

Eggs, Dietary Cholesterol and Heart Disease Risk: an International Perspective

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During the past 5 years, there have been a number of reports from epidemiological studies on the relationships between dietary factors and coronary heart disease (CHD) morbidity and mortality. The results from these studies indicated no significant relationship between dietary cholesterol intake and CHD incidence when multivariate analysis of the data included dietary fat and fibre. Two of the larger studies have involved analysis of data from over 43,000 male health professionals which indicated that dietary cholesterol (0.1 mg kcal^{-1}) did not contribute to the risk of either a myocardial infarction (relative risk 1.03) or fatal CHD (relative risk 1.06). In the Nurses' Health Study of over 80,000 nurses, dietary cholesterol was not a significant contributor to CHD incidence.

One additional piece of evidence against the 'cholesterol-independent effect' is the observation that across cultures there is a negative relationship between per capita egg consumption and CHD mortality. The countries with the highest per capita egg consumption (Japan, Mexico, Spain and France) are the countries with the lowest rates of CHD mortality. These data argue against an independent effect of dietary cholesterol on CHD risk and, in part, can explain the observations of Stamler and colleagues. In groups with extremely high dietary cholesterol intakes, greater than 750 mg day^{-1} , there is a correspondingly lower intake of fruit and vegetables, and higher intake of animal products. The lower intakes of fruit and vegetables result in a lower intake of dietary fibre, antioxidant vitamins, B vitamins and polyunsaturated fat. This dietary pattern would be predicted to lead to a higher incidence of hyperlipidaemia, increased oxidative stress and hyperhomocysteinaemia, all defined risk factors for CHD. The increased risk associated with an extremely high dietary cholesterol intake may not be due to the dietary cholesterol but rather the multiple nutrients, which are absent from a diet high in animal products. These confounding variables were never considered in the 'cholesterol-independent effect' hypothesis proposed by Stamler, yet are consistent with the most recent



epidemiological observations. The epidemiological data indicate that dietary cholesterol is not a significant contributor to either elevated plasma cholesterol levels or increased CHD incidence across populations.

Dietary Cholesterol and Egg Restrictions

In 1972, the American Heart Association published an update on its dietary recommendations, which included a numerical restriction in dietary cholesterol intake to less than 300 mg day⁻¹. The recommendations also included the statement that the public should limit their egg consumption to no more than three eggs per week. To date, this is the only food-specific restriction listed in the American Heart Association's dietary guidelines. Since that time, numerous health promotion agencies in the USA have included quantitative limits on dietary cholesterol intakes as part of their overall dietary recommendations. These agencies are the US Department of Agriculture/US Department of Health and Human Services and National Research Council, Committee on Diet and Health, Food and Nutrition Board, Commission on Life Sciences. However, other dietary recommendations have not included specific limits on any single food item. Interestingly, on an international basis, the majority of countries which have developed national dietary guidelines have not included dietary cholesterol restrictions as part of the general population recommendation (Truswell, 1994). The 1995 version of Dietary Guidelines for Americans (US Department of Agriculture/US Department of Health and Human Services, 1995) included numerical limits on dietary cholesterol intakes. An effort was made to assure consistency with the Food and Drug Administration Nutrition Facts Label and dietary recommendations from the National Cholesterol Education Program (Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults reported by Adult Treatment Panel II, 1994).

Dietary Cholesterol, Plasma Cholesterol and CHD Risk

Howell (Chapter 2) has presented the results of clinical studies investigating the relationship between dietary cholesterol and plasma cholesterol levels. These data indicate that dietary cholesterol, when consumed within physiological ranges, has only a limited effect on the plasma cholesterol level of most individuals. Data also indicate that between 15 and 20% of the population have hypersensitivity to dietary cholesterol whereas the majority of the population have little if any plasma cholesterol response to changes in the amount of cholesterol in the diet (McNamara, 1995).

Over the past 10 years, a second argument has been developed regarding the role of dietary cholesterol in determining coronary heart disease (CHD) risk based on a hypothesis suggesting that dietary cholesterol can increase CHD risk independently of any effect on plasma cholesterol concentrations. Shekelle and Stamler (1989) used data from the Western Electric Study to propose that dietary cholesterol could be related to increased CHD incidence even after adjustment for plasma cholesterol levels. This hypothesis is now being used as an adjunct argument for population-wide dietary cholesterol

restrictions (Krauss *et al.*, 1996). However, evidence from a number of recently reported epidemiological studies, as well as international data on per capita egg consumption patterns, all contradict the hypothesis that dietary cholesterol has an ‘independent effect’ on CHD risk.

Shekelle and Stamler (1989) reported that those individuals in the uppermost quintile of dietary cholesterol intakes had an increased relative risk for CHD (Fig. 5.1). The level of cholesterol intake in this top quintile was more than 1079 mg day⁻¹; the fourth quintile, with an average cholesterol intake of 827 mg day⁻¹, was not significantly different from the lowest quintile. These data would seem to suggest that the overall dietary pattern of the study subjects in the top quintile were substantially more different than just having a high cholesterol intake. These extreme dietary cholesterol intakes also suggest that these individuals had very high overall intakes of animal products and, correspondingly, very low intakes of grains, fruit and vegetables. Thus, the question must be raised of whether the higher CHD incidence in this group was due to what was excessive in the diet or, perhaps, what was inadequate in the diet. With today’s understanding of the role of antioxidants and the B vitamins in CHD risk, it is clear that increased relative risk can occur not only from nutrient excesses but also from nutrient deficiencies. The potential importance of such confounding dietary variables, which in theory could make a major contribution to the higher CHD incidence in this quintile, was not evaluated by Stamler and colleagues and raises serious questions regarding the validity of their ‘independent effect’ hypothesis.

In contrast, studies reported by Connor and co-workers (Artaud-Wild *et al.*, 1993) indicated that different populations could consume diets with similar cholesterol–saturated fat index (CSI) values yet have significantly different CHD incidence rates (Fig. 5.2). France and the UK have similar dietary CSI

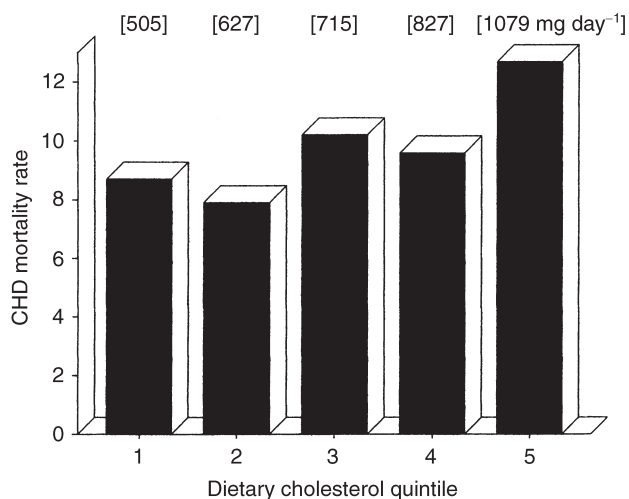


Fig. 5.1. CHD mortality rates by dietary cholesterol quintiles from the Western Electric Study (Shekelle and Stamler, 1989). The data suggest that very high intakes of dietary cholesterol are related to increased CHD incidence.

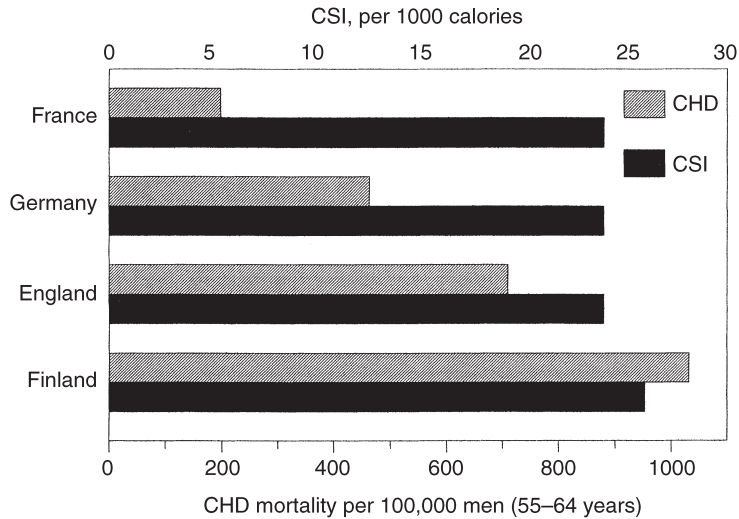


Fig. 5.2. Rates of CHD mortality in four countries relative to the cholesterol-saturated fat index (CSI) dietary patterns for each country. Data from Artaud-Wild *et al.* (1993).

patterns and yet differ almost fivefold in CHD mortality rates. These investigators concluded that a high CSI value was not a contributor to CHD risk if the diet contained large amounts of fruit and vegetables and vegetable oils. In a similar manner, in the Ireland-Boston Study, the CHD cases had a lower vegetable-food score (-0.44 versus 0.06) and a higher animal-food score (0.24 versus -0.04) than controls (Kushi *et al.*, 1985). These data are consistent with the concept that the diet-heart disease relationship is a function of both what is in the diet and what is missing from the diet.

Stamler and Shekelle (1988) also used data from a selective number of clinical studies to add additional support to the dietary cholesterol 'independent effect' hypothesis. While the data suggest that dietary cholesterol is related to increased CHD risk, it should be noted that the difference in dietary cholesterol intakes between cases and controls was only $16 \text{ mg day}^{-1} 1000 \text{ kcal}^{-1}$. Given an average intake of $400\text{--}500 \text{ mg day}^{-1}$ and an average endogenous cholesterol synthesis of 1000 mg day^{-1} , it is clear that this difference can hardly provide a plausible explanation for the differences in CHD incidence. In contrast, Ravnskov (1995) compiled a much larger number of clinical studies and presented evidence that there were no differences in dietary cholesterol intakes between cases and controls. Based on the available data, Ravnskov (1995) concluded that there was no evidence for an 'independent effect' of dietary cholesterol on CHD relative risk (Fig. 5.3).

The epidemiological evidence from cross-cultural and within-population studies has been unable to document a significant relationship between dietary cholesterol intakes and CHD incidence. The results of an analysis of the Twenty Countries database by Hegsted and Ausman (1988) found that dietary cholesterol was not a contributing factor to CHD incidence. Data from the

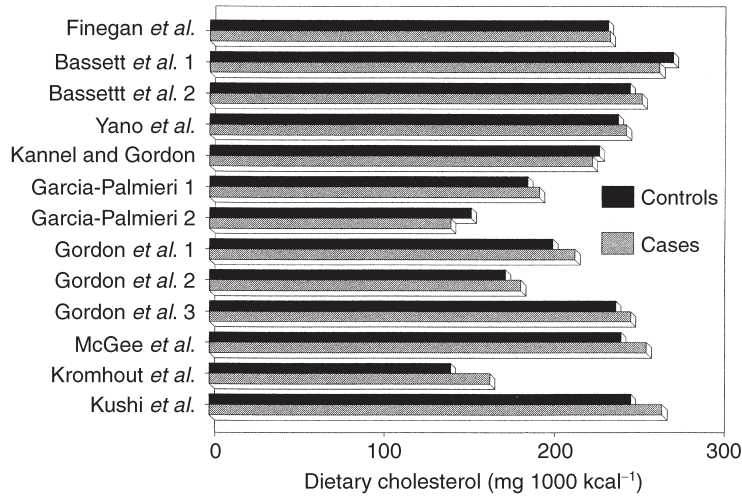


Fig. 5.3. Comparison of dietary cholesterol intakes in CHD cases and controls from 13 epidemiological trials as reported by Ravnskov (1995). See original text for specific study references.

Framingham Heart Study have also failed to document any relationship between dietary cholesterol intakes and either plasma cholesterol levels or CHD incidence (Dawber *et al.*, 1982; Millen *et al.*, 1996). Esrey *et al.* (1996) reported data from the Lipid Research Clinic's Prevalence Study of 4546 men showing that dietary cholesterol was not related to either plasma lipid levels or CHD incidence either with or without adjustment for plasma cholesterol levels. Two recently published epidemiological studies have found similar results. Data from a study in over 43,000 male health professionals indicated that saturated fat calories were related to CHD incidence while dietary cholesterol had no significant effect on relative risk of CHD, as shown in Table 5.1 (Ascherio *et al.*, 1996). In a similar manner, data from a study of 80,000 nurses indicated that dietary cholesterol did not contribute to CHD incidence, as indicated in Table 5.1 (Hu *et al.*, 1997).

From these data sets, it is clear that across cultures and within populations, dietary cholesterol is not a significant contributor either to the average plasma cholesterol level of a population or to CHD morbidity or mortality. The hypothesis that dietary cholesterol contributes to CHD risk independently of its effects on plasma cholesterol is not supported by the existing body of evidence and, therefore, should be considered an invalid argument for population-wide restrictions in dietary cholesterol intake or in egg consumption.

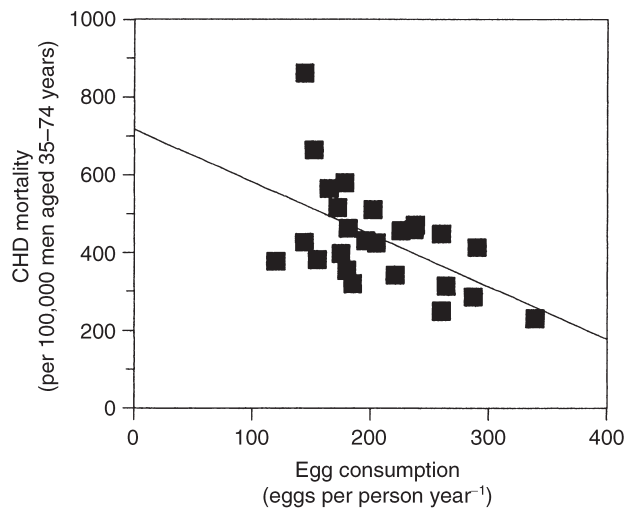
Eggs and CHD Mortality Rates

Figure 5.4 illustrates the relationship between per capita egg consumption and CHD mortality rates per 100,000 men age 35–74 years in 24 industrialized countries. There is a negative relationship between per capita egg

Table 5.1. Relationship between dietary lipids and relative risk for CHD in men and women.

Dietary lipid	Relative risk: males ^a	
	Myocardial Infarction	Fatal CHD
Cholesterol (100 mg 1000 kcal ⁻¹)	1.03	1.06
18 : 3 (1% kcal)	0.41	0.57
<i>Trans</i> -fatty acids (2% kcal)	1.13	0.93
18 : 2 (5% kcal)	0.97	0.69
Saturated fatty acids (5% kcal)	0.86	1.34
Dietary lipid	Relative risk of CHD: females ^b	
Cholesterol (200 mg 1000 kcal ⁻¹)	1.12	
Monounsaturated fatty acids (5% kcal)	0.81	
<i>Trans</i> -fatty acids (2% kcal)	1.93	
Polyunsaturated fatty acids (5% kcal)	0.62	
Saturated fatty acids (5% kcal)	1.17	

From: ^aAscherio *et al.*, 1996; ^bHu *et al.*, 1997.

**Fig. 5.4.** Relationship between national CHD mortality rates and per capita egg consumption of 24 industrialized countries.

consumption and CHD mortality rates. In fact, the highest per capita egg-consuming countries are Japan, Mexico, Spain and France, which also happen to be the countries with the lowest CHD mortality rates of any of the industrialized countries (American Heart Association, 1998). The data indicate that egg consumption *per se* is not related to CHD mortality and, in fact, appears to be negatively related to CHD deaths. It has been suggested that egg consumption has no relationship to CHD risk when included in diets high in fruit and vegetables (Kushi *et al.*, 1985).

Changes in Egg Consumption and Plasma Cholesterol Levels

It has been suggested that the decrease in per capita egg consumption from 405 eggs in 1945 to 235 eggs in 1995 explain in part the decrease in plasma cholesterol observed in the population (Stamler *et al.*, 1998). It is calculated that this 170 eggs per year decrease resulted in a 2.2 mg dl^{-1} decrease in the average plasma cholesterol level ($0.46 \text{ eggs day}^{-1} \times 215 \text{ mg cholesterol per egg} \times 0.022 \text{ mg dl}^{-1} \text{ mg}^{-1} \text{ day}^{-1}$ change in dietary cholesterol) (Howell *et al.*, 1997; McNamara, 1998). Thus, a 46% decrease in per capita egg consumption contributed to only a 1% decrease in the average plasma cholesterol level of the American population.

Eggs, Nutrition and Nutrient Density

Eggs contribute one-third of the cholesterol in the American diet (Federation of American Societies for Experimental Biology, 1995) yet its contributions to other nutrients in the diet are substantially greater than its contribution to the total caloric content. As shown in Table 5.2, eggs contribute only 1.3% of the total calories but substantial amounts of high-quality protein, folate and riboflavin, as well as a number of other nutrients in excess of its caloric contributions. The nutrient density of eggs make them a valuable contributor to the overall nutritional balance of the diet (Table 5.3) and, as an economical source of high-quality protein, an important component in the diets of the elderly, low-income families and growing children. High nutrient value at low economical and caloric expense are important considerations in the diets of many

Table 5.2. Contributions of eggs to the nutritional quality of the American diet.

Nutrient	Daily value (%)	Nutrient	Daily value (%)
kcal	1.3	Protein	3.9
Riboflavin	6.4	Vitamin A	4.3
Vitamin E	4.3	Folate	5.1
Vitamin B ₆	2.1	Vitamin B ₁₂	3.7
Zinc	2.8	Iron	2.4

From: NHANES III (Federation of American Societies for Experimental Biology, 1995).

Table 5.3. Recommended daily values of major nutrients from two large eggs (140 kcal).

Nutrient	Daily value (%)	Nutrient	Daily value (%)
Food energy	6	Protein	20
Riboflavin	30	Folate	12
Vitamin B ₁₂	16	Iron	8
Vitamin D	12	Phosphorus	16
Vitamin A	12	Selenium	34
Vitamin E	6	Zinc	8
Vitamin B ₆	8		

segments of the population, and undue restrictions on inclusion of such items in the diet are unfounded, unnecessary and potentially harmful.

Conclusions

Most industrialized countries do not recommend specific restrictions in dietary cholesterol intakes for their populations. The findings from clinical trials and epidemiological surveys indicate that dietary cholesterol is not a significant contributor to either an elevated plasma cholesterol level or an increased risk for CHD. In contrast, the dietary recommendations in the USA have resulted in eggs being considered a 'bad food' and an item to be restricted rigorously in the diet. For many segments of the population, such restrictions only result in a reduction in the nutritional value of the diet. The value of eggs as an affordable, nutrient-dense, convenient commodity is far in excess of its potential contribution to changes in plasma cholesterol. Rather than a constant over-emphasis of the dietary cholesterol content of eggs, consumers need to understand better the value of eggs in the diet and the importance of nutritional balance, variety and moderation.

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Introduction

Canadian Egg Marketing Agency

The Canadian Egg Marketing Agency (CEMA) is a national producer organization, celebrating its 25th anniversary this year. Over 1300 egg producers are involved in egg production in Canada. Laying operations have an average flock size of 13,600. The provincial range is 6500–25,000. Canada produces almost half a billion eggs each year. Since our creation in 1972, CEMA has had, as part of its mandate, the promotion of eggs in Canada. This is accomplished with a coordinated, national effort geared towards advertising, promotion, research and nutrition education. At the Agency and at provincial levels, our focus is on increasing the total market for eggs by encouraging new consumption habits.

Quality assurance

Consumers in Canada value Canadian-produced food for its quality, nutritional value and record of safety. They expect the government and food producers to ensure that they have access to the best quality of food available. This is aided by labelling eggs with the Grade 'A' symbol and 'best before' date.

Egg Consumption Trends

Confidence in the food supply enabled egg consumption to increase gradually over several decades. However, in the late 1980s, consumption patterns changed (Figs 8.1, 8.2 and 8.3). Our industry was threatened by two prominent factors: research linking dietary cholesterol to heart disease and a *Salmonella* outbreak in the UK. CEMA and egg producers around the world rallied

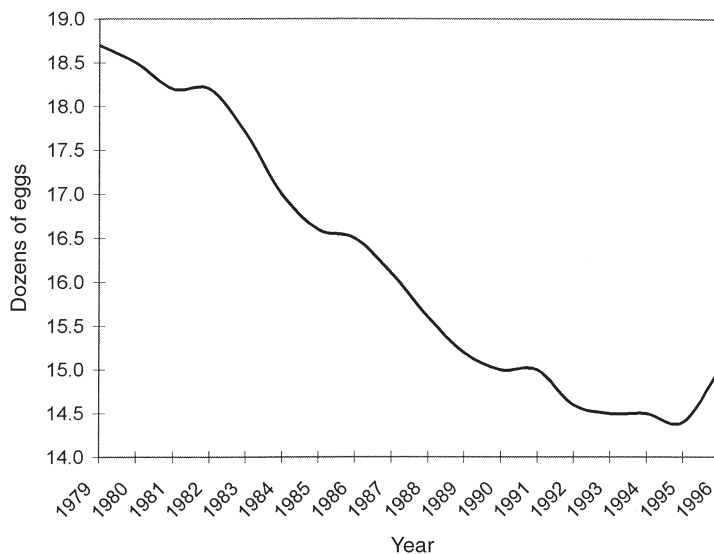


Fig. 8.1. Per capita consumption of eggs in Canada 1979–1996.

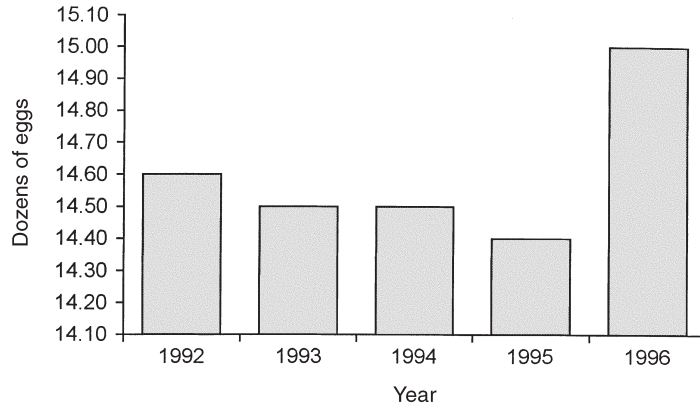


Fig. 8.2. Per capita consumption of eggs in Canada 1992–1996.

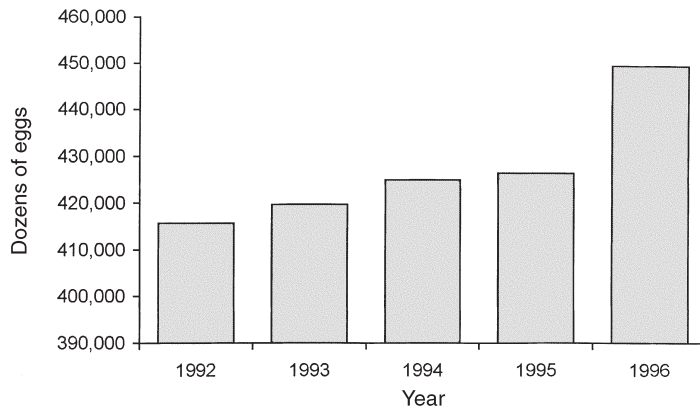


Fig. 8.3. Total consumption of eggs in Canada 1992–1996.

to address these issues. Each in its own way contributed to public chaos, confusion and panic, thereby resulting in a rapid drop in egg consumption.

In response to the *S. enteritidis* outbreak, the UK required eggs to be destroyed, culled birds and established new regulations to stabilize the situation. Unfortunately, these measures occurred after the public had lost confidence in the egg supply.

Salmonella Control Programme

Negative publicity caused Canada to respond by developing and implementing a *S. enteritidis* control programme. To establish a bench mark and dispel any concerns we had about the safety of eggs from Canadian flocks, Agriculture Canada conducted a random survey of 10% of all Canadian flocks that existed at that time. Our concerns were dispelled when the results of the survey and risk factor study showed the chance of having a Grade A egg infected with *S. enteritidis* is one in a million or once in 82 lifetimes.

CEMA remains committed to keeping eggs safe. The 'Start Clean, Stay Clean' programme introduced biosecurity measures to control *S. enteritidis* to producers. Annual on-site inspections, educational support and a compensation programme that is now linked to the strengths and weaknesses of a producer's operation are incentives used to ensure that Canadian egg producers are leaders in *S. enteritidis* control programmes.

Educational resources were also developed providing background information as well as decals or stickers to constantly remind food service workers to follow safe food-handling practices. CEMA continues to promote safe food-handling practices by participating in consumer food safety programmes. Recently, CEMA committed both financial and staff resources towards a multi-agency educational campaign on food safety called 'Fight BAC'.

Cholesterol Concerns

Addressing the cholesterol concerns associated with egg consumption was equally challenging. By the mid 1980s, the media had ensured that consumers, even those with very little interest in nutrition, could associate eggs with cholesterol. For a while it appeared that not eating eggs was a cure for heart disease.

Addressing public concern for heart disease has been an uphill struggle. At times, the egg industry has had some formidable opponents. The American Heart Association and the American Surgeon General advised consumers, up until recently, to limit egg consumption. While the Canadian government chose to focus on saturated fat rather than cholesterol, many health professionals continued to identify eggs as a food that should be consumed less frequently. How do you market a product in such a negative environment?

Consumer Studies

Understanding your consumer becomes essential. The first step involves routine market surveillance or a situational analysis. CEMA has been fortunate to have a board that values research and measurement. Since the early 1980s, CEMA has commissioned national Consumer Usage and Attitude studies (U & A). The primary objective of the study is to gather information about Canadian shoppers. We want to understand how and when they eat eggs, and why.

The research identifies personal egg consumption by the primary grocery shopper, household egg consumption, egg usage, purchasing patterns, health concerns, attitudes towards eggs and advertising recall. Information is collected from more than 1200 telephone interviews.

In 1997, the U & A provided some very positive news for CEMA:

- Although cholesterol continues to be of concern, it is having less of an effect on people's egg eating behaviours.
- Eggs are perceived as an excellent source of protein, and a good source for many vitamins and minerals.
- Eggs are identified as one of their top three staples.

Clearly the scientific findings being generated and that CEMA is promoting have started to reach the consumer.

CEMA has gone beyond looking at light, medium and heavy egg consumers. Research was used to determine quantitatively who in the household is eating eggs, how many eggs each member is consuming in what form, who prepares them and when. Detailed information based on extensive record-keeping assists us in developing secondary target audiences. For the first time in CEMA's history, we are now considering developing targeted messages to individual household members, specifically teenagers.

Another tool used to monitor consumer habits is the National Institute of Nutrition's Tracking Nutrition Trends Study. CEMA has been one of the founding sponsors for this research. Three reports have been produced to date: 1989, 1994 and 1997.

Two conclusions from the most recent report impact on CEMA's strategy:

- 'Nutrition should continue to play a significant role in food product development and marketing activities of the agri-food industry. Special focus should be placed on quick and easy solutions in healthy eating, which provide convenience in conjunction with nutrition value'.
- 'Education efforts should continue to maximize consumer understanding of the nutritional information that is provided and to put nutrition in some type of meaningful context for Canadian consumers'.

New Egg Marketing Strategies

As a result of these combined findings, CEMA has developed our most recent marketing strategy to promote 'It's okay to eat eggs more often'. Our goal is to build on the shifting attitudes towards eggs. We will do this by promoting quick and easy egg recipes that portray eggs in a healthy way. The same messages will be incorporated into our integrated marketing plan. TV advertisements, retail promotions, magazine inserts and educational resource material will focus on promoting nutritional value, versatility and convenience.

While consumers have responded favourably to our current marketing campaign, it is not enough. The egg industry must work with health professionals to add credibility and strength to our message that eggs are part of a healthy diet.

By establishing a Resourceful Partner theme, CEMA has entered into an important dialogue with health professionals.

Through conference sponsorships and exhibits, CEMA enjoys one on one dialogue with health professionals. We learn which resources are recognized and used, how best to distribute them and what new material is needed.

Our scientific fact sheets and newsletters provide professionals with current findings in order to update their knowledge on dietary fat. A scientific advisory group assists in the identification of new topics as well as in the development of new resources. Our material is seen as excellent, with minimum industry bias.

Our biggest compliment came when CEMA resource materials were advertised to Canadian physicians using the Physicians' Hotline catalogue. The

orders for the first month of the programme exceeded the 6 month projections. CEMA has entered into partnership with the Dieticians of Canada as a sponsor of their National Nutrition Month Campaign. The campaign profiles the dietician as a source of reliable nutrition information and provides CEMA with an opportunity to promote our message that eggs are part of a healthy eating pattern to both health professionals and consumers.

Our most recent partnership is with the Canadian Heart and Stroke Foundation. Our goal is to move the focus away from cholesterol and onto risk factors, such as activity and healthy body weight, that have a greater impact. CEMA will assist with the development of new resource material as well as participating in community events.

CEMA strives to ensure that health professionals, the media and consumers have access to up to date, relevant and credible information on the nutritional and food safety aspects of eggs. We value partnerships and look for initiatives to build on a foundation of scientific knowledge.

While we are confident that we have turned the corner on *Salmonella* and cholesterol, CEMA also recognizes that a new nutrition discovery, quickly taken out of context or blown out of proportion, could damage the egg market. Maintaining confidence in the food supply is essential. Working collectively, I am confident that egg producers, scientists and government officials can respond to future issues in a constructive and timely manner. Eggs offer Canadian consumers a convenient and versatile source of nourishment. They have a place in a healthy eating pattern.