.5
Pigeons	4–5	0.4
Quail	7	0.15
Ratite		
Ostrich	40–55	55
Rhea	44–48	62

[a]RTC = Ready-to-cook weight (i.e., body weight excluding feathers, blood, digestive tract, head and feet).

raised on commercial farms in countries such as Australia, South Africa, Israel, Canada, the United States and Zimbabwe.

Poultry production figures for 1998, of selected countries, are presented in Table 1.2. Some of the main changes from the 1996 figures (not presented) result from the significant increases in broiler production in China (4,400 to 5,460, respectively) and in Brazil (4,130 to 4,490). These changes represent the growing popularity of poultry meat in China and the increase in exports from Brazil. One of the main reasons for Brazil increasing its exports is its large increase in corn and soybean production, thus resulting in relatively low production costs. Table 1.3 shows that Brazil had one of the lowest producing costs in 1997. Data from Aho (1996) indicate that Brazil enjoyed very low feed and plant labor costs (Figure 1.4). This obviously gives Brazil an advantage over other countries, making it one of the major players in the poultry export market. Countries like the United States, due mainly to their relatively low feed costs (Figure 1.4), are also competitive on the international trade market. Another example from South Asia is Thailand, where low plant labor costs have

Table 1.2. Poultry Production in Selected Countries (1998). Reported in 000 Metric Tons. From U.S. Department of Agriculture (1999).

Country	Broiler	Turkey
United States	11,515	2,395
China	5,460	NA
Brazil	4,490	107
France	1,235	732
United Kingdom	1,144	275
Japan	1,075	NA
Canada	710	139
The Netherlands	648	57
Australia	524	NA
Russian Federation	1,142[a]	NA

[a]Estimates for 1995. NA = not available.

allowed it to be a major exporter to markets such as Japan. Figure 1.4 can be divided into four major zones with regard to overall production costs. Brazil had the lowest costs in 1996, with China and the United States having similar production costs when combining feed and plant labor costs, while Argentina, Turkey and Thailand make up a third group with similar overall costs. Finally, the countries on the right side of the figure have high production costs, thus excluding them from the export market. The above is very important in understanding world trade in poultry meat, as will be discussed later in this chapter.

Table 1.3. Cost and Wholesale Price (Per kg) Comparison of Broiler Production in Various Countries (1997). From Mulder and Schlundt (1999).

Country	Raising Costs (U.S. Cents)	Wholesale Price (U.S. Cents)
United States	57	123–213
Brazil	55	94–108
China	80	133
Thailand	100	140
France	90	205–442
The Netherlands	83	194–320
Japan	132	287–1,021
Russian Federation	185	265
Saudi Arabia	222	379
Sweden	110	270–400
Finland	152	412

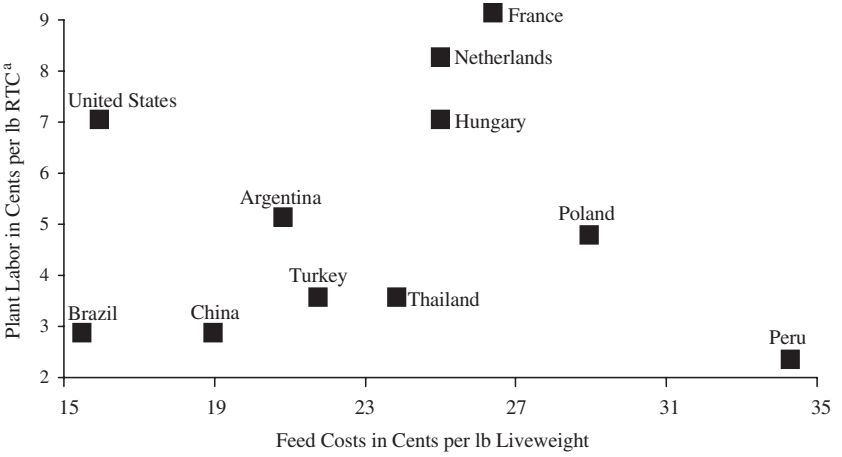

Figure 1.4. *Poultry Production Competitive Advantage. From Aho (1996). With Permission from Watt Publishing.* [a]*RTC = Ready to Cook.*

While the human population is currently increasing at 1.4% per year, it is forecasted to increase by an average of 1.2% to 2020, reaching 7.7 billion. Urbanization is increasing, and incomes are rising in many parts of the world. Both of these trends are associated with increased per capita demand for meat that is increasing at a faster rate than population growth (CAST, 1999). Per capita meat consumption for 1983 and 1993, and a projection for 2020, are presented in Figure 1.5. The projection for 2020 is based on a model developed by the International Food Policy Research Institute for developed and developing countries. Although, as recently as the 1980s, people in the developing world consumed just over one-third of the global meat supply, they are now consuming closer to half. By 2020, this group is forecasted to be consuming 63% of total meat production. Per capita consumption is forecast to be little changed in the developed world, increased by more than 50% in developing countries, and almost doubled in China. Various factors could influence this projected increase, a major one being the current relatively low meat intake of some countries.

Urbanization is also associated with an increased demand for animal products. On the average, the rate of people moving to cities is 3.5% per year in developing countries vs. 0.75% in developed countries (CAST, 1999). Higher average incomes are another important factor directly affecting increased demand for meat. In the past two decades, industrialization and higher incomes have been greatest in Asia, where the largest increase in meat consumption has been seen. The annual rate of increase in meat demand, from the early 1980s to 1990s, was 5.4% in Asia, with the exception of India and China, compared to 1.8% in the United States and an even smaller increase in Europe. China

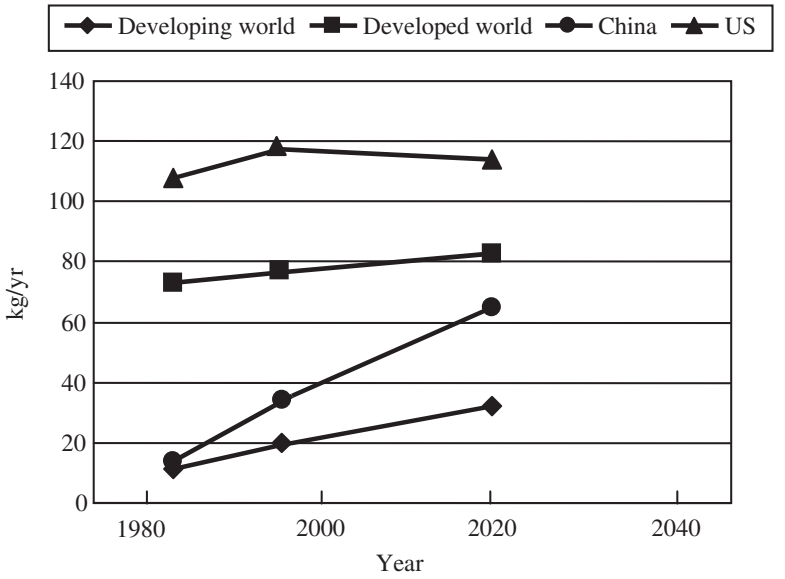

Figure 1.5. *Per Capita Meat Consumption (kg/yr). From FAO data in Delgado et al., 1998. Report by CAST (1999). With permission.*

has experienced an 8.3% increase, while India, for religious and cultural reasons, retained its preference for vegetarian diets. If the Indian preference should change to any significant extent, its population that is rapidly approaching one billion, would have a major effect on world livestock markets.

Recent growth in consumption of different meats and projected figures are presented in Table 1.4. In developed and developing countries, the largest recent and projected increases are in poultry meat. The high annual growth rates in poultry, pork and beef in developing countries (7.4, 6.1 and 2.8%, respectively, for 1983 to 1993) are not expected to be sustained; however, rates above 2% per year are projected for these meats in developing countries through 2020. As a result, developing countries are projected to produce more meat than developed countries. Higher demand in developing countries is expected to increase imports from various developed countries, which will be discussed later in this chapter.

Looking into the future, we must remember the achievements and changes experienced by the poultry industry during the last century. Table 1.5 shows tremendous improvement in selecting and raising meat-type broilers. Whereas, in the early 1900s, it took about 120 days (17 weeks) to raise broilers to a live weight of 1 kg, with a feed:gain ratio (kg feed/kg weight gain) of 5.0:1; today, it takes an average of 50 days (7 weeks), with a target live weight of 2.6 kg and a feed:gain of 1.9:1. This has been the result of significant selection for meat-type producing broilers. In addition, advances in pharmaceutical

Table 1.4. Past and Projected Production Trends of Various Meats, to the Year 2020.[a,b]

Region	Annual Growth of Production 1983–1993	Projected Annual Growth of Production 1993–2020	Total Production			Per Capita Consumption		
			1983	1993	2020	1983	1993	2020
	(%/yr)		(Mt)			(kg)		
Developed								
Poultry	2.8	1.2	17	26	37	14	20	27
Beef	0.4	0.8	32	33	40	27	25	29
Pork	0.9	0.4	35	37	42	29	29	30
Meat	1.2	0.8	92	100	124	77	78	89
Developing								
Poultry	7.4	3.0	9	21	46	3	5	7
Beef	2.8	2.4	17	22	42	4	5	7
Pork	6.1	2.8	21	39	84	6	9	13
Meat	5.2	2.7	51	88	182	15	21	29

[a]Sources: Delgado et al., 1998. Raw data prior to 1995 from FAO (9/17/97), and projections to 2020 from a model described by Delgado. From CAST (1999). With permission.

[b]Meat includes beef, pork, mutton and goat and poultry. Annual growth of meat production 1982–1993 is the compound growth rate from regressions fitted to FAO annual data. Metric tons and kilograms are three-year moving averages centered on the year shown.

Table 1.5. Growth Characteristics of Mixed-Sex Broilers Grown to Typical "Market Weights." From Leeson and Summers (2000). With Permission.

Time Period	Age (Days)	Live Wt (kg)	Live Wt Gain (g/Day)	Feed:Gain	Mortality (%)
1920s	120	1.0	8	5.0:1	20
1930s	100	1.2	12	4.6:1	15
1940s	85	1.4	17	4.0:1	10
1950s	75	1.5	20	3.2:1	8
1960s	70	1.6	23	2.5:1	8
1970s	60	1.9	32	2.2:1	5
1980s	50	2.2	44	2.0:1	5
1990s	50	2.6	51	1.9:1	4

products and husbandry practices have resulted in dropping mortality from 20% in the early 1900s to about 4% today. This has allowed the industry to become much more competitive and cost efficient as compared to red meat sources. For comparison purposes, it should be noted that a common feed:gain ratio for pork production is about 5:1, and it takes 8–12 months to market. For beef, feed:gain is around 7:1, and it takes 12–24 months to reach market weight. In the case of beef, it should be mentioned that grazing and foraging diets (high in fiber, which is undigested for monogastric animals such as poultry and pork) can result in a relatively low feed cost for cattle.

Table 1.6 also illustrates some of the major changes in the way agriculture is practiced today in various western countries. The example is from Ontario, but it is applicable to many other areas. One of the major changes is the huge reduction in the number of farmers raising poultry. The table shows that the number has been reduced by 98.5% over a 40-year period. In the early 1950s, farmers used to keep small backyard flocks that supplied them with poultry and eggs for their own farm consumption and some for sale at local markets. Today, such operations are almost nonexistent, and the average poultry operation size is measured in thousands. While the price of meat has increased over the years, as would be expected by increases in living costs, it is interesting to note that the actual price the consumer pays (after adjusting for inflation) is much lower today than it was 50 years ago. Egg production data is also shown in the table in order to illustrate the major advances in egg production and the separate selection programs designed to improve egg-producing lines. Egg prices have also significantly decreased (after adjusting for inflation) over the past 50 years as a result of technological advances in genetics, nutrition, management and disease control.

Table 1.6 also shows the tremendous increase in chicken production in Ontario. Half a century ago, 4.5 million people consumed 10 kg of poultry meat per person/year. In 1991, 10 million people consumed 30 kg/year, which was

Table 1.6. Changes in the Poultry Industry and in Ontario's Agriculture. Adapted from Surgeoner and Leeson (1993).

	1951	1991
Ontario population (M)	4.5	10
Farms (poultry/eggs)	100,000	1,500
Chicken[a] (kg)	10	30
Chicken production (M-kg)	45	300
Price (kg)	C$1.4	C$4.2
Adjusted for inflation[b]	C$8.2	
Eggs[a]	280	214
Egg production (M-doz)	107	180
Price (doz)	C$.72	C$1.50
Adjusted for inflation[b]	C$4.3	
Eggs/hen	160	290
Feed efficiency (kg/doz)	3.4	1.6

[a]Per person year.

[b]Price index increased 498%.

mostly raised in the same area. This obviously represents significant economical growth, but it has also put pressure on the environment. Problems such as pollution are receiving more attention today, and certain countries, such as the Netherlands, are currently limiting or even reducing animal production.

It should also be mentioned that the present number of around 1,500 poultry farms in Ontario is probably relatively high compared to similar production in the United States. This is mainly due to political differences, where in Canada, the existence of Marketing Boards is still providing room for some small/medium-sized farms. This is different from in the United States, where a relatively smaller number of large corporations are responsible for raising most of their broilers. When it comes to further processing plants, the situation on both sides of the border is fairly similar, where few large plants are employed to process all of the area's poultry production.

CONSUMPTION

Poultry meat consumption varies around the globe, where various factors affect consumers' demand. Among these factors are consumer preference, tradition, price and source of feedstuff available. Figure 1.6 shows broiler consumption in selected countries. At the top are Hong Kong, the United States and Israel, followed by Saudi Arabia, Singapore and Canada. It is interesting to note that in countries such as the United States, where total meat consumption is

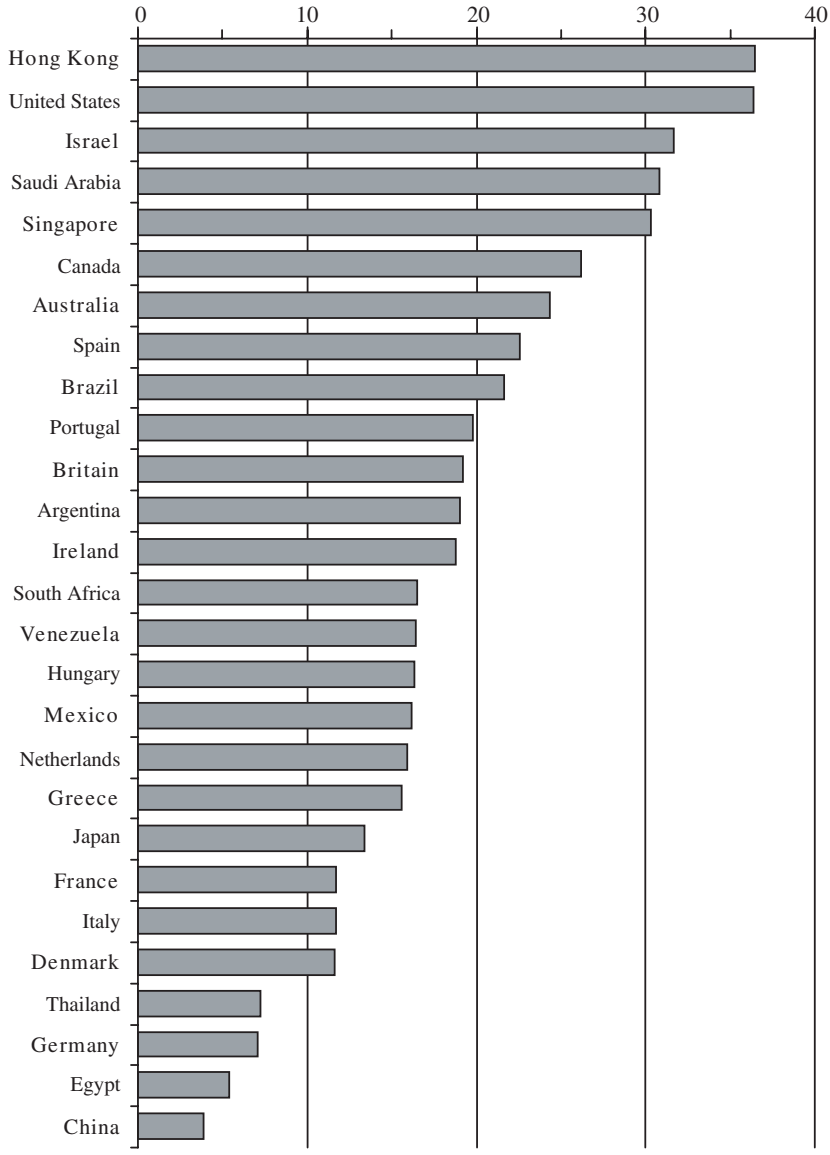

Figure 1.6. *Chicken Meat Consumption (kg per Capita) in Selected Countries during 1996. From U.S. Department of Agriculture (1999).*

high (Figure 1.5), a lot of poultry is consumed. In other countries such as Israel and Saudi Arabia, where pork meat is unpopular because of religious concerns, poultry meat consumption is very high.

Turkey meat consumption is shown in Figure 1.7, indicating that the highest consumption is in Israel, followed by the United States and France. Again,

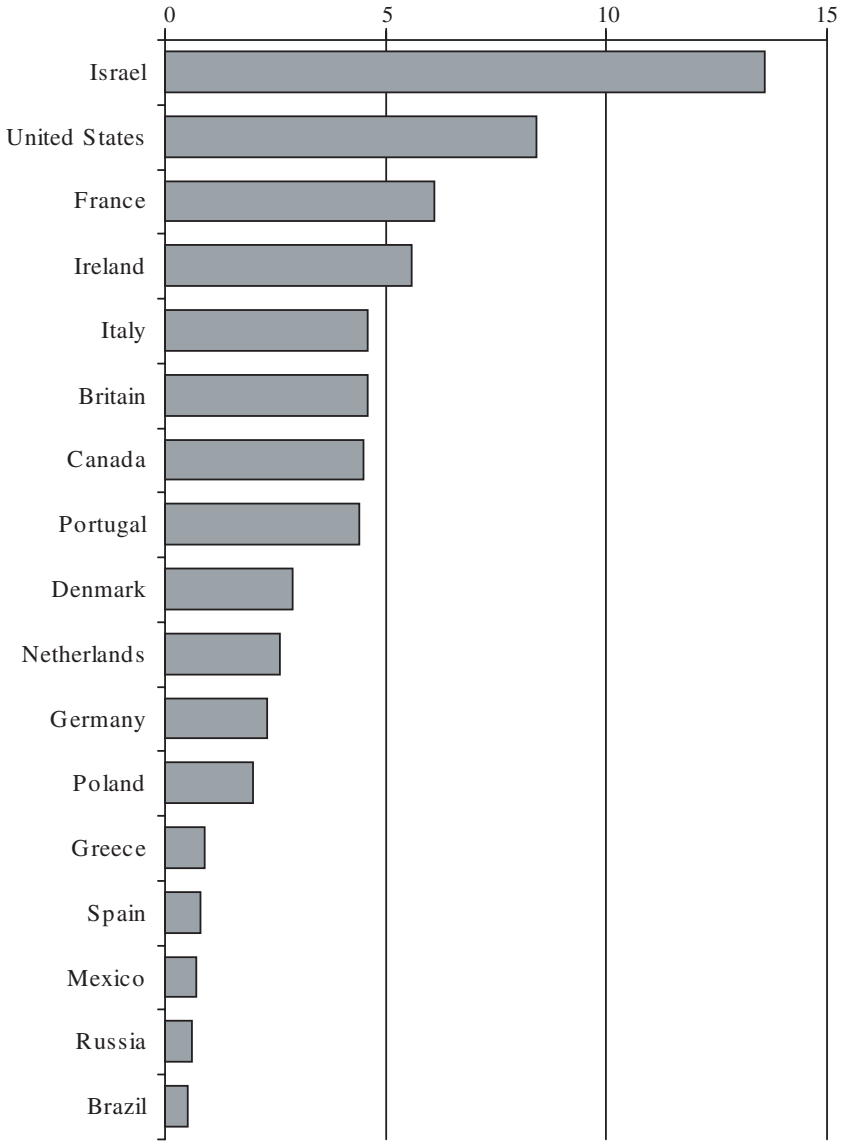

Figure 1.7. *Turkey Meat Consumption (kg Per Capita) in Selected Countries during 1996. From U.S. Department of Agriculture (1999).*

some of the factors contributing to high demand are religious concerns, while others are tradition and relative cost.

It is also important to study trends in poultry meat consumption within the same region. Figure 1.8 shows changes in some of the European Union countries between 1984 to 1996. In all countries, an increase in poultry meat

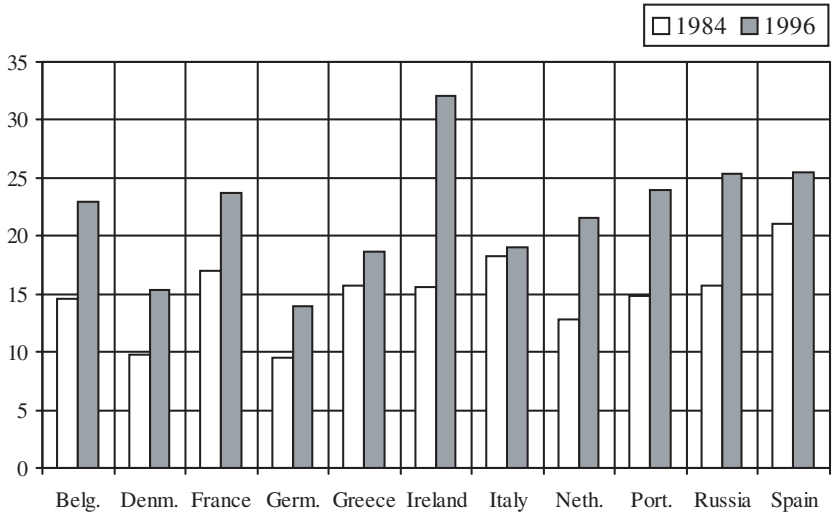

Figure 1.8. *Changes in Poultry Meat Consumption (kg Per Capita) in Some European Union Countries. From French Meat Industry Center (2000).*

consumption has been observed, but the highest was seen in Ireland. This is encouraging for the poultry industry and has resulted from the introduction of new further processed products, marketing of cut-up poultry (e.g., a package of a single turkey drumstick suitable for a small family) and the development of favorable consumer perception toward lean poultry meat. In other countries such as Japan, which was and still is a major fish and seafood consuming country, total poultry and red meat consumption have increased nearly five-fold from 1965 to 1995 (Figure 1.9). The increase in poultry meat consumption has been as significant as that of pork and beef. This is a tremendous change in the eating habits of a nation over a period of 30 years.

The relative changes in meat consumption patterns in the United States are shown in Table 1.7. It is interesting to note that the relatively flat poultry consumption figure of 17 lb/capita/year of the 1940s, doubled after the second World War to 34 lb in 1960. Poultry meat consumption doubled again in the United States over the next 20 years and reached almost 60 lb in 1980. By 1998, poultry meat consumption increased by one-third over the 1980 figure. Beef and pork consumption figures are presented for comparison reasons. It can be seen that poultry meat has replaced some red meat over the years and is representing a major competitor to red meat. Some of the main reasons for the shift seen in meat consumption trends are as follows:

- significant reduction in production costs
- introduction of new further processed products (e.g., poultry hot dogs, which were unavailable in the market 30–40 years ago)

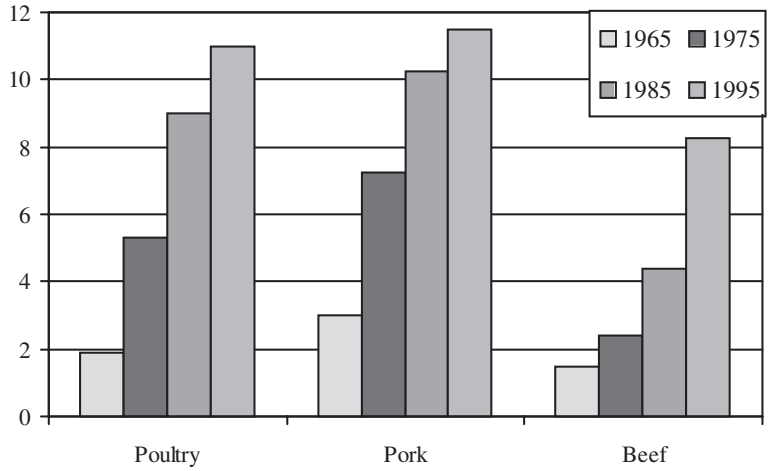

Figure 1.9. *Changes in Japanese Meat Consumption (Per Capita, kg/yr). From French Meat Industry Center (2000).*

- changing consumer demand patterns (A prime example is the total change in turkey meat sales in North America and Europe, which moved from a seasonal pattern consisting of major peaks around Thanksgiving and Christmas, to year-round sales.)
- introduction of products with small portions, such as a single turkey drumstick in a package (This change was apparently necessary to sell products to small families.)
- offering of convenient deboned and/or marinated products that do not require excessive preparation (Today, products such as fully seasoned barbecue skewers are available for purchase that only require opening the package and placing the skewers on the barbecue.)

Table 1.7. Per Capita Consumption (in lb) of Poultry Meat in the United States. Based on Retail Disappearance. From the U.S. Department of Agriculture.

Year	Chicken	Turkey	Poultry (Total)	Beef	Pork
1910	NA	NA	15.0	51.0	NA
1940	NA	NA	17.0	50.0	68.0
1960	26.5	6.5	34.0	69.4	60.3
1970	40.6	8.1	48.7	84.6	56.0
1980	48.8	10.3	59.1	76.6	57.3
1990	63.0	17.6	80.6	67.8	49.8
1998	73.9	18.1	91.1	68.1	52.6

NA: not available.

- offering ground meat products, such as lean ground turkey (e.g., turkey hamburger patties, emu patties), to compete with the traditional ground beef product
- introduction of new products with a healthier image [A fairly recent entry is turkey bacon, which is made from layers of white and dark meat (see also Chapter 8). Another example is turkey-ham, which is made from dark turkey thigh meat and is promoted as a leaner product compared to traditional ham. It is interesting to note that the introduction of new products such as turkey-ham was not without opposition from groups manufacturing traditional ham, who tried to challenge in court the use of the term "ham" for a poultry product.]
- consumer education campaigns showing the consumer that poultry products can be made with less fat and that poultry fat is more unsaturated [The latter is often mentioned in diet guidelines as being preferred over saturated fat. In addition, poultry meat does not have marbling (unlike red meat species), and removing abdominal and subcutaneous fat can result in extremely lean cuts of meat.]

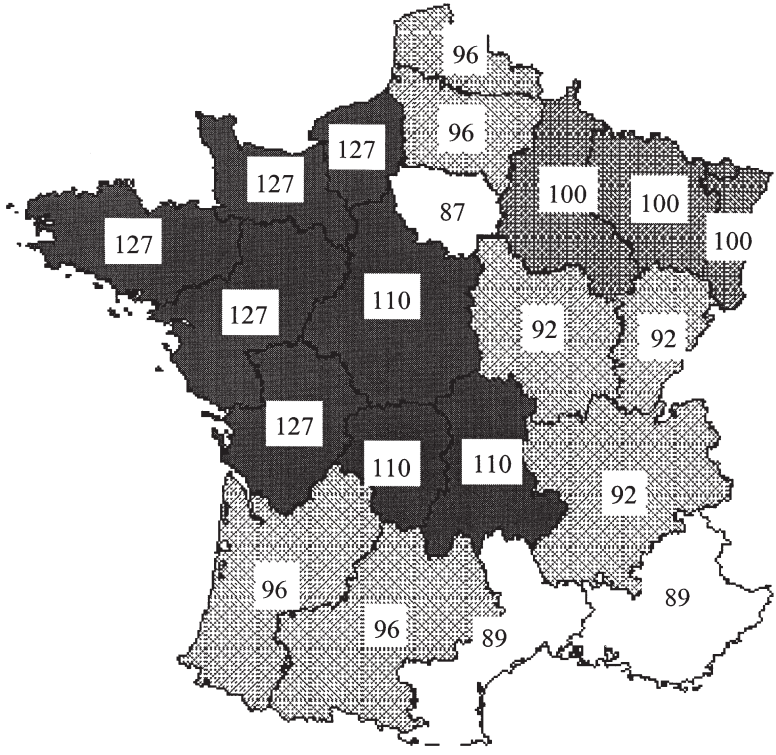

Figure 1.10. *Household Purchases of Turkey Meat in Different Regions in France during 1996 Compared to a National Average (100%). From French Meat Industry Center (2000).*

All of these factors helped to give poultry meat a healthy image and, in combination with inexpensive prices, resulted in increased consumption (Figure 1.8). However, it should be remembered that a national per capita consumption figure can vary within different regions (Figure 1.10). This figure illustrates a fairly wide variation in consumption of turkey meat in various parts of France. A similar figure for chicken meat consumption (not presented here) indicates that the variations in chicken meat are not as great and are usually close to the national average (numbers vary from 95–108% with the majority of regions consuming 100 ± 3% of the national average). The reasons

Table 1.8. Poultry Consumption Trends in Several European Countries and the United States. From French Meat Industry Center (2000).

Country		1991	1992	1993	1994	1995	1996	1997
Belgium	Turkey	2.5	2.5	2.1	2.4	3.0	3.4	3.4
	Level (%)	100.0	100.0	84.0	96.0	120.0	136.0	136.0
	Poultry	17.2	18.1	18.2	21.4	23.1	22.1	21.0
	% Turkey	14.5	13.8	11.5	11.2	13.0	15.4	16.2
Britain	Turkey	4.1	3.9	4.6	4.7	4.9	5.1	5.1
	Level (%)	100.0	95.1	112.2	114.6	119.5	124.4	124.4
	Poultry	19.9	21.2	20.2	21.8	25.1	26.2	25.5
	% Turkey	20.6	18.4	22.8	21.6	19.5	19.5	20.0
France	Turkey	5.8	6.2	5.7	5.6	6.4	5.9	5.6
	Level (%)	100.0	106.9	98.3	96.6	110.3	101.7	96.6
	Poultry	21.9	21.9	20.9	22.3	22.6	23.8	24.0
	% Turkey	26.5	28.3	27.3	25.1	28.3	24.8	23.3
Germany	Turkey	3.0	3.4	3.4	3.6	4.0	4.4	4.7
	Level (%)	100.0	113.3	113.3	120.0	133.3	146.7	156.7
	Poultry	12.2	12.5	12.4	12.8	13.4	14.1	14.5
	% Turkey	24.6	27.2	27.4	28.1	29.9	31.2	32.4
Greece	Turkey	0.5	0.4	0.6	0.7	0.8	0.9	0.9
	Level (%)	100.0	80.0	120.0	140.0	160.0	180.0	180.0
	Poultry	16.7	18.2	18.0	18.5	17.7	19.8	20.3
	% Turkey	3.0	2.2	3.3	3.8	4.5	4.5	4.4
Ireland	Turkey	4.0	4.0	5.4	5.3	5.6	6.7	6.7
	Level (%)	100.0	100.0	135.0	132.5	140.0	167.5	167.5
	Poultry	23.3	23.5	25.3	27.7	30.9	31.3	32.0
	% Turkey	17.2	17.0	21.3	19.1	18.1	21.4	20.9
The Netherlands	Turkey	2.0	2.2	2.3	2.5	2.7	2.5	2.7
	Level (%)	100.0	110.0	115.0	125.0	135.0	125.0	135.0
	Poultry	17.7	18.5	18.9	20.0	20.4	21.4	21.8
	% Turkey	11.3	11.9	12.2	12.5	13.2	11.7	12.4
United States	Turkey	8.2	8.2	8.1	8.1	8.1	8.4	8.0
	Level (%)	100.0	100.0	98.8	98.8	98.8	102.4	97.6
	Poultry	41.8	43.4	44.6	45.3	45.1	46.1	46.6
	% Turkey	19.6	18.9	18.2	17.9	18.0	18.2	17.2

for the different consumption figures can range from cultural differences to availability of certain meats in different regions.

Changes in poultry consumption in different European countries and in the United States are shown in Table 1.8. It can easily be seen that the proportion of chicken vs. turkey meat in different countries is quite variable. For example, in Greece, turkey meat consumption represents about 5%, and in France, 25%. Overall, changes in poultry meat consumption differ greatly among countries. Greece has experienced an 80% increase in turkey meat consumption, whereas France and the United States have seen a slight decline of 3–4% between 1991 and 1997. But, in both France and the United States, this decline was more than compensated for by an increase in chicken meat consumption.

TRENDS IN POULTRY MEAT MARKETING

The relative price of poultry meat has decreased over the years in the western world (Table 1.6). An example of the situation in the United States is presented in Table 1.9. The absolute retail price for 1 lb of a whole fryer has increased from 41.7¢ in 1970 to 104.4¢ in 1998. Similarly, the wholesale and retail spread has increased. However, the relative expenditure for poultry and red meat (combined figure) has decreased from 4.2% to 2.0% of disposal income from 1970 to 1998, even though total meat consumption has increased over the same period of time. This is the result of improved efficiencies in poultry production, as previously discussed.

Major changes have also occurred in the way poultry meat is marketed (Figure 1.11). At the beginning of the 1900s, most poultry in the western world was sold live or slaughtered only (i.e., not eviscerated). This is still the situation in some of the developing countries where traditional customs and/or lack of refrigeration dictate selling live birds. Figure 1.11 shows that a sharp decline in the sale of whole birds has occurred during the past 40 years in the United States. Whole birds, which used to be about 85% of the market in the early 1960s, dropped to about 15% of the market by the end of the century. The proportion of cut-up and parts has increased threefold from 15–45%. The proportion of further processed products has increased more than tenfold. This trend continues today as a higher proportion of further processed poultry products are sold to the consumer as convenient food items.

Changes in The Netherlands and Germany also indicate the same trend (Figure 1.12). The sale of whole chicken as a percentage of the total has declined in The Netherlands from 34% to 22% between 1994 and 1998, and in Germany, it declined from 69% to 58% during the same period of time. The percent of chicken sold as cut-up or parts has proportionally increased. The differences in marketing between the two countries illustrate differences in consumption habits. In general, the poultry industry is usually quick to re-

Table 1.9. Information on Chicken Prices in the United States and Their Relative Cost to the Consumer (1970–1998). From U.S. Department of Agriculture (1999).

Year	Cost Per 1 lb of Whole Fryer			Expenditure		
	Retail Price (¢)	Wholesale (¢)	Retail Spread (¢)	Poultry[a] Per Capita (¢)	Poultry and Red Meat	
					% of Disposable Income	% of Total Food Cost
1970	41.7	29.8	11.8	19.7	4.2	26.0
1975	64.3	49.4	14.9	29.9	4.2	25.8
1980	71.9	53.5	18.5	50.1	3.6	23.5
1985	76.3	56.2	20.1	70.8	2.7	19.9
1990	89.9	60.5	29.4	103.9	2.4	17.8
1995	91.7	64.4	27.3	117.5	2.1	16.3
1998	104.4	71.0	33.4	129.5	2.0	15.8

[a]Chicken and turkey.

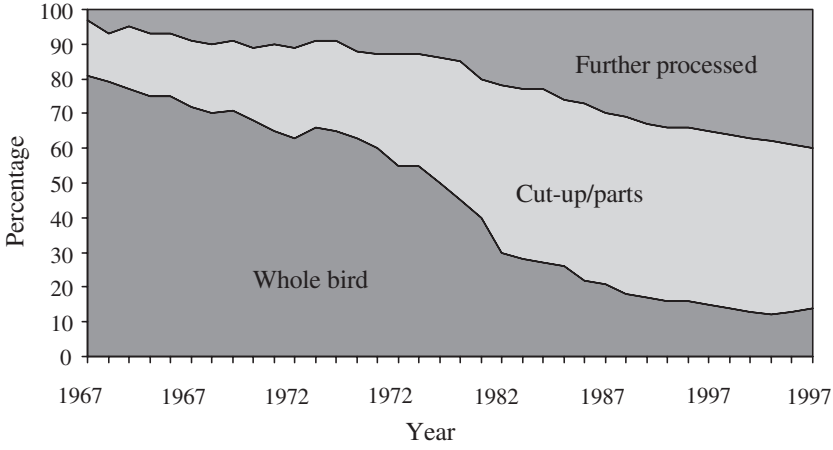

Figure 1.11. *Changes in Broiler Marketing in the United States from 1962 to 1997. From Smith (1999). With Permission from Watt Publishing. Based on Data from the U.S. National Chicken Council.*

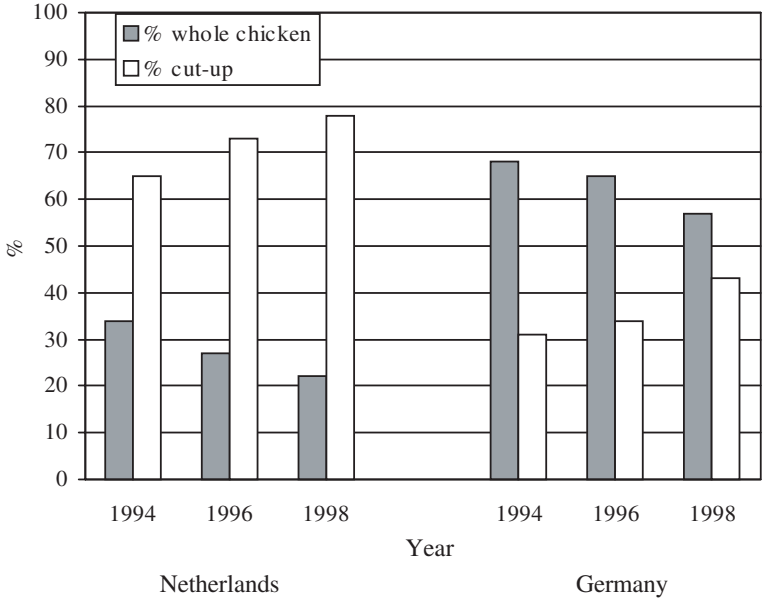

Figure 1.12. *Consumption of Whole Chicken vs. Cut-Up in The Netherlands and Germany. Adapted from Uijttenboogaart (2000).*

spond to changes in consumer preferences. It is expected that sales of cut-up chicken will increase faster in Germany than in The Netherlands, where a higher proportion of poultry is already sold as cut-up and parts.

A breakdown of cut-up and further processed products sold around the world is provided in Table 1.10. Distribution varies greatly among countries, however, further processed products sales represent roughly 13% across the world. This is small compared to the situation in North America, Europe and Japan. However, it also highlights the great opportunity for further processing to expand in regions where little further processing is presently done. Overall, markets continue to demand more value-added products, and this trend seems to be growing (Neuwirth, 1997).

The term "value-added products" refers to further processed products beyond the cut-up and ready-to-cook poultry. Increasing the consumption of value-added products represents a shift from poultry meat sold as a commodity item, to brand name value-added products sold at a premium. It appears that the food service business has substantially influenced the development and sale of convenience food items by introducing new products. One example is the chicken nugget that was introduced by one of the fast-food chains 2–3 decades ago and became a huge success story for the poultry industry. The nuggets are also currently sold in large quantities at retail stores in frozen form. In addition, convenient products such as entire dinners, entrees, appetizers and boneless marinated products have helped increase demand for poultry meat. Table 1.11 shows the relative distribution of food service and retail sales in different markets. Changing traditional buying habits and the movement toward more industrial societies are resulting in a higher proportion of food sold as further processed products. The fast-food industry,

Table 1.10. Estimates on Global Poultry Sales. From Neuwirth (1997). With Permission.

	Whole Bird (%)	Cut-Up (%)	Further Processed (%)
North America	20	50	30
Asia	48	34	18
Europe	55	25	20
South America	76	19	5
Africa	50	45	5
Soviet Union	84	12	4
Eastern Europe	61	25	14
Oceania	38	40	22
Average	58	29	13

Table 1.11. Estimates on Global Poultry Marketing. From Neuwirth (1997). With permission.

	Retail (%)	Foodservice (%)	Export (%)
North America	48	35	17
Asia	56	34	10
Europe	68	25	7
South America	64	28	8
Former Soviet Union	93	77	0
Eastern Europe	85	10	5
Oceania	67	32	1

which continues to expand, is undoubtedly helping the introduction and sale of poultry products around the world. An example is McDonald's, which has around 27,000 restaurants in 114 countries on five continents, serving 38 million customers a day. In 1999, about 2,000 new restaurants were built with only about 15% in the highly competitive North American market. One of the main regions for expansion was South America, where the number of stores almost doubled. In Japan, McDonalds opened its first restaurant in 1971, had 1,000 by 1993 and about 3,000 by 1999. This number is expected to at least double within the next decade, which obviously represents a major increase in the amount of further processed poultry product sales.

In order to stay competitive, the poultry industry must develop new products to satisfy emerging consumer demand. The increase in the number of new poultry products and poultry meal entrees in the United States is presented in Table 1.12. The number has more than doubled since 1993 in the poultry sector. The market is very competitive, and the poultry industry is competing with other meat sources as well as vegetarian entrees. Overall, one of the fastest growing segments in food retail is the frozen dinners and entrees category,

Table 1.12. New Entries of Poultry, Seafood and Red Meat Products in the United States. From Galosich (1997). With Permission.

	1996	1995	1994	1993
Poultry	202	85	132	68
Poultry meals and entrees	146	116	164	85
Fish	212	106	184	52
Fish meals and entrees	47	37	36	21
Meat	182	187	154	126
Meat meals and entrees	123	108	96	72
Totals	912	639	766	424

which reached total sales of $3.9 billion in 1998. This figure represents a 6.2% increase in sales over the previous year, and the number of units sold reached 1.83 billion. The frozen TV dinner was introduced in North America about half a century ago and since then has gone through various modifications. But, the overall concept of introducing a high quality, convenient meal for a reasonable value is still in demand. Today, the term home meal replacement (HMR) is often used to describe the concept of providing the consumer with an easy to prepare, convenient, fast meal. Some of the HMR products include presliced and marinated chicken breasts, oven-crisp chicken breast chunks and chicken tenders packaged in resealable plastic bags with serving suggestions. All are designed to allow the consumer to prepare a meal within 10 to 12 minutes. An example of chicken cacciatore with fettuccini is provided in Figure 1.13. This product exemplifies a convenient entree that can be prepared within 7 minutes in a microwave oven, as well as a meal appealing to the nutrition-conscious consumer. Clearly marked on the main product's package is the fact that the product can be prepared in a microwave (shown by a logo of a microwave oven), that the product contains less than 300 calories (of which only 10% are from fat) and that the product is also a source of fiber. Figure 1.13 also shows suggested cooking recommendations, an ingredients list and detailed nutritional information. In addition, the manufacturer provides a toll-free number for consumers' questions and concerns as part of the overall image of a "high quality product you can count on." It should be mentioned that nutritional information such as provided for this product is not mandatory in most countries but is included to attract a certain segment of the population. Such a product represents the high end of this category, which is designed to attract health conscious consumers who are also looking for a fiber source. Other products, such as a fried chicken entree, described on the package as "seasoned boneless chicken with potatoes, corn and apple-cranberry dessert" do not necessarily show the calorie content (e.g., 420 for a 290 g meal) on the package. As one industry person has said, this is a tough category because these meals compete not only with everything in the frozen category, but also with every other food option available out there, such as fast food, deli, sandwich shops and restaurants. Another segment of the convenient-food industry is refrigerated lunch kits. In the United States, this category reached sales of 0.64 billion in 1998 with about 333 million units sold. This represented an increase of 14.5% in actual dollars and 12% in the number of units sold over the previous year. The tremendous increase in HMR is related to the fact that recent surveys in North America have shown that over two-thirds of adults do not know in the morning what they are going to eat for dinner. This number is reduced to about one-quarter by 4:00 pm. This obviously will continue to present a big opportunity for the food industry, where people strapped for time are interested in finding quick meal solutions, such as semi/fully cooked poultry products, salad mixes, shredded cheese, etc.

CHICKEN CACCIATORE

with fettuccine

Tender chicken pieces in tomato sauce with red peppers, mushrooms and onions served over fettuccine pasta.

UNDER 300 CALORIES -- A SOURCE OF FIBRE

ONLY 10% CALORIES FROM FAT

PREPARATION INSTRUCTIONS:

Microwave (700 Watts): Lift corners of film to let steam escape. Microwave on high for 4.5-5 minutes, turning tray once. Let stand for 1 minute before serving.

Oven: Preheat oven to 375ºF (190ºC). Lift corners of film to let steam escape. Place tray on a baking sheet on middle rack of oven and heat for 25-30 minutes. Ovens may vary in rate of heating. Times given are approximate.

NUTRITION INFORMATION

per 1 tray serving (290 g)

ENERGY: 220 Cal; **PROTEIN: 22** g; **TOTAL FAT: 2.3** g (10% CALORIES FROM FAT); POLYUNSATURATES: 0.6 g; MONOUNSATURATES: 0.8 g; SATURATES: 0.7 g; CHOLESTEROL: 27 mg; **TOTAL CARBOHYDRATE: 27** g; SUGARS: 6.8 g; STARCH (COMPLEX CARBOHYDRATES): 17 g; DIETARY FIBRE: 3.3 g; **SODIUM: 730** mg; **POTASSIUM: 620** mg.

KEEP FROZEN UNTIL READY TO USE.
DO NOT USE IN TOASTER OVEN.
PROMPTLY REFRIGERATE ANY UNUSED PORTION.
DO NOT REHEAT TRAY.

INGREDIENTS: WATER, SEASONED CHICKEN (BREAST FILLETS, WATER, SALT), PASTA, TOMATOES (CONTAIN TOMATO JUICE, SALT, CALCIUM CHLORIDE, CITRIC ACID), RED PEPPERS, MUSHROOMS, ONIONS, CHICKEN EXTRACT, TOMATO PASTE, MODIFIED CORN STARCH, BROWN SUGAR, GARLIC, CHICKEN FAT, CONCENTRATED LEMON JUICE, SPICES, SALT.

QUESTIONS OR COMMENTS, PLEASE CALL TOLL FREE (800) 123-4567

Figure 1.13. *Information Presented on a Chicken Entree Package.*

Another interesting trend worth mentioning is the increased consumption of specially raised poultry such as the French Label Rouge. Figure 1.14 shows the percent increased consumption of these free-range chickens. The Label Rouge concept (see below) was introduced in 1965 in France and, in 1998, it captured about 30% of the market with about 97 million broilers (Laszczyk-Legendre, 1999). Currently, Label Rouge broiler production represents about 10% of the total volume of French poultry production and 16% of the chickens produced in France. During the beef BSE crisis in 1996, demand for Label Rouge poultry increased significantly, because consumers felt more confident buying meat produced by a certified organization that prides itself on having a third party auditor. Other key factors that attracted consumers were that the feed contained no animal proteins and that the third party certification process, which allows tracing the bird to a particular flock and farm, was in place.

The concept of Label Rouge traditional free-range poultry was created in the 1960s to promote a better quality product and was introduced to take the place of the traditional "Sunday chicken." The rearing specifications included the following factors: the birds should be from a special slow-growing breed; the birds should have access to an open air environment; the usable area of the poultry house, at any single production site, should not exceed 1,600 m^2; the stocking density is limited to 12 birds (maximum 25 kg) per m^2; the feed formula contains at least 75% cereals, with no animal products; the marketing age is at least 90 days; and transportation from the farm to the slaughterhouse should be no more than 2 hours or 100 km. It should be noted that these specifications are also part of the European Union specification 1538-91 for traditional free-range poultry.

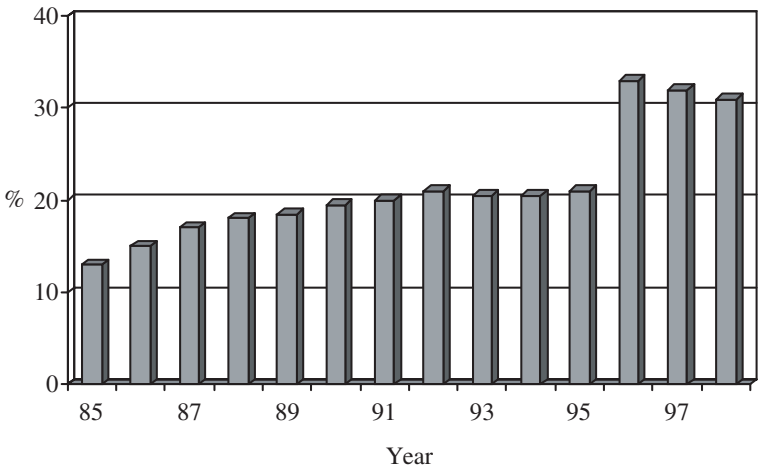

Figure 1.14. *Increase in Label Rouge Poultry Consumption in France. Adapted from Laszczyk-Legendre (1999).*

The Label Rouge logo is a trademark owned by the French Ministry of Agriculture and is conceded to certify an organization recognized for higher quality food products. Laszczyk-Legendre (1999) has indicated that "the capacity of the national organization to constantly adapt the product, method of production and certification system has brought Label Rouge poultry to a top quality level and transformed this avant garde concept to one of the future." Because this book is focusing on further processing, it will only be said that other countries are taking note of this growing trend and, depending on consumer demand in other parts of the world, further increase might be seen.

EXPORT MARKETS

Demand for poultry meat is expected to sharply increase over the next decade (Figure 1.15), in which the projected demand for poultry meat is higher than for other food commodities including red meat. Developing countries are projected to exceed the average world demand growth in all major commodities except rice. The demand for poultry and red meat, vegetable oil and grain is expected to be sharply higher in the developing countries compared to the developed countries. This will obviously result in more global shipments of poultry from high producing areas to demanding markets. It is expected that the major players will be the United States, Brazil, the European Union and Thailand. Net importers will be countries such as the former Soviet Union, Japan and China (Table 1.13).

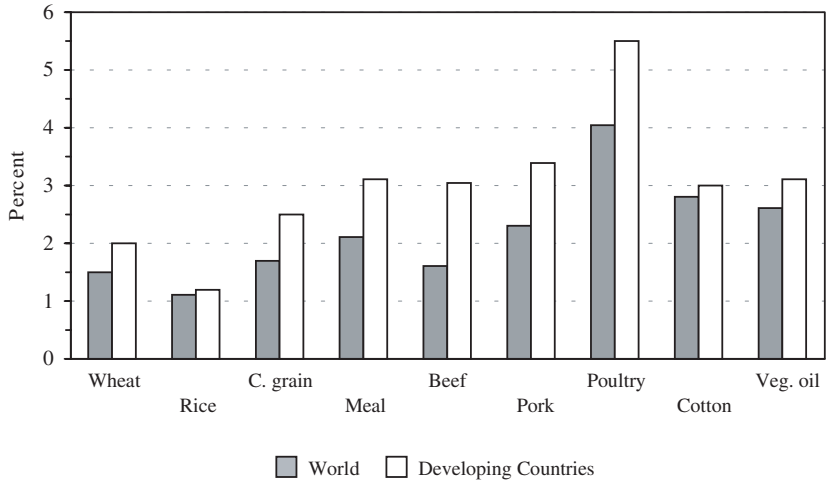

Figure 1.15. *Projected Annual Demand Growth, 1996–2007. From U.S. Department of Agriculture.*

Table 1.13. Statistical Trends for World Poultry Meat Trade. Reported in 1,000 Tons. From U.S. Department of Agriculture.

	1986	1996[a]	2006[b]
Exporting (net)	1,052	3,327	4,737
United States	257	2,052	3,058
Brazil	225	530	932
European Union	217	575	530
Thailand	65	165	161
Eastern Europe	288	5	56
Importing (net)	1,108	3,327	4,736
Saudi Arabia	180	290	341
Japan	174	533	764
Former Soviet Union	173	834	1,014
Hong Kong	89	213	284
Canada	30	35	40
Mexico	14	95	321
South Korea	—	42	154
China	28	300	672
Other countries	420	985	1,146

[a]Estimates.

[b]Projections.

Precise prediction of the world import/export market is difficult because many political and economical variables can be introduced without advanced notice. Incidences such as a major drought can result in higher feed prices in certain parts of the world and change the production cost equation (Figure 1.4) quite radically. Another example of a drastic change in the broiler's export market is shown in Table 1.14. A sharp decline in export to the former Soviet Union was seen in 1998 by United States exporters when political problems and devaluation of the Russian ruble occurred. This also had a strong effect on the average price of certain broiler meat portions (Table 1.14). The prices indicated show the average value per ton but do not include a description of the meat shipped. Overall, meat shipped to the former Soviet Union included less expensive cuts (leg meat, mechanically deboned meat), compared to higher valued meat cuts (e.g., chicken breast filets, whole birds) shipped to Western Europe, the Middle East and South America.

Overall, the material presented in this chapter indicates that an increase in the world's population and higher per capita consumption of poultry meat are expected to increase over the next few decades. This represents an excellent opportunity for the poultry industry to grow and improve. The material in the following chapters will hopefully be of value to industry personnel, students,

Table 1.14. U.S. Exports of Broiler Meat to World Regions. Summary from Thornton (1999). Based on U.S. Department of Agriculture Data.

	Region	Value in Million Dollars		Change 1997 to 1998		Volume in Metric Tons		Average $ Per Metric Ton
		1997	1998	Million Dollars	%	1997	1998	
1	Former Soviet Union	858,232	669,841	−188.4	−22	1,093,313	937,711	714
2	Asia	509,235	481,211	−28	−5.5	581,941	628,936	765
3	North America	252,635	266,435	13.8	5.5	166,799	185,477	1,436
4	Caribbean	81,486	91,774	10.3	12.6	74,915	90,488	1,014
5	Eastern Europe	48,915	62,356	13.4	27.5	66,557	84,946	734
6	Middle East	24,034	31,279	7.2	30.1	17,464	31,180	1,003
7	Africa	32,846	27,223	−5.6	−17.1	42,287	38,883	700
8	South America	16,696	23,290	6.6	39.5	18,310	29,958	777
9	Oceania	17,072	22,683	5.6	32.9	11,653	22,096	1,027
10	European Union	21,606	20,114	−1.5	−6.9	29,871	48,720	413
11	Central America	11,039	17,371	6.3	57.4	11,573	20,467	849
12	Other Western European countries	1,248	914	−0.3	−26.7	966	701	1,304
	Total	1,875,044	1,714,491	−160.5	−8.6	2,115,649	2,119,563	809

Table 1.15. Glossary. Source: French Meat Industry Center (2000).

English	French	German	Italian
Poultry	Volailles	Geflügel	Aves
Hens	Poulet	Hähnchen	Pollo
Cock	Coq	Hahn	Gallo
Turkey	Dinde	Pute	Pavo
Goose	Oie	Gans	Oca
Duck	Canard	Ente	Patos
Quail	Caille	Wachtel	Codorniz
Partridge	Perdrix	Rebhuhn	Perdriz
Feather game	Gibier a plume	Federwild	Caza con pluma
Cuts	Découpes	Teilstücke	Despieces
Giblets	Abats	Innereien	Menudillos
Leg	Cuisse	Schenkel	Muslo
Drumstick	Pilon	Schenkeule	Pata
Wing	Aile	Flügel	Ala
Breast	Blanc	Brust	Pechuga
Meat	Viande	Fleisch	Carne
Neck	Cou	Hals	Cuello
Tail	Croupion	Bürzel	Rabadilla
Skin	Peau	Haut	Piel
Liver	Foie	Geflügelleber	Higadillos
Heart	Cour	Herz	Corazón
Gizzard	Gesier	Kaumagen	Molleja

equipment manufacturers, ingredient suppliers, government personnel and consumers interested in obtaining information about further processing of poultry. In addition, to assist the reader in this international field, a table converting different poultry terms to four languages is provided in Table 1.15.

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1 CHAPTER 1 Poultry Meat Processing and Product Technology

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Poultry Volailles Geflügel Aves

Hens Poulet Hähnchen Pollo

Cock Coq Hahn Gallo

Turkey Dinde Pute Pavo

Goose Oie Gans Oca

Duck Canard Ente Patos

Quail Caille Wachtel Codorniz

Partridge Perdrix Rebhuhn Perdriz

Feather game Gibier a plume Federwild Caza con pluma

Cuts Découpes Teilstücke Despieces

Giblets Abats Innereien Menudillos

Leg Cuisse Schenkel Muslo

Drumstick Pilon Schenkeule Pata

Wing Aile Flügel Ala

Breast Blanc Brust Pechuga

Meat Viande Fleisch Carne

Neck Cou Hals Cuello

Tail Croupion Bürzel Rabadilla

Skin Peau Haut Piel

Liver Foie Geflügelleber Higadillos

Heart Cour Herz Corazón

Gizzard Gesier Kaumagen Molleja

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Courtesy of Safeline Inc., Tampa, FL, U.S.A.

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