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**Rural Industries Research and
Development Corporation**

Gluten-free Grains

**A demand-and-supply analysis of prospects for the
Australian health grains industry**

A report for the Rural Industries Research and Development Corporation

by Grant Vinning and Greg McMahon
Asian Markets Research Pty Ltd

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Foreword

This report presents the results of an analysis of the prospects for a number of gluten-free grains. It emanated from an awareness that in Australia and overseas there are a number of people who either must or choose to consume products free of gluten.

The project sought to establish the size of this market segment and analyse the market prospects for a number of the grains that are or could be grown in Australia specifically for the gluten-free market. The seven gluten-free grains, or 'health grains', identified are amaranth, buckwheat, millet, quinoa, sesame, sorghum and teff.

The report looks at the likely size of the gluten-free market in Australia and provides data on the supply of and likely future demand for the seven health grains. It also identifies the major factors creating that demand. Finally, it makes recommendations about how the Australian health grains industry could position itself to ensure access to a wider market—beyond people who cannot or choose not to consume gluten-based products.

The project was funded from RIRDC core funds, which are provided by the Australian Government. It is an addition to RIRDC's diverse range of over 1500 research publications and forms part of our New Plant Products R&D Program, which aims to facilitate the development of new industries based on plants or plant products that have commercial potential for Australia. Most of RIRDC's publications are available for viewing, downloading or purchasing online through our website:

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Peter O'Brien

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Acknowledgments

This report is based on a large number of interviews. Some of them were structured and quite formal; many were with people who had a busy schedule but managed to squeeze in time for us; and a number were conducted on the job, especially those with store workers in the seven countries visited and with booth workers at the Natural Products Expo in Anaheim, California. To these individuals and organisations we extend our thanks.

Four other people deserve special recognition:

- In California, Dr Kaye Crippen organised an excellent series of meetings with health care workers, people in the retail sector, and other relevant individuals. Without Kaye's detailed knowledge of Los Angeles and Dana County, it would have been impossible to cover the area we did in such a short time.
- In Ottawa, Jan Perkin's extensive knowledge of the city and of Canada in general enabled us to do a surprisingly large number of interviews and store visits in a very short time.
- In Geneva, the staff of the library at the International Trade Centre provided assistance beyond what one normally receives from a library.
- We estimate we visited about 70 stores in seven countries. Mary McMahon's talent for finding the gluten-free section, or at least the gluten-free products, was a great asset.

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Executive Summary

What the report is about

Many grain and non-grain sources provide gluten-free raw ingredients. Of the grains, seven so-called 'health grains' were chosen for study—amaranth, buckwheat, millet, quinoa, sesame, sorghum and teff. This report provides data on the grains' production, health attributes, use and trade, both overseas and in Australia. Five of the grains—amaranth, buckwheat, millet, sesame and sorghum—are currently grown in Australia. Buckwheat production is oriented to the Japanese soba market, and millet and sorghum production is oriented to non-human consumption.

Who is the report targeted at?

The recommendations in this report will assist the Australian health grains industry to position itself to a wider market.

Background

Coeliac disease is characterised by an inability to digest gluten. People with the disease who eat products containing gluten can experience adverse reactions ranging from discomfort to bordering on life threatening. Wheat is the most common, although not the only, source of gluten. Coeliacs have learnt to avoid wheat-based products, but they have also had to learn about gluten's pervasive presence in the entire food spectrum.

In addition to coeliacs, there are other people for whom a gluten-free diet is recommended, and there is a proportion of the population who, for various reasons, choose to consume gluten-free foods. It is estimated that the Australian market for gluten-free products amounts to about a million consumers.

Aims/Objectives

This project is a market analysis of five "health grains"; amaranth, buckwheat, millet, quinoa, sesame, sorghum and teff.

Methods used

Asian Markets Research was responsible for this project. In Australia, interviews were conducted with about 50 producers of health grains, primary processors (such as millers), food manufacturers and retailers. In the United States, Canada, France, Switzerland, England, Ireland and Wales, similar interviews were conducted with stakeholders along the supply chain. An important part of the North American research was attending, in March 2004, the Natural Products Expo in Anaheim, California, which is possibly the largest gathering of people involved in the natural foods industry. Many interviews were conducted at the Expo.

Results/Key findings

In Australia, as overseas, the demand for gluten-free products will continue to show strong growth. Part of the reason for this is that increases in demand are being measured from a very low base. But the rate of growth is not even across all gluten-free products: the pattern appears to be that stronger growth—between 10 and 20 per cent annually—is associated with higher levels of value-adding. The high rate of growth also disguises a significant degree of substitution as coeliacs stop making their own foods with minimally processed gluten-free ingredients and move to higher value-added products. Annual growth in the minimally processed products is about 5 per cent.

On the basis of investigations in stores in the United States, Canada, England, Ireland, France and Switzerland, it would appear that Australian coeliacs have access to a smaller range of higher value-added gluten-free products.

It is expected that Australia will follow the trend identified overseas, where the evidence suggests that annual growth rates for sales of gluten-free foods will start to level off in the near term—say, five years. This is a result of the increasing number of coeliacs becoming ‘overt’ as a result of publicity making consumers aware that they have the disease. Improved and cheaper methods of detecting the disease will also lead to an increase in the number of ‘covert’ coeliacs becoming overt. As the number of overt coeliacs, as well as others who for medical reasons must consume gluten-free foods, reaches the estimated absolute number, the overall rate of growth for gluten-free foods will slow, eventually paralleling growth rates for the general population.

This project also involved determining where gluten-free foods can be obtained. The sources range from health product stores to pharmacies, lifestyle stores, conventional retailers and food service outlets. Lifestyle stores provide the bulk of the gluten-free foods currently available, and it is expected that this will continue in the future.

For reasons of consistency in supply and quality, the Australian food manufacturers interviewed as part of the project preferred to import amaranth, quinoa and even buckwheat. No data on precise volumes could be obtained. If production challenges can be overcome, however, there is in Australia an inherent preference for Australian-grown produce. Existing production of millet and sorghum in Australia is considered adequate to meet any induced demand for gluten-free products, even though varieties different from the current ones might be involved.

The gluten-free grain considered to have the greatest potential is quinoa. In the overseas countries studied for the project, it was most consistently mentioned by retailers as the health grain whose products are most often sought. Coeliac societies in a number of the countries also made specific reference to quinoa. The same applied in Australia. Amaranth and buckwheat were the next most commonly mentioned gluten-free grains in Australia. Spelt—whilst technically a wheat and thus not part of the study—was also often mentioned.

Implications for relevant stakeholders

Three other gluten-free grains were excluded from the study—corn, rice and soy. In addition, gluten-free starch from potatoes, which is readily available, was excluded. Producers of the seven identified health grains must be aware that production from any one of these four alternative sources dwarfs the health grains’ combined production. More than half the Australian food manufacturers interviewed for the project mentioned using at least two of the alternative products. Overall, corn starch and potato starch were the most favoured non-health grain sources of gluten-free ingredients. Provided they do not contain any other gluten-containing products, products made from the health grains could readily be declared gluten free. This is not happening in Australia and overseas because of concerns about litigation.

The statement that a product is free of gluten is a declaration of purity. As noted, if a coeliac inadvertently consumes gluten the consequences can be serious. Inadvertent consumption could occur as a result of inadvertent contamination of gluten-free products with products containing gluten. Such contamination can occur all along the production chain. For example, the machinery used to harvest a gluten-containing grain might be used to harvest a gluten-free grain; when milling, inadvertent mingling of gluten-free and gluten-containing grains might occur; and in manufacture, especially at the higher levels of value-adding, there is the question of the gluten-free status of a very large number of co-ingredients. Given the legal requirement for purity, food manufacturers who deal with both gluten-containing and gluten-free products are very sensitive to the possibility of cross-contamination. Until these manufacturers can guarantee the isolation of the two streams of products and operations, they will be unwilling to declare their products free of gluten.

Recommendations

A number of factors were identified as influencing the future marketing of gluten-free foods, primarily the following:

- labelling—especially labelling that is more informative than ‘wheat free’
- a common international logo
- greater knowledge on the part of store staff
- increases in the product range
- the educational activities of the various coeliac and gluten-intolerant groups.

It is likely that growth in demand for the seven designated health grains will not be based solely on the fact that they are free of gluten. This is because there are a large number of products that can make that claim. In the main, though, what those other products cannot claim is the levels of nutrition contained in most of the designated health grains. It is the promotion of these values—rather than sole dependence on the gluten-free attribute—that will determine the success of the health grains.

The same advice is relevant to the marketers of gluten-free foods. The evidence from overseas is that, whilst manufacturers should state that the product is gluten free, a host of other attributes should also be declared—for example, ‘yeast free’, ‘egg free’, ‘dairy free’, ‘fat free’ or at least a defined percentage of freedom from fat, and even ‘produced in a facility free from ...’

If these two broad recommendations were to be adopted, the market that will open up for the designated health grains will be much larger than that estimated as a result of work done for this project.

1 Introduction

Inability to digest gluten is a serious problem for some people; the condition is called coeliac disease.¹ Wheat is the most common source of gluten, and bakery and pasta products are among the most obvious foods containing wheat. Coeliacs have learnt to avoid the obvious, but they have also had to learn that the use of gluten in foods is much more widespread than is commonly appreciated. Most modern foods are manufactured, and this usually entails using ingredients that bind, thicken and colour. These are some of the things gluten does.

Greater availability of products not containing gluten would appreciably improve the lifestyle of people suffering from coeliac disease.

A number of grains are gluten free, among them corn, rice, grain amaranth², buckwheat, quinoa³, millet, sorghum and teff. Many other raw products can produce gluten-free flour and thus to some extent replace wheat flour⁴; arrowroot, lentils, a number of nuts, soy, and tapioca are examples.

This report uses the term ‘health grains’ to describe a group of gluten-free grains that are or could be grown in Australia.

The presence in the market of foods derived from gluten-free produce is the result of two forces: coeliacs demanding such foods and manufacturers seeing an opening to supply such foods. This raises the perennial question of the primacy of these two forces. To use the economists’ analogy: on one hand, if producers of raw health grains and the manufacturers of gluten-free foods were aware of the size of the market they would increase their production to meet that demand; on the other hand, if coeliacs were aware of all the products that could be made available to them, they would exercise their market power and express their demand to manufacturers, who would increase their supply.

What is emerging, however, is the fact that the demand for health grain products is not confined to coeliacs. There is growing awareness of the role of healthy eating, and grains, including the health grains, loom large in this. The US Department of Agriculture’s food guide pyramid recommends six to 11 daily servings of the ‘grain’ group. Some of the health grains are being promoted as more beneficial for general health compared with the mainstream grains for reasons of better nutritional properties and digestibility and even dietary variation. The debate surrounding the role of carbohydrates in the fight against obesity has focused heavily on the role of grains in the general diet. It appears, too, that gluten-free products could play a part in dealing with other diseases, such as autism.

Australia does have a health grains industry. There is extensive production of grain sorghum and maize⁵, albeit almost exclusively for animal feed. Rice is also an important crop, as is soy bean. Lentils are widely grown. Millet is produced commercially. Among the better known health grains, buckwheat has an erratic production record, and production of some of the other grains varies between semi-commercial and hobby farming.

The demand for products based on health grains is growing. Food processors’ ability to meet this demand is limited by limited supplies. The fact that the raw materials are largely drawn from imports

¹ Among other terms used are coeliac sprue, coeliacs, coeliacs disease, Gee–Herter’s syndrome, gluten intolerance, gluten sensitivity enteropathy, gluten sensitivity, idiopathic steatorrhea, intestinal infantilism, malabsorption syndrome, and non-tropical sprue.

² Amaranth is consumed in two forms—as a vegetable and as a grain. Except where specifically noted, this report uses ‘amaranth’ to describe amaranth consumed in grain form.

³ Pronounced ‘keen-wa’.

⁴ The caveat ‘some extent’ is vital because there are a large number of technical reasons (such as viscosity and heat tolerance) that mean that not all grains are equally substitutable across all uses.

⁵ The term ‘maize’ is used here to refer to the product used in animal feed; ‘corn’, especially sweet corn, refers to the product used for human consumption.

clearly points to a market for such grains and products in Australia. Processors of health grains have expressed a preference for Australian-grown products because of the country's clean, healthy agricultural production and the usual concerns about importing, such as currency movements, parcel sizes and documentation requirements.

The purpose of this report is to determine the demand and supply parameters of the health grain industry in Australia. Chapter 2 looks at who is demanding health grains and the actual number of these people. Chapter 3 discusses the products derived from health grains; this involves identifying what grains should be the focus of this study. Chapter 4 analyses supply factors associated with such grains. Chapters 5 and 6 examine the factors likely to affect future demand and supply. And Chapter 7 discusses future directions for the Australian health grain industry.

Grant Vinning and Greg McMahon of Asian Markets Research were responsible for this project. Greg did most of the fieldwork in Australia, conducting about 50 interviews with producers of health grains, primary processors (such as millers), food manufacturers and retailers; Appendix A lists the people interviewed. Grant did the fieldwork in the United States and Canada, conducting a similar number of interviews. An important part of this North American research was attending, in March 2004, the Natural Products Expo in Anaheim, California, which is possibly the largest gathering of people involved in the natural foods industry. Many interviews were conducted at the Expo—see Appendix B. Grant also researched the industry in the United Kingdom. Both researchers carried out store-based research in England and Switzerland; Grant also did this in the United States, Canada and France and Greg in Ireland, Wales and southern England. About 70 stores were visited. Examples of the range of gluten-free products were collected in Australia, the United States, England and Switzerland; collages of these are presented in Appendix C. Grant made extensive use of the library of the International Trade Centre in Geneva to garner most of the hard data used in the report, and he was responsible for final preparation of the report.

2 The demand for health grains

2.1 Coeliacs

Coeliac disease, an inflammatory condition of the small intestine, is precipitated by the ingestion of the protein gluten, which is predominantly found in wheat. The reaction results in a decrease in the surface area available for nutrient, fluid and electrolyte absorption. It is the availability of surface area that determines the small intestine's efficiency. The reaction to the gluten differs between individual coeliacs: some experience severe symptoms such as diarrhoea, weakness and weight loss; some suffer anaemia-related fatigue; some have the extreme reactions of osteophyte bone disease, tetany and some neurological disorders; another group suffers from *Dermatitis herpetiformis*, characterised by surface blistering, burning and itchy rashes.

Two main factors are involved in the development of coeliac disease:

- *Heredity*. Coeliac disease runs in families. The condition primarily affects people of north-west European ancestry; it rarely affects people of negroid, Jewish, Asian or Mediterranean background.⁶ Twice as many females as males are implicated.
- *Stress*. The stress caused by events such as emotional trauma and surgery can result in asymptomatic disease becoming endemic.⁷

In combination, genetic predisposition and reaction to gluten produce a continuum of sensitivity. At one extreme is complete intolerance, where ingestion of gluten results in a severe reaction.⁸ At the other extreme are people who can consume with impunity any products containing gluten. Within the gluten-intolerant group, the reaction time for people who, having been on a gluten-free diet, are reintroduced to products containing gluten varies from hours to years. Treatment of coeliac disease involves avoiding consumption of all products containing gluten.

There is an emerging group of individuals who are gluten tolerant but have varying degrees of sensitivity to gluten. Since the degree of sensitivity relates to what is defined as 'allergy' and 'intolerance', it is useful to refer to the schematic presentation in Figure 2.1, which categorises adverse reactions to food as follows:

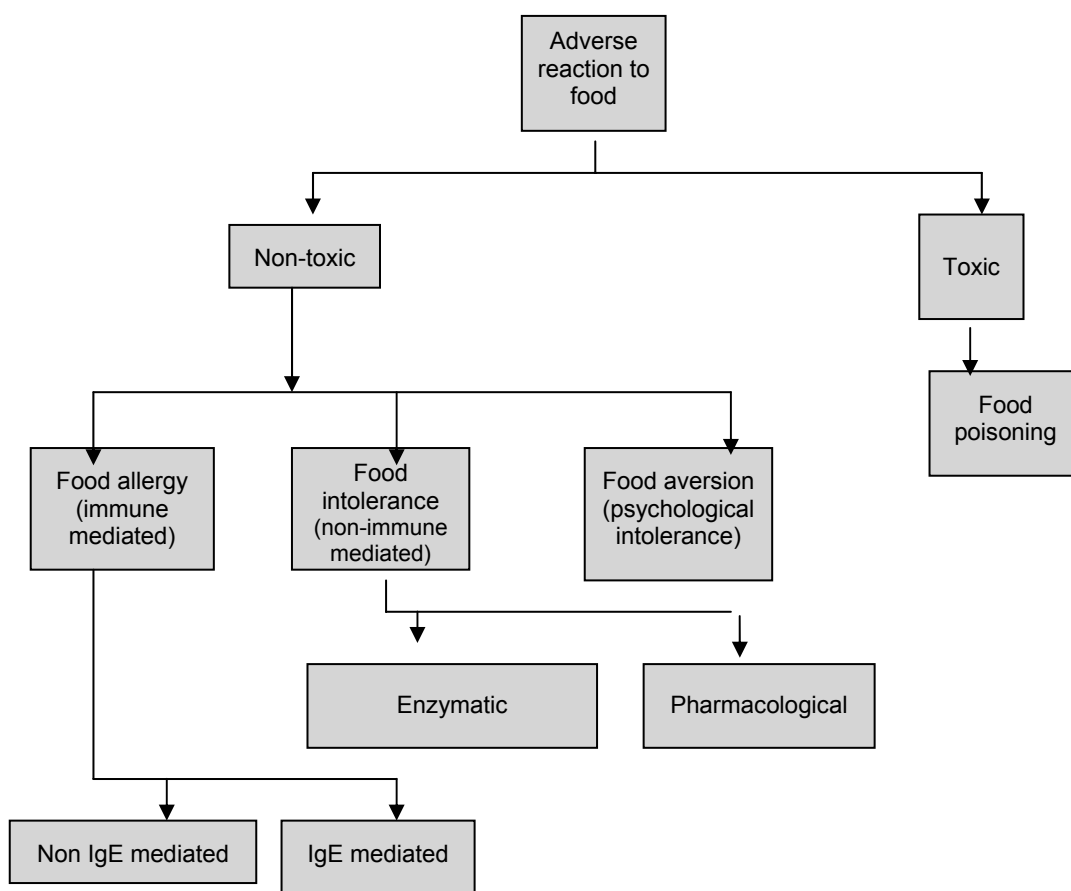
- A *toxic reaction* such as food poisoning is generally the result of contamination of the food by pathogenic micro-organisms. Despite extreme unpleasantness at the time, the impact is short lived and rarely fatal.
- A *non-toxic reaction* is also unpleasant but tends to be a reaction to a specific food or ingredient and is usually reproducible. The response can take the form of an allergic reaction or an intolerance.
 - An *allergic reaction* occurs when the body initiates an immune response to an antigen. Food allergies involve antibodies from the immunoglobulin E family. True wheat allergies will cause the body to produce IgE antibodies when the gluten is ingested.
 - A *food intolerance* does not elicit an immune response. An *enzymatic intolerance* occurs where a deficiency in the enzyme leads to an intolerance of that enzyme. A *pharmacological food intolerance* is associated with the body's reaction to naturally occurring substances within the food itself.
 - A *food aversion* is a psychologically induced motivation to avoid a product. At stake are the emotions associated with the food, rather than the food itself.

⁶ Tidwell, J <<http://allergies.about.com/cs/gluten/a/aa020899.htm>>, viewed February 2004.

⁷ The greater likelihood of such stresses occurring later in life may explain why most coeliacs are diagnosed between the ages of 30 and 45 years and why more over-60s are diagnosed than under-16s.

⁸ Allergies can be expressed in the form of asthma, eczema, hives, arthritis, chronic fatigue, fibromyalgia, cerebellar ataxia, type 2 diabetes, depression, migraine, Crohn's disease, irritable bowel syndrome, lymphoma and gastrointestinal cancers.

Figure 2.1 Adverse reactions to food



In the case of coeliacs, coeliac disease and gluten intolerance, three consumer groups emerge from this analysis:

- people who are physically unable to tolerate gluten
- people who are physically unable to tolerate gluten but able to tolerate wheat
- people who are psychologically unable to tolerate gluten and wheat.

2.2 Other potential consumers of health grains

In general terms, there are two other groups of potential consumers of gluten-free products:

- people whose consumption is medically based
- people whose consumption is health based.

Gluten-free products are now being recommended for autism, attention deficit disorder and schizophrenia.

The health-based group consists of three subgroups:

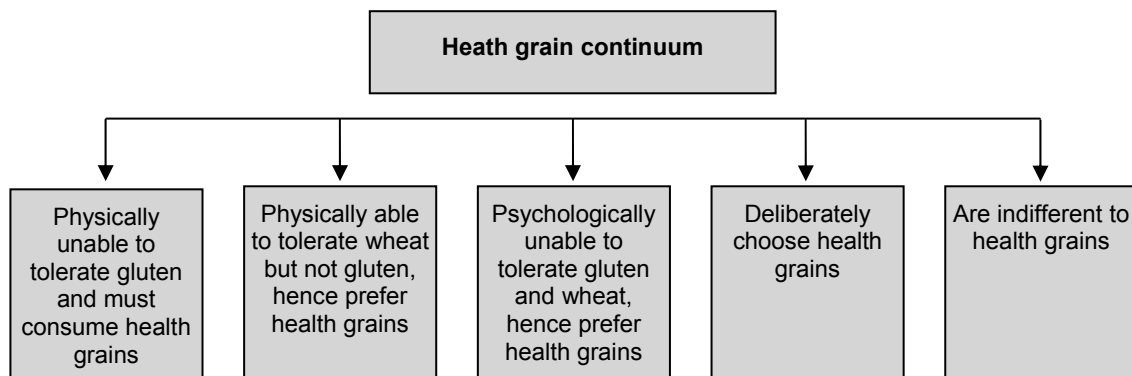
- committed, health-conscious consumers who seek diversity in their diet
- consumers who are simply interested in trying something different
- the fashion conscious, which can be divided into two subsets
 - people who have become aware of the product through talk shows on radio and television. In these situations the product is presented in the context of a lifestyle—‘naturalness’, ‘antiquity’, ‘indigen-ness’, and so on—rather than on the basis of its scientific merits. This is particularly the case for a number of nutraceuticals and dietary supplements. There is a group of consumers who believe that products associated with antiquity or that have

indigenous connotations are more valuable than modern products.⁹ As discussed in Chapter 4, one of the main promotional claims associated with some of the health grains concerns their antiquity, with frequent references being made to their being ‘lost’ and ‘rediscovered’

- people following a dietary fad that happens to mention a specific product, almost as an afterthought.¹⁰

On this basis, Figure 2.2 illustrates the demand for health grains products.

Figure 2.2 The demand for health grain products



⁹ See Vinning (1999) for a discussion on the growth of popularity of kava, *Piper methysticum*, in the United States in the late 1990s.

¹⁰ An example is the Atkins diet, which advocates a low carbohydrate – high protein formula. Dr Atkins’ book sold more than 15 million copies, its popularity boosted by media-based figures, especially film stars. As a result of such publicity, bread and potato consumption in the United Kingdom fell (*Sunday Herald*, 3 August 2003). The UK Flour Advisory Bureau has developed an energetic media briefing service to counter the impact of the low-carb diet. At the Natural Products Expo in Anaheim, California, in March 2004 the prevalence of promotional material relating to ‘low-carb’ products was so overwhelming across so many products as to reinforce the notion of it being a fad. Some of the exhibitors said it was only a few years ago that a comparably overwhelming theme was ‘complex carbohydrates’.

2.3 Demand

When estimating the potential market for health grain products, the market can be divided into three groups:

- people who must consume gluten-free products—that is, coeliacs
- people for whom health workers have recommended gluten-free products
- people who choose to consume gluten-free products.

Fasano (1996) argued that coeliac disease is more common than previously thought. Although he said the disease is evenly distributed in Europe, he also pointed out that ‘presentation of the disease may greatly vary even between neighbouring countries’.

The difficulty is establishing whether the disease is under-diagnosed or is in fact rare. The non-uniformity of symptoms is part of the problem: people with no gastrointestinal symptoms but experiencing fatigue, weight loss, asthma, migraine, depression or anaemia might also have the disease. A number of authorities consider that a person has coeliac disease only after it is identified by means of a biopsy. This is because the three blood tests currently available¹¹ are considered not to be 100 per cent accurate. In establishing the number of coeliacs and people with gluten intolerance, there is also the problem of the number of organisations representing those people. As part of the research for this project, three representative organisations in the United States were contacted by telephone or email. These bodies are not fully government funded, so it is in their interest to use as high an estimate for coeliacs as is feasible in order to boost their profile and attract support. There is thus considerable potential to overestimate the number of coeliacs.

This report uses the estimate reported by Fasano et al. (2003), who put the figure at 1.5 million US citizens with coeliac disease—that is, one in 133. (If allowance is made for that part of the population not genetically susceptible to the disease, the incidence would be higher.) The European estimate is one in 150 to 200 people. An old estimate for the United Kingdom is one in 1000¹², but in a presentation to a 2004 conference on coeliac disease the estimate was revised sharply down, towards the US figure.¹³ The 2003 Fasano et al. study found that one in 22 first-degree relatives were at risk of the disease and one in 39 second-degree relatives were at risk.

It is estimated that the number of people who are advised to consume gluten-free products for medical reasons—that is, people with autism, attention deficit disorder or schizophrenia—is comparable with the number of people who have coeliac disease.

Given that demand for health grains also comes from people choosing to consume these grains—as distinct from people who must consume them—and given that this component consists of lifestyle as well as fleeting consumers, it is estimated that 5 per cent of the population represents the potential demand for health grains.

¹¹ WmA, testing for endomysial antibodies; AGA, testing for gliadin antibodies; and tTg, testing for tissue transglutimase.

¹² Coeliac UK’s website. It is of note that the UK Federation of Bakers has put the figure at ‘approximately one person in 1000–1500’—Federation of Bakers Factsheet no. 13.

¹³ Coeliac UK, pers. comm., May 2004.

2.4 Australia

The Coeliacs Society of Australia estimates that there are 150 000 coeliacs in Australia.¹⁴ The Society reached this figure by assuming that its existing membership of 15 000 equates to one-tenth of the actual number of coeliacs. At the same time the Society accepts the overseas estimate that one in every 150 Australians is a coeliac.

Because of the importance of heredity in coeliac disease and the genetic comparability between Australia and the United States and the United Kingdom, this report accepts that 1.5 per cent of the Australian population—or 300 000 people—are coeliacs.

This figure has important marketing implications. First, it defines the size of the coeliac market, and manufacturers of gluten-free foods need to factor this in. Second, account must be taken of the rate of growth in demand from coeliacs alone. A number of interviewees reported strong growth, often in the order of 10 to 20 per cent.¹⁵ These impressive growth rates are, however, calculated from a very low base and represent the demand from people who are aware that they are coeliacs and that there are gluten-free products available for consumption. It is considered that this demand is asymptotic; that is, the current rates of growth are high because greater levels of public awareness and improved detection techniques have led to an increase in the number of identified coeliacs. But the final number of coeliacs is finite, and as this number is approached the rate of growth in demand will slow. When the final number is reached, the rate of growth will parallel the rate of population growth.

If the other two major groups demanding gluten-free foods—the medically based and health-based segments—are added to the 300 000 figure for the number of coeliacs in Australia, the number of potential customers becomes approximately 1 million.

¹⁴ Coeliacs Society of Australia, pers. comm., November 2003.

¹⁵ One interviewee reported the demand for their wheat-free white-corn tortilla increased by 30 to 40 per cent a year—San Diego Tortilla Factory, pers. comm., February 2004.

3 Demand for health grain products

As with most agricultural products, it is rare that health grains are consumed in the form in which they are produced.¹⁶ It is the products created from them that are consumed. In order to determine what products coeliacs demand, it is necessary to first describe the sources of gluten and the health grains that are the subject of this report.

3.1 Gluten and grains

It is important to avoid generalisations when dealing with gluten-free grains and grains in general.

There are two forms of gluten—glutinan and gliadin. The four most commonly recognised sources of gluten are wheat, rye, the wheat–rye cross triticale, and barley. All four are members of the grass family. There are, however, members of the grass family producing grains that do not cause coeliac reactions; rice and corn are two examples.

It is difficult to conduct scientific controlled feeding tests on coeliacs, partly because of funding restrictions but mainly because it would be necessary to perform intestinal biopsies. In the absence of feeding tests, scientists tend to use taxonomic studies, protein analyses and DNA testing in order to determine whether a grain is unsuitable for people with coeliac disease. Such studies are, however, hampered by the lack of knowledge about the exact sequence of the harmful proteins in wheat gluten.

Grains containing gluten

Wheat is *Triticum aestivum* var. *aestivum*. The following grain types are also wheat:

- durum and semolina wheats¹⁷—*T. turgidum* var. *durum*
- spelt, or spelta—*T. aestivum* var. *spelta*
- einkorn¹⁸—*T. monococcum* var. *monococcum*
- Kamut[®], or Polish wheat¹⁹—*T. turgidum* var. *polonicum*.

The Gluten Intolerance Group of North America states that the following grains contain gluten and should not be consumed by coeliacs:

- barley
- durum and semolina wheat
- farina
- Kamut
- rye
- spelt²⁰
- triticale
- wheat.²¹

¹⁶ In this regard, ‘agriculture’ differs from ‘horticulture’, where the bulk of consumption occurs in the form in which the product is grown. The same applies to fisheries. In contrast, nearly all pastoral products are not consumed in the form in which they are produced.

¹⁷ Bulgur, or bulgor, boulgur or burghul, is a durum wheat that has been cleaned, cooked, dried and pulverised.

¹⁸ Also called small spelt.

¹⁹ Because Kamut is a registered trademark, the term ‘Polish wheat’ is increasingly being used instead.

²⁰ Called *Dinkel* wheat in Europe and *faro* in Italy.

²¹ Pers. comm., March 2004. See also the GIG website <www.gluten.net>.

Gluten-free grains

The following grains are free of gluten and thus are considered not harmful to coeliacs:

- amaranth
- buckwheat
- corn
- millet
- quinoa
- rice
- sesame
- sorghum
- teff.

The Codex Alimentarius of the UN Food and Agriculture Organization and the World Health Organization has developed a standard for gluten-free food—see Appendix D.

Grains of uncertain status

Oats are generally considered not harmful to people with coeliac disease or *Dermatitis herpetiformis* (see Kasarda 2000), although there is certainly not universal agreement on this. In addition, there is concern about cross-contamination between oats and wheat, especially on farms.

3.2 The health grains

Knowledge about corn, rice and sorghum is comparatively widespread. For that reason, corn and rice are not covered in this report. In Australia, most sorghum-related knowledge is associated with its animal feeding properties. In Africa, however, sorghum is a major source of food for humans. In addition, it is increasingly being found in health food stores and specialist outlets in the developed world.

The primary focus of this report is the lesser known health grains—amaranth, quinoa and teff, although buckwheat, millet, sesame and sorghum are also examined in some detail.

There are many non-grain products that are gluten-free, among them almond, arrowroot, beans (*Phaseolus* spp., including fava and garbanzo beans), carob, chestnut, flaxseed, guar gum, lentils (including green peas), potato, psyllium, sago, soya bean, and tapioca. Although these are not discussed, it is useful to mention them in order to develop a list of gluten-free products.

3.3 Gluten-free products

The authors' observations in the United States, Canada, Ireland, England and Australia suggest that gluten-free products can be seen as going through a product life cycle. First, they can be presented with very limited value-adding. At this stage of the life cycle raw grain and grain in minimally processed forms (such as muesli) are the most common form of presentation. The example of millet is representative for most of the raw gluten-free grains:

- unhulled millet
- hulled millet
- millet flour
- millet meal
- millet flakes and husks
- puffed millet
- rolled millet
- organic millet
- non-organic millet.

A little more value-adding occurs with products such as cake and pancake mixes, tortilla wraps, and muesli and health bars. After that, the level of sophistication increases, moving through delicatessen items to refrigerated items and sauces and condiments.

The range of products available for coeliacs and people choosing a gluten-free diet is quite extensive. In compiling the following list, it was important to ensure that generic products, and not proprietary items, were included²²:

- grains and cereals
 - a large range of rice types and rice-based products
 - a large range of corn and corn-based products
 - quinoa cereals
 - amaranth cereals
 - non-wheat couscous²³
- bakery products
 - bread made from gluten-free grains
 - tortillas made from corn, sorghum or millet
 - meringues
 - identified baking mixes
 - flours from amaranth, corn, flax seed, garbanzo beans, potato, rice, tapioca, xanthan gum, almonds, black beans, fava beans, green peas, soy, buckwheat, sorghum, guar gum, millet, quinoa or teff
 - biscuits
- pastas made from gluten-free grains
- snacks
 - identified health bars
 - a variety of chips—including tortilla chips made with different-coloured corn
 - tuber- or pulse-based goods.
- dried fruit and nuts
- frozen items
 - rice-based foods such as curried rice and nasi goreng
 - chicken marsala

²² The list is based on information obtained from store visits in the United States, Canada, England and Ireland.

²³ Couscous is more the product of a process rather than the product of a specific grain type. It can be made from hard wheat, sorghum, finger millet, pearl millet, *fonio*, maize or rice. Hard-wheat couscous tends to be more popular because it takes less time to prepare and is thought to taste better. Couscous made from pearl millet tends to be darker and more gelatinised compared with couscous made from sorghum.

- tacos, taquitos, tamales and enchiladas
- specific juice concentrates
- waffles
- french fries
- specific ice creams
- shepherd’s pie
- frozen vegetables
- refrigerated and delicatessen items
 - salsa
 - roulades
 - sauerkraut
 - turkey products
 - margarine
 - butters made from various oils
 - egg salad
 - egg substitutes
 - cheese-based spreads
 - hummus
 - tahini
 - puddings made from soy, rice or tapioca
 - soy beverages
 - tofu
 - sausages—chicken, Italian, turkey, Polish, knackwurst, cabanossi, weisswurst, bratwurst, kashanka, debreziner²⁴
- dairy products
 - cheeses
 - yoghurts—specifically soy-based yoghurts and yoghurts using vanilla extract made from corn alcohol
 - sour cream
- soups that use modified corn starch as a thickener
- sauces and condiments
 - vinegars—sherry wine, apple cider and balsamic
 - dressings and sauces that use modified corn starch
 - honey
 - chutney
 - specific ketchups
 - stuffed olives that use vinegar derived from corn
- beverages
 - specified juices
 - soy-based drinks
 - protein drinks
 - rice-based beverages.

Store personnel and store operators in the countries visited said the highest rates of growth in demand are associated with the higher levels of value-adding.

²⁴ The authors acknowledge The Sausage Kitchen, Bytown, Ottawa, which allowed Grant to sample most of these gluten-free sausages.

3.4 Wheat and gluten

The foregoing might be construed as suggesting that gluten is a bad thing. This is far from the case. To illustrate gluten's contribution to food, a comment on bread is warranted.

Wheat flour contains glutenin and gliadin, and these two proteins combine with water to form gluten. Gluten acts like elastic, allowing the dough to stretch and trap air bubbles. This enables wheaten bread to rise higher than bread made from flours milled from grains with little or no gluten, such as barley, rye, corn, oats and millet. This means more bread can be made from the same quantity of grain, and in commercial terms this means potentially more revenue from the same outlay. This is partly why wheat is the preferred grain of commercial bakers.

Bread itself is a remarkable product. Its consumption has been an essential element of almost all cultures (except in the rice-growing regions of Asia) for more than 6000 years, and it is a rich source of vitamins, proteins and carbohydrates. The many variations in bread are the result of combinations of four main factors:

- *Grain type.* Flour made from a number of grains—wheat, oats, sorghum, millet, barley, rye and corn—can be used to make bread. One grain type can be used, as in wheat bread, or a combination such as rye and wheat can be used.
- *Grain form.* The grain used can be whole grain, cracked grain or decorticated (hulled) grain.
- *Fermentation.* Breads can be made with or without a fermentation process. Fermentation makes the bread rise and thus changes the product's texture and volume. The usual fermenting agent is yeast, but agents such as baking soda can be used. This use of a fermentation agent allows the bread to be classed as 'risen', as opposed to 'flat'. Fermented breads use the power of the fermenting agent to create more air bubbles and thus cause the bread to rise even more.²⁵
- *Ingredients.* Apart from the grain(s) and any fermenting agent, the basic ingredients are salt, sugar and water. After that, a multitude of ingredients can be added to give the end product its distinctive flavour, texture and nutritional value. The nature of the flour itself is also important. The erroneous belief that white flour was more pure than unrefined flour resulted in widespread use of flours with reduced levels of vitamins and minerals. Many countries now require that white flour be fortified with the elements lost during the refining process. The United Kingdom's Bread and Flour Regulations require that flour contain not less than 0.24 milligrams of thiamine (vitamin B1), 1.6 milligrams of nicotinic acid (another B vitamin) and 1.65 milligrams of iron per 100 grams. In addition, 235–390 milligrams of calcium carbonate per 100 grams of flour is added to all flours other than wholemeal and some self-raising varieties. The nutritional value of bread is now such that the US Department of Agriculture's food pyramid recommends that we do indeed take our daily bread.

Appendix E lists the main types of bread made in various parts of the world and provides data on the trade in bread.

²⁵ Two examples of totally unleavened bread are matzoh, traditionally eaten during the Jewish Passover, and tortillas. These are simply made from grain flour (millet for matzoh and sorghum for tortillas) and water.

3.5 Sources of health grain products

In theory, coeliacs can acquire their health grain products from four sources:

- primary producers
- manufacturers
- retail outlets
- the food service sector.

Primary producers

Only rarely do people acquire raw health grains direct from the primary producers. It can, however, occur through cooperative-style buying, where the farmer supplies the grain to a group of consumers who have formed some kind of organisation in order to achieve economies of scale in transport or for some other purpose. There is also some marketing through farmers' markets and Sunday markets, where the farmer brings the produce directly to the market.

Manufacturers

Some manufacturers supply directly to the consumer but this too is uncommon. There is, however, a form of trade whereby a highly specialised manufacturer produces gluten-free products and markets them directly to the public, often through farmers' markets. There is also a small mail order trade. Bakery products are perhaps the main gluten-free product marketed in this way.

The products most commonly associated with direct marketing by the manufacturer are those that are traditionally made at the premises from which they are marketed. Two types of products are of note here: bakery products and delicatessen goods, especially sausages. In both cases the product can be made either for a general customer base or upon request by clients.

In the United Kingdom it was observed that marketing by manufacturers was more common in non-metropolitan areas. This could be a result of the general industrialisation of butcheries and bakeries and their development in large-scale retailers' outlets. In Ottawa, Canada, it was observed that what had started out as an artisanal marketing venture supplying to an ethnically based clientele had grown into a fully commercial operation. In this case, in order to eliminate the potential for contamination of gluten-free grains with grains containing gluten, and thus the threat of litigation, all products made on the premise were made with gluten-free grains.

Retail outlets

Three types of retailers handle gluten-free products: health food stores, mainstream health food stores and mainstream retail outlets.

Health food stores

Health food stores vary greatly in their degree of sophistication—from small, charmingly disorganised alternative lifestyle stores to what could be considered mainstream stores in terms of layout and product presentation. Within this broad category the authors observed three basic types of stores:

- *Health shops.* The dominant product lines in health shops tend to be nutraceuticals and dietary supplements. Marketing processed foods is usually a minor activity. The stores visited in the United States, Canada and Europe had few, if any, gluten-free products. Most of the shops were part of a chain; some were franchises. Staff's knowledge was poor.
- *Pharmacy-type stores.* These stores stocked the full range of pharmaceutical and nutraceutical products and had a small section dedicated to gluten-free products. Here the emphasis tended to be on the pill form rather than the food form. In England and Switzerland such stores had small, dedicated gluten-free product 'islands'. Staff knew their products and were able to quickly locate the gluten-free islands. The term 'island' is used to signify that gluten-free products are still such an oddity that they are kept separate from mainstream products. In this regard, gluten-free foods

mirror the organic produce of about five years ago, when it was kept separately. Today, organic produce appears alongside mainstream goods.

- *Lifestyle stores.* These stores stock the full range of health products, from raw products to highly processed items. They also stock pills, although these tend to be in raw rather than highly processed form. Most of the stores had a large range of gluten-free products in both the raw and the near-to-raw forms, as well as manufactured products. The raw-form products were invariably a host of grains. Many of the stores had virtually every gluten-free type of grain. Within these stores, the gluten-free products were presented very differently from the non-specialised goods:
 - Colour coding was used to differentiate wheat free from gluten free.
 - The better stores had the gluten-free grains on the top rows, so that in the event of a spill it would be the gluten-free grain being mixed with the gluten-containing grain on the lower shelves, thus avoiding the possibility of the gluten-free grains becoming contaminated, with the potential health dangers (and litigation) that could entail.
 - Some stores had available a broad variety of information about the specific products as well as about coeliac disease. This documentation ranged from generic publications available through any good bookstore to proprietary leaflets and pamphlets.
 - A number of stores produced their own product range. In the main, these products tended not to require sophisticated manufacturing. House-brand muesli and other breakfast cereal mixes were the most popular item, followed by health bars.

Mainstream health food stores

Many gluten-free products can be found in a store type that is half-way between a mainstream retailer and a health food shop. Probably because of the size of the market, these mainstream health food stores are common in the United States. They are often part of a chain, although the chain might comprise only three to 10 stores.²⁶ The following are the distinguishing features of such stores:

- the wide range of gluten-free products stocked. For example, such stores tend to have relatively large refrigerated sections compared with lifestyle stores and so can stock a wider range of gluten-free delicatessen products
- artisanal products tending to be fewer than the more mainstream gluten-free products
- staff knowledge
- in-house education and extension dealing with a range of health-related matters. Seminars, workshops and guest appearances by experts are commonly organised by such stores.

Mainstream retail outlets

The mainstream retail outlets are chains such as Coles and Woolworths in Australia; Tesco, Sainsbury, Selfridges, and Marks and Spencer in the United Kingdom; Loeb's and Loblaw's in Canada; and Albertsons, A&P, Kmart, the Kroger organisation, Safeways, Supavalue, Target and Wal-Mart in the United States. In the main, these stores do not stock gluten-free products; some gluten-free products are available in some stores but these are not main lines.²⁷ The reason is simple: mainstream retailers stock mainstream products, and at present mainstream food manufacturers are not manufacturing gluten-free products.

The food service sector

The only examples of gluten-free products being available in the food service sector were in the highly specialised and localised outlets that are an adjunct to the health shops and lifestyle stores just discussed.

Not one dedicated gluten-free foods café or restaurant was seen in any of the seven countries visited. There is, however, anecdotal evidence that such outlets exist, usually operated by people with a

²⁶ Three such chains were visited in the United States—Wild Oats, Gelsons, and Mothers.

²⁷ Several stores of three English retail chains were visited. The range of gluten-free products stocked was very small. In some cases there was no stock. Staff knowledge varied considerably, from reasonable to a complete lack of knowledge.

coeliac in the family. In learning to cater for the special needs of the family member, the exercise has been extended to a semi-commercial basis.

3.6 Australia

The range of gluten-free products available to Australians seeking such products appears to be much narrower than that in the United States, Canada, Ireland and England.

In terms of growth, however, Australia's experience seems to parallel the experience in at least the United States, Canada and England. That is, there is direct link between the rate of growth in the demand for gluten-free products and the degree of value-adding, and as a result the demand for minimally processed gluten-free flours has levelled off at around 5 per cent a year. The demand for gluten-free food mixes with a very high flour content (such as cakes, muffins, and bread) has increased by 15–20 per cent a year. Ready-to-eat gluten-free foods such as pies and pizzas have shown rates of increase of about 30 per cent. Some very high value-added foods (for example, chocolate biscuits) have experience rates of growth well over 50 per cent. The authors were advised that some of the highest rates of growth were associated with products that were gluten-free versions of mainstream cereals.

These figures do, however, need to be viewed with some caution. First, as previously noted, the increases have been achieved on a small base figure of demand. Second, much of the increase with ready-to-eat food has been the result of coeliacs abandoning cooking their own foods and turning to pre-prepared foods. The substitution element explains the drop-off in the rate of growth for flour and the commensurate increase in the rate of growth for value-added products.

3.7 Summary

A surprisingly wide range of gluten-free products are made from the seven identified health grains—amaranth, buckwheat, millet, quinoa, sesame, sorghum and teff.

People demanding gluten-free products can obtain them from a number of sources, ranging from direct acquisition from the primary producers to retail outlets, which vary in their size, nature and degree of sophistication. In the main, the level of acquisition direct from the two ends of the supply spectrum—that is, the raw grain supplier and the nationwide retail chain—is relatively small. The most common outlets are specialty health stores, some of which are part of a chain.

Rates of growth in the demand for gluten-free products are in the order of 15–20 per cent. They are lower for minimally processed products and higher for products with higher levels of value-adding. The rates of growth are high because of the low base from which demand is measured. There is also a high degree of substitution.

4 The current supply of health grains

Chapter 3 identifies the seven health grains that are the focus of this study:amaranth

- buckwheat
- millet
- quinoa
- sesame
- sorghum
- teff.

Interviews in Australia revealed that, of the seven grains, the least is known about quinoa and teff. As a result, these two grains are dealt with here in a little more detail. The analysis that follows focuses on the seven grains' uses, health attributes, production and marketing and the situation in Australia.

4.1 Amaranth

Amaranth (*Amaranthus* spp.) is an annual plant whose name derives from the Greek for 'never fading' flower. A relative of pigweed, lamb's-quarters and cockscomb, it is not a 'true' grain. Growing to between 1 and 3 metres, it has a thick stalk with a pronounced bushy topping. Its predominantly self-pollinated flowers are purple, red, pink, orange or green.

There are about 60 species of amaranth, and there is no definite distinction between amaranth grown for the leaf (vegetable) and the seed (grain). Grain varieties are being developed from *Amaranthus caudatus*, *A. cruentus* and *A. hypochondriacus* (syn. *A. leucocarus*) and their hybrids. The seed colours of the grain varieties are white, tan, gold or pink.

Uses

In the Americas amaranth is invariably consumed as a grain²⁸, whereas in Asia it is consumed as a vegetable.

Grain amaranth can be puffed like tiny popcorn or ground into flour that can be either whole-grain or lightly coloured. It seems to perform better with other grains because it does not stick together well when cooked by itself. A disadvantage is that the flour keeps well only when frozen. The grain form has numerous uses:

- breakfast cereals—in South America as a porridge or gruel
- breadings for meat, fish, poultry and vegetable dishes
- confectionery products—being added to chocolate for taste and texture
- salad condiments such as croutons
- puffed grain sprinkled directly onto salads
- baked products such as breads, muffins and biscuits
- extruded snack foods
- chips
- pastas
- noodles
- soups

²⁸ Amaranth was a primary food source for Central American Indians before Columbus arrived in the New World. The Spanish conquistadors outlawed production for religious and political reasons, having observed that the popping of amaranth seeds played a central role in Aztec ceremonies. It was also suspected that the grain would give physical sustenance to the enemy. The conquistadors did all that they could to eliminate the crop.

About 40 products containing amaranth were seen on the market in the United States. In volume terms, the most common form was breakfast cereal.

Health attributes

Amaranth has an excellent nutrient profile (see Table 4.1). It contains large amounts of dietary fibre, iron and calcium and is a good source of vitamins and other minerals. It also has an ideal balance of amino acids and contains high levels of lysine, methionine and cysteine.

Table 4.1 Amaranth: nutritional profile

Nutrient	Amount
Protein (%)	12–17
Lysine (%)	0.85
Carbohydrate (g/100g)	63
Calcium (mg/100g)	162
Iron (mg/100g)	10
Phosphorous (mg/100g)	455

In terms of the protein value score chart, where 100 is considered ideal, amaranth compares well with other products:

- amaranth—75
- cow's milk—72
- soybeans—68
- barley—62
- wheat—60
- peanuts—52
- corn—44.

Amaranth is also very low in sodium and contains no saturated fat. The cooked grain has a total digestibility of about 90 per cent.

Production

Amaranth has a C-4 photosynthetic pathway, making it a more efficient user of production resources than most broad-leaf crops when grown under conditions of high temperature and limited rainfall. Weed control is the biggest problem: the only methods currently available are the labour-intensive ones of cultivation and rousing. Seed shattering and plant lodging can cause severe yield losses following a freeze.

It is estimated that in the United States the area planted to amaranth is 'a few thousand acres' (Laux 2004). However, two amaranth exhibitors at the Natural Produce Expo in Anaheim in March 2004 put the figure at a much higher 10 000 acres (or about 4000 hectares). Production occurs in Colorado, Illinois and Nebraska, with the Nebraska Panhandle being considered the primary area of production.

The American Amaranth Institute²⁹ has made several amaranth varieties available to growers without formal release. At present only Amont and Plainsman are available through certified seed channels.

²⁹ A number of efforts were made to contact the Institute. It is staffed only part time, and the efforts were fruitless.

Marketing

In early 2004 there were three main buyers of amaranth in the United States—Arrowhead Mills, in Texas; Health Valley, in California; and Nu-World Amaranth, in Chicago. Some growers are also marketing directly to consumers or local bakeries. Proprietary promotional material emphasises the following properties of the grain:

- superior nutrition
- rich in lysine and high-quality protein
- nutty, slightly spicy and sticky, gelatinous texture
- pops like popcorn
- strong, sweet, spicy, nutty-flavoured flour
- strong moisture retention
- high in fibre.

Australia

In Australia amaranth is grown at Deniliquin, Guyra and Glen Innes in New South Wales and at Clifton and Gayndah and on the Atherton Tableland in Queensland. The crop is very susceptible to stress and needs the cooler temperatures of the tablelands of New South Wales and Queensland. Product from Gayndah is considered the most reliable.³⁰ One production difficulty concerns the fact that the preference is for the white-seeded variety, but occasionally some regressive black-seeded types occur.

4.2 Buckwheat

Buckwheat (*Fagopyrum* spp., especially *F. esculentum*) was the subject of another RIRDC project—see Vinning (2001a). That study established the basic facts in relation to the grain:

- Buckwheat is a native of temperate East Asia and has been cultivated in China and Japan since well before 1000 AD. It is widely adapted in North America and Europe.
- The basic products produced from buckwheat are flours of a number of grades; *farinetta*, or buckwheat bran; groats, or hulled whole buckwheat kernel; and grits, or hulled broken kernel (that is, the coarse granulated product made from groats).
- Buckwheat has traditionally been used as flour for pancake mixes in North America. In Europe it has a wider role, being combined with wheat flour in bakery products and being used in a variety of ‘ethnic foods’. Consumption of buckwheat as *kasha*, or roasted buckwheat, is common among people of Eastern European origin. In Japan, buckwheat is milled into flour for use in soba, the popular noodle.
- Buckwheat has market potential in animal feeds where lysine supplements are low or absent.

Data on global production of buckwheat are provided in Appendix F.

Health attributes

There has been extensive analysis of buckwheat’s nutrient content.³¹ Tables 4.2 and 4.3 show the results of Edwardson’s (1996) work.

³⁰ Micronised Foods, pers. comm., November 2003.

³¹ See ‘buckwheat’ in *NutritionData*, 17 April 2004.

Table 4.2 Buckwheat: essential amino acid composition compared with that of selected other grains

Amino acid	Content as percentage of whole grain						
	Wheat	Maize	Barley	Oats	Rye	Triticale	Buckwheat
Arginine	0.52	0.40	0.40	0.65	0.56	0.56	0.90
Histidine	0.32	0.25	0.24	0.22	0.26	0.33	0.33
Isoleucine	0.46	0.33	0.40	0.37	0.40	0.50	0.46
Leucine	0.91	1.20	0.79	0.73	0.74	0.95	0.84
Lysine	0.39	0.26	0.42	0.40	0.45	0.47	0.77
Methionine	0.18	0.18	0.15	0.15	0.15	0.16	0.19
Phenylalanine	0.64	0.47	0.59	0.49	0.54	0.65	0.56
Threonine	0.40	0.33	0.39	0.35	0.40	0.43	0.49
Valine	0.56	0.44	0.55	0.50	0.54	0.59	0.60

Source: Edwardson (1996).

Table 4.3 Buckwheat flour: mineral composition compared with that of selected other flours

Product	Content (mg/100 g)								
	Ca	Fe	Mg	P	K	Na	Zn	Cu	Mn
Buckwheat flour	41	4.00	251	337	577	0	3.12	0.090	0.099
Corn meal (whole grain)	6	3.45	127	241	287	35	1.82	0.193	0.498
Semolina	17	1.23	47	136	186	1	1.05	0.189	0.619
Wheat flour	15	1.17	22	108	107	2	0.70	0.144	0.682
Soybean flour	206	6.37	429	494	2515	13	3.92	2.920	2.275

Source: Edwardson (1996).

Buckwheat contains up to 6 per cent of the antioxidant bioflavonoid rutin³², which is not found in grains such as rice or wheat or in beans. Among other claimed health attributes of buckwheat are the following:

- *Cholesterol.* The high level of dietary fibre in buckwheat helps the body reduce cholesterol, which in turn increases blood flow and so lowers blood pressure.
- *Fat accumulation.* Buckwheat protein is considered to be particularly powerful in preventing the accumulation of fat in the body.
- *Bowel movement.* The dark buckwheat flour stimulates the intestines.
- *Diabetes.* When fed to diabetic rats, buckwheat extracts lowered blood glucose levels by up to 19 per cent.³³ Animal and human studies have shown that chiro-inositol, a compound found in relatively high quantities in buckwheat and rarely found in other foods, plays a significant role in glucose metabolism and cell signalling. Although buckwheat will not cure diabetes, there is potential to include it in food products as a management aid for the condition. Among the factors being researched are the volume needed for buckwheat to be effective and the form in which it should be consumed—that is, as flour or as an extract.

Buckwheat also contains choline, a neutralising agent that improves the function of a liver overburdened by alcohol. Perhaps this is why soba made from buckwheat in Japan, the world's largest importer of buckwheat, is served as a snack after drinking.

³² Bioflavonoids include the important catechins of green tea and the polyphenols of red wine.

³³ *Journal of Agriculture and Food Chemistry*, December 2003.

Uses

Buckwheat is consumed in a number of forms:

- as a fine flour combining the aleurone layer of the hulled seed and the seed embryo, which is the richest part of the seed
- as a light flour comprising the inner endosperm but excluding the hull, aleurone layer and embryo
- as a dark flour containing a proportion of hull and endosperm
- as groats, or the hulled seed
- as *kasha*, or roasted groats
- as grits, the coarse granulation of groat
- hull, the outer black layer of seed.

Table 4.4 shows the average nutrient composition of buckwheat seed, groats and flours.

Table 4.4 Buckwheat: nutrient composition of seed, groats and flours

Product	Nutrient content (per cent)				
	Protein	Carbohydrate	Fat	Fibre	Ash
Seed	12.3	73.3	2.3	10.9	2.1
Groats	16.8	67.8	3.2	0.6	2.2
Dark flour	14.1	68.6	3.5	8.3	1.8
Light flour	11.7	72.0	2.5	1.6	1.8
White flour	6.4	79.5	1.2	0.5	0.9

Source: Edwardson (1996).

Marketing

Proprietary promotional material notes the following properties associated with buckwheat:

- high in all eight essential amino acids
- high in calcium and vitamins E and B
- a mild flavour.

Australia

In Australia buckwheat is produced in Tasmania, Victoria and New South Wales (see Bluett 2001). Produce goes primarily to the Japanese noodle market. Table 4.5 provides details.

Table 4.5 Buckwheat: Australian production and exports, 1994 to 2000

(tonnes)

	1994	1995	1996	1997	1998	1999	2000 (est.)
Production	400	500	800	1000	1500	1600	2000
Exports	300	350	500	650	1100	1150	1200

Source: Bluett (2001).

More recently, plantings have expanded to the Toowoomba area in Queensland, and there has been some exporting to South Africa and New Zealand.³⁴

The main outlet in Australia is the Haku Baku noodle manufacturer in Victoria. The domestic market is very small, at about 10 tonnes a year.

³⁴ Buckwheat Enterprises, pers. comm., December 2003.

4.3 Millet

Millet is a tall annual grass that looks like maize. It tends to flourish in hotter, drier conditions and in poor and sandy soils. It has a growing season of less than 65 days and is a more efficient user of moisture than sorghum and maize.³⁵ Large yield variations are common, and rust can be a major problem for pearl millet (Lee & Hanna 2002). Losses to birds are also a problem.

There are an estimated 6000 varieties of millet³⁶, among them the following:

- Pearl millet (*Pennisetum glaucum*, *P. typhoides*, *P. typhideum* and *P. americanum*) is also called bulrush millet, *babala*, *bajra*, *cumbu*, *dukhn*, *gero*, *sajje*, *nyoloti*, *dukkin sanio* and *souna*. In the United States it is called cattail millet and *Pencillaria*; in Europe it is called candle millet and dark millet. Pearl millet is the most widely grown of all the millets, being common in Sahelian, central, eastern and southern Africa; India and Pakistan; and along the southern coast of the Arabian peninsula. Of all the millets, it yields best under conditions of drought and heat stress.
- Finger millet (*Eleusine coracana*) is called *ragi* in India. It is common in eastern Africa and Asia—especially northern India, Nepal and Bhutan. This type has a slightly greater water requirement compared with the other millets and is grown at cooler, higher altitudes.
- Proso millet (*Panicum miliaceum*), or common millet, is widely cultivated in temperate regions of Australia, Russia, the Ukraine, Kazakhstan, the United States and Argentina. It is commonly used for bird seed in the developed world.
- Foxtail millet (*Setaria italica*) is grown in more moderate climates in China, parts of India, the Korean Peninsula and parts of southern Europe.
- Fonio³⁷ is grown in Africa. There are two types: white fonio (*Digitaria exilis*) and black fonio (*Digitaria iburua*). The former is common in southern Mali, north-east Nigeria, southern Niger, western Burkina Faso, eastern Senegal and northern Guinea and the latter is found in parts of Nigeria, Togo and Benin.
- Guinea millet (*Brachiaria deflexa*) is found in parts of Guinea and Sierra Leone.
- Barnyard millet³⁸ (*Echinochloa crusgalli* and *E. colona*) is common in tropical and subtropical India. Red millet (*E. coracana*) is a variation.
- Little millet (*Panicum sumatrense*) is widely grown in India, Nepal, Pakistan, Sri Lanka, Myanmar and eastern Indonesia.
- Kodo millet (*Paspalum scrobiculatum*) is grown in western Africa and India. It is sometimes referred to as ditch millet because of its habit of growing alongside paths and in ditches and low spots.
- Job's tears (*Coix lachryma-jobi*) is a minor millet, production of which is confined largely to Southeast Asia.

³⁵ 'Pearl millet is one of the most drought tolerant grains in commercial production' (Lee & Hanna 2002).

³⁶ Because of data differences, the following draws largely on *Sorghum and Millets Outlook*, published jointly by ICRISAT (the International Crops Research Institute for the Semi-Arid Tropics) and the UN Food and Agriculture Organization.

³⁷ Also *founi*.

³⁸ Also Japanese barnyard millet.

Health attributes

Millet is nearly 15 per cent protein and contains high levels of fibre, the B-complex vitamins (including niacin, thiamine and riboflavin), the essential amino acid methionine, and lecithin. It also has high levels of magnesium, phosphorus, zinc, copper and potassium, and it is considered to have the highest level of iron of any of the cereals. There is evidence that the seeds are rich in phytic acid, which is thought to lower cholesterol, and phytate, which is associated with a reduction in the risk of cancer.

The grain's alkaline pH makes it an easy grain to digest. The pH stays high after cooking, an important consideration for wheat-intolerant consumers. The grain also contains relatively high levels of oil (4.2 per cent), which is 50 per cent polyunsaturated.

One potential difficulty lies in the fact that millet hulls and seeds contain small amounts of substances that limit the thyroid gland's uptake of iodine. Whether these substances are solely responsible for the relatively high incidence of goitre in millet-consuming communities or whether other dietary deficiencies are involved is yet to be clarified (see, for example, Birzer & Klopfenstein 1988). Another area of uncertainty is whether cooking plays a part in destroying these thyroid function inhibitors.

Uses

Because it is extremely hard and indigestible to humans, the hull of the millet seed must be removed before consumption. In contrast, it is the hardness of the unhulled grain that makes it useful as a feed for seed-eating birds. The hulling process does not appear to detract from the grain's nutritional value because the germ stays intact.

Humans consume millet in the following forms:

- breads
- porridges
- steamed products—principally couscous
- boiled products—such as soups
- beverages—alcoholic and non-alcoholic
- snack foods
- pasta.

Although millet consumption is widespread in Africa, it is not uniformly so: an FAO study showed that consumption in eastern and southern Africa varied considerably, the 1992–1994 annual average being 6.2 kilograms in Angola, 2.0 kilograms in Ethiopia, 1.4 kilograms in Kenya, and 0.2 kilograms in Mozambique. In the developed world, millet is consumed as a cooked cereal and in casseroles, soups, stews, soufflés and pilaf.

The breads made from millet are flat breads. To produce breads that rise, the flour mix needs to have up to 30 per cent gluten-containing flour. The grain's propensity for popping might encourage its inclusion in traditional Western breakfast cereals.³⁹ Millet can also be sprouted, allowing for its consumption in salads.

³⁹ White-seeded types of pearl millet are preferred for popping.

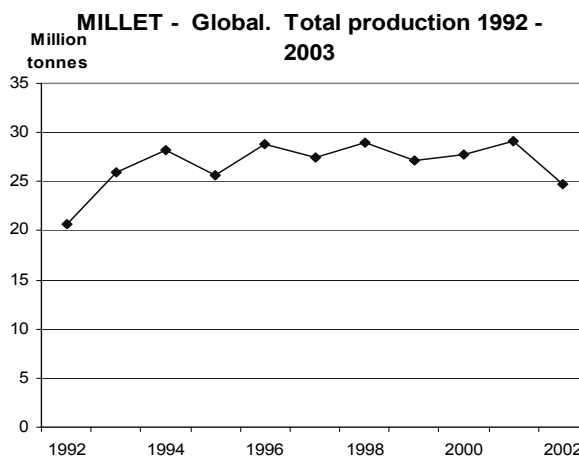
Production

The FAO data set does not differentiate between the different types of millets. It is estimated that production of the main types is as follows:

- pearl millet—about 40 per cent
- foxtail millet—about 20 per cent
- proso millet—about 15 per cent
- finger millet—about 10 per cent.

Global production is about 25 million tonnes a year. Seasonal production variations of 50 per cent in individual countries are quite common but, because the largest producer—India, with 9 million tonnes in 2003⁴⁰—provides only a third of the global total and, because it is rare for seasons of low production to coincide in a number of the major producing countries, global production tends to be relatively steady (see Figure 4.1).

Figure 4.1 Millet: global production, 1992 to 2002



Source: UN Food and Agriculture Organization.

After India, the largest millet producers are in Africa. Burkina Faso, Chad, Ethiopia, Mali, Niger, Nigeria, Senegal, Sudan, Tanzania and Uganda each produce over 200 000 tonnes a year. Significant production also occurs in Angola, Cote d'Ivoire, The Gambia and Namibia. Seasonal variations in production are common.

Away from Africa, China produces about 2 million tonnes annually, mainly of foxtail millet. Kazakhstan, Russia and the Ukraine produce just over 1 million tonnes, almost all of it proso millet. Bangladesh, Pakistan, Sri Lanka, Nepal, Bhutan and Myanmar grow about 700 000 tonnes a year. In the last three countries millet is an important crop.

Trade

International trade in millet tends to account for a constant 10 per cent of global production. Appendix G provides details. No particular country dominates the export market, and export volumes can vary greatly.

In the seven years to 2002 the United States was consistently the biggest exporter. There appears little relationship between growth in local production and growth in exports, and it would appear that local consumption expanded dramatically during that period. The data do not distinguish between millet for human consumption and millet for animal feed.

⁴⁰ About two-thirds of Indian production is pearl millet; the other main type is finger millet.

Export prices have averaged about US\$200 a tonne in the past five years. France is an anomaly though: its millet exports were valued at more than US\$1000 a tonne for each of the four years to 1999. What makes the situation even more interesting is that the FAO database does not record production in France, even though production is known to have occurred there.

A large number of countries—well over 100—import millet. Europe is the biggest importer, mainly using the grain for animal feed rather than human consumption. Apart from Japan and Korea, and with the notable exception of Africa, imports tend to be evenly distributed throughout the world.

Even though import volumes are static, the prices are gradually declining. Australia appears to pay more than European importers, the difference seeming larger than would be accounted for by transport costs. The United States and France are special cases since they are both exporters of note and significant importers. But the United States does pay a premium: in 2002 the average CIF price was US\$580 a tonne, compared with US\$408 a tonne for Australia.

Marketing

Proprietary promotional material makes the following claims for millet:

- alkali free
- gluten free
- rich in lycine
- high-quality protein
- rich in vitamin B.

Millet also has appeal because of its acid-reducing characteristics.⁴¹

Australia

Australian millet production is concentrated in Queensland; lesser volumes are grown in New South Wales and Victoria. Production fluctuates widely, depending on seasonal conditions. The official statistics put production at about 40 000 tonnes a year, although this appears to be an underestimate, with real production being about 60 000 tonnes (see Twyford-Jones 1995).

Millet is used in Australia mainly as a grain for human consumption, although some varieties are used for forage and fodder. It is favoured because it is fast growing and has low input requirements. The main varieties grown are White French and Panorama.

⁴¹ Peterson (1988) reported the use of millet in the diet of Russian athletes to combat the lactic acid build-up associated with intensive exercise.

4.4 Quinoa

Quinoa (*Chenopodium quinoa*) is a member of the Chenopodiaceae family; other members of the family are sugar beet, table beet spinach, and Swiss chard. There are over 120 species of *Chenopodium* but only three main varieties of quinoa are cultivated:

- the white or sweet variety, which has a very pale seed⁴²
- a dark–red fruited variety called red quinoa
- purple or black quinoa.

Quinoa seeds are similar in size to those of millet but are flat with a pointed oval shape, looking like a cross between a sesame seed and a millet seed. The succulent-like plant grows from 1 to 2 metres tall and has many angular branches. The flower heads are branched and when in seed look much like those of millet, with large clusters of seeds at the end of a stalk.

Like buckwheat and amaranth, quinoa is considered a cereal. This categorisation is due both to the plant's high nutritional value and the way it is cooked and eaten.

The cooked grain is slightly crunchy, with a fluffy consistency and a mild, delicate, nutty flavour.

Uses

In the West, quinoa is becoming increasingly popular as a breakfast cereal. Part of its appeal is that it is starchy, with just enough tang to produce a pleasant flavour.

Before cooking, the seeds must be fully rinsed to remove their bitter, resin-like coating of saponin, a toxic glycoside that is frequently associated with plant lipids and can cause minor intestinal damage and reduce intestinal absorption of nutrients.

There are two types of saponin:

- a rarer acid and neutral saponin group (found in white quinoas) that can be used commercially in the production of pharmaceutical steroids
- a more common type (prevalent in yellow quinoa cultivars) that is used in the manufacture of soaps, detergents, beer, fire extinguishers, shampoos, cosmetics, synthetic hormones and some photographic products.

Quinoa saponin is also a haemolytic; that is, it can destroy red blood cells.

There are two ways of removing the saponin—washing with water or peeling by friction. Addition of lemon juice is said to make washing easier, and a device has been developed that effectively dry-peels the seed, thus eliminating the saponin.

Health attributes

Quinoa is very rich in nutrients: it is high in protein, calcium and iron and is a relatively good source of vitamin E and several of the B vitamins (see Table 4.6).

⁴² Quinoa seed can be white, yellow, grey, light brown, orange, pink, red, purple or black.

Table 4.6 Quinoa: nutritional properties

Property	Value
Calories	372
Protein (g)	11.49 ^a
Fat (g)	4.86 ^b
Carbohydrates (g)	71.2
Calcium (mg)	66
Iron (mg)	8.5
Vitamin A (g)	1
Vitamin C (g)	1
Thiamin (g)	0.24
Riboflavin (g)	0.23
Niacin (g)	1.4

a. Claimed to be as high as 20 per cent.

b. Claimed to be as high as 7 per cent.

Source: Erdos (1999).

About half a cup of quinoa will meet a child's daily protein needs. The fat content is relatively high compared with other grains, but quinoa is low in sodium and provides valuable starch and fibre. It contains more protein than any other grain; moreover, the protein is of an unusually high quality, with an essential amino acid balance close to the ideal and comparable with that of milk. Quinoa also contains albumen, a protein found in egg whites, blood serum and many plant and animal tissues.

Compared with a number of other cereals, quinoa has a significantly higher alpha-amylase content. Mechanical abrasion of the seeds has been found to greatly increase alpha-amylase activity; this appears to be a result of the reduction in the pericarp content. Table 4.7 shows, however, that quinoa is not as extraordinarily nutritious as some of its proponents suggest.

Table 4.7 Quinoa: nutrient profile compared with that of selected other grains

(% of dry weight)

Grain	Water	Crude protein	Fat	Carbohydrates	Fibre	Ash
Quinoa	9.4–13.0 ^a	13.8	5.3–8.4 ^b	53.5–74.3 ^a	2.1–4.9 ^a	3.4
Barley	9.0	14.7	1.1	67.8	2.0	5.5
Buckwheat	10.7	18.5	4.9	43.5	18.2	4.2
Corn	13.5	8.7	3.9	70.9	1.7	1.2
Millet	11.0	11.9	4.0	68.6	2.0	2.0
Oat	13.5	11.1	4.6	57.6	0.3	2.9
Rice	11.0	7.3	0.4	80.4	0.4	0.5
Rye	13.5	11.5	1.2	69.6	2.6	1.5
Wheat—hard red	10.9	13.0	1.6	70.0	2.7	1.8

a. From Landauer (2001).

b. From Landauer (2001); Erdos (1999) puts it at 4.86 grams per 100 grams.

Source: Oelke et al. (1992).

Where quinoa does stand out, though, is for its mineral content (see Table 4.8) and its high proportion of important amino acids (see Table 4.9). It is considered to contain an almost perfect balance of the eight essential amino acids needed for tissue development in humans. It is exceptionally high in lysine, cystine and methionine—amino acids that are typically present in low quantities in other grain—and it

is a good complement for legumes, which are often low in methionine and cystine. The protein in quinoa is considered a complete protein because of the presence of all eight essential amino acids.

Table 4.8 Quinoa: mineral content compared with that of selected other grains

	Ca	P	Mg	K	Na	Fe	Cu	Mn	Zn
Grain	Per cent				Parts per million				
Quinoa	0.19	0.47	0.26	0.87	115	205	67	128	50
Barley	0.08	0.42	0.12	0.56	200	50	8	16	15
Corn	0.07	0.36	0.14	0.39	900	21	–	–	–
Wheat	0.05	0.36	0.16	0.52	900	50	7	–	14

– Zero.

Source: Oelke et al. (1992).

Table 4.9 Quinoa: essential amino acids compared with selected other foods

Amino acid	Content (% per 100g protein)			
	Quinoa	Wheat	Soy	Skim milk
Isoleucine	4.0	3.8	4.7	5.6
Leucine	6.8	6.6	7.0	9.8
Lysine	5.1 ^a	2.5	6.3	8.2
Phenylalanine	4.6	4.5	4.6	4.8
Tyrosine	3.8	3.0	3.6	5.0
Cystine	2.4	2.2	1.4	0.9
Methionine	2.2	1.7	1.4	2.6
Threonine	3.7 ^b	2.9	3.9	4.6
Tryptophan	1.2	1.3	1.2	1.3
Valine	4.8	4.7	4.9	6.9

a. Landauer (2001) puts it at 6.8 grams.

b. Landauer (2001) puts it at 4.5 milligrams.

Source: Oelke et al. (1992).

With its high levels of lysine, methionine and cystine, quinoa is an excellent food to combine with, and so boost the protein value of, other grains that have low levels of these amino acids.

Production

It is generally recognised that quinoa has been cultivated in the Andes since about 3000 BC. Production appears to have been widespread until the Spanish conquest in the 1500s, after which it declined.⁴³ Two main reasons are put forward for this:

- the introduction of wheat and barley
- a Spanish prohibition based on depriving the Incas of this highly nutritious food source and the crop's association with Incan religious and social rites.

Production declined to the extent that quinoa consumption became restricted to peasants in remote areas. In Ecuador, production virtually ceased. Thus arose an association between quinoa and the peasantry, which caused the grain's popularity to further wane. The authors sighted a reference to an 1894 document that claimed quinoa was grown in Australia, with the lighter coloured grains being favoured by the wealthy and the darker ones being the food of the less affluent.

⁴³ The name *quinoa* comes from Spanish. In the Quechua of the Incas it was called *chisiya mama*, meaning 'mother grain'. Spanish synonyms are *trigo inca* (Incan wheat) and *arroz del Peru* (Peruvian rice).

Current mainstream production occurs traditionally in the Andean regions of Colombia, Ecuador, Peru, Chile, Bolivia and Argentina. Quinoa's preferred growing conditions are saline to alkaline soils⁴⁴, relatively low rainfall⁴⁵ and relatively low temperatures. It is also frost resistant and has a short growing season. These conditions are typically associated with higher altitudes: quinoa grows best between 2500 and 4000 metres above sea level.

Adaptation to cold, dry climates, a similarity to rice in terms of seed processing, and excellent nutritional qualities make quinoa a crop of considerable value to highland areas around the world, which have limited opportunities for crop diversity and limited access to foods of comparable nutritional value.

Quinoa production in the United States began in 1987, in Colorado. It is also grown in Canada, France and Nepal and the authors saw references to production in highland areas of East Africa and in Austria. Quinoa is also grown in Japan, where it is mixed with rice to boost nutrient levels.⁴⁶ Experimental work is being done in Nepal, Mexico and Denmark. Table 4.10 shows quinoa production in Bolivia, Ecuador and Peru from 1994 to 2003.

Table 4.10 Quinoa: production in Bolivia, Ecuador and Peru, 1994 to 2003

(tonnes)

Country	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Bolivia	19 465	18 814	23 498	26 366	20 291	22 498	23 785	23 000	23 500	23 500
Ecuador	362	408	555	304	938	938	650	320	350	375
Peru	16 629	13 773	16 070	23 612	28 614	28 441	28 382	22 348	30 373	28 000

Source: UN Food and Agriculture Organization.

It is estimated that Peru exports about 30 per cent of its harvest (Erdos 1999). Indications are that the bulk of this trade occurs within the Andean region.

Marketing

There appear to be two forms of quinoa in the marketplace. One includes the indigenous varieties from South America. The other consists of hybrids that have been developed from the indigenous forms. For marketing, product differentiation occurs in terms of 'indigenous-ness': the 'indigenous' school argues that its product has a 'richer, more delicious flavour', 'higher fibre content' and greater nutritional value; it also argues that its method of removing the saponin by washing, rather than mechanical processing, retains more of the nutrients.

Being a relatively new grain—at least to the US market—quinoa is usually found in health food and specialty stores; it is not commonly stocked in supermarkets. Although it is more expensive than most grains, it increases in volume about three or four times during cooking, thus counteracting this price disadvantage.

In 1991 the market in the United States was estimated at about 250 tonnes (Oelke 1992), but eight years later Erdos (1999) estimated that US imports had risen to 1360 tonnes. Imports were mainly of Bolivian quinoa.

In the United States quinoa flakes are usually eaten as a hot cereal. From the flake form various recipes have been developed—muffins, for example. Quinoa's appeal is based on the fact that is not overly sweet. Proprietary promotional material makes the following claims in relation to quinoa:

⁴⁴ This may, however, apply only to the so-called *salaes quinoa*, the quinoa that grows on the salt flats of Bolivia. This quinoa has a bitter seed and a lower protein content.

⁴⁵ Some sources refer to an annual rainfall of less than 600 millimetres.

⁴⁶ Haku Baku (Australia), pers. comm., January 2004.

- naturally high in calcium, iron and fibre
- a complete source of vegetarian protein
- contains all eight essential amino acids
- packed with nutrition
- high in lysine
- contains an ideal-quality protein compared with wheat
- has more iron, phosphorus, vitamins A, E and B, and calcium and fat than other grains
- the flour contains twice the protein of corn and rice.

The authors' interviews with a range of trade people suggest that in the United States quinoa is the most popular of the newly emerged grains. Part of its appeal is that it has a shorter cooking time for most uses and can be consumed as a stand-alone side dish.

Trade

Ecuador began exporting quinoa in 1987. Since then shipments have been made to the United States, the Netherlands, Spain, the United Kingdom, Germany, Italy and Japan.

Australia

None of the people interviewed in Australia mentioned that quinoa is being grown in this country. All supplies are imported.

4.5 Sesame

Sesame (*Sesamum* spp.), an ancient herbaceous plant of African origin, is a member of the Pedaliaceae family. Growing over 1 metre tall, the plant develops bell-shaped flowers that produce capsules containing the seeds, which can be white, brown or black. True sesame (*S. indicum*) is the primary species for commercial production.

Health attributes

Sesame seeds contain 40 per cent fat and 18 per cent protein and are rich in potassium, calcium, iron and niacin. The oil, which is 44 per cent polyunsaturated, keeps well.

Uses

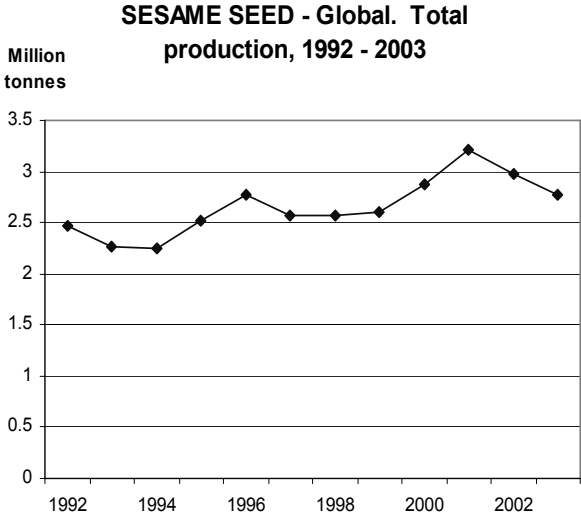
In the Middle East and places with sizeable populations of Middle Eastern origin sesame seed is widely consumed as tahini, a paste made by grinding the seed. It is also consumed as halva, a sweet that originated in the Middle East; for this, the crushed seeds are combined with honey, flavourings and nuts.

In the two main importing countries, Japan and Korea, sesame seed is consumed more as an ingredient in a dipping sauce for various dishes, as well as being used as a cooking oil.

Production

Global production of sesame seed is gradually increasing (see Figure 4.2). In 2002, production was estimated at 2 765 000 tonnes.

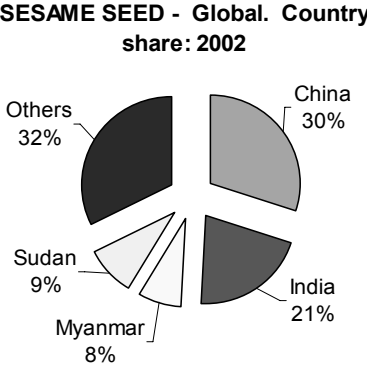
Figure 4.2 Sesame seed: global production, 1992 to 2003



Source: UN Food and Agriculture Organization.

About 70 countries record some production of sesame seeds. China (producing about 895 000 tonnes in 2002) and India (620 000 tonnes) account for about half of world production (see Figure 4.3).

Figure 4.3 Sesame seed: global production, by country, 2002



Source: UN Food and Agriculture Organization.

After China and India, Sudan (269 999 tonnes) and Myanmar (225 000 tonnes) are the next biggest producers, followed by Uganda (106 000 tonnes), Nigeria (75 000 tonnes) and Pakistan (61 000 tonnes).

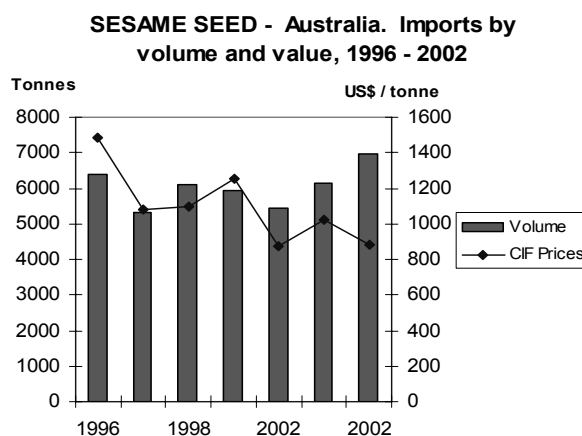
Trade

In the past five years world trade in sesame seed has been relatively constant, at about 15 per cent of production (see Appendix H).

Japan is the world's largest importer of the seed, importing about 150 000 tonnes a year in the seven years to 2002. Korea is next largest importer, importing about 60 000 tonnes annually. Together, Egypt, Iran, Israel, Jordan, Lebanon, Saudi Arabia, Syria and Turkey imported 223 092 tonnes in 2002.

Although China is the world's largest producer, it also is a significant importer: this may be a consequence of internal logistical and distribution problems rather than preferences for different types of sesame. China imported an average of 39 000 tonnes a year in the seven years to 2002. The United States is also an importer of note—46 299 tonnes in 2002, with a seven-year average of 46 000 tonnes a year. Australia is a consistent importer of sesame seeds; in 2002 it imported 6983 tonnes. As Figure 4.4 shows, the volume imported oscillated around 6000 tonnes between 1996 and 2002, but there has been a persistent decline in the CIF price: prices almost halved during the period.

Figure 4.4 Sesame seed: Australian imports, by volume and value, 1996 to 2002



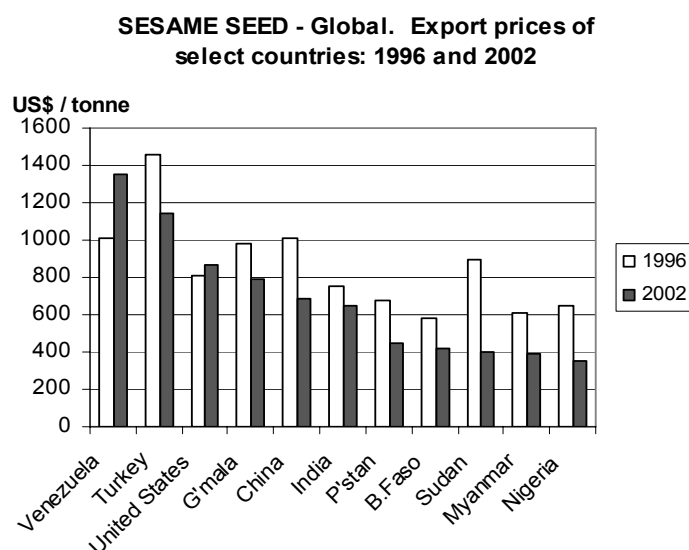
Source: UN Food and Agriculture Organization.

India and China are large exporters. An analysis of the export data reveals several features:

- The quantities India and China export represent only a small proportion of their total production.
- Sudan is not only the biggest exporter but also the most consistent.
- In Myanmar exports shrank dramatically during the seven years to 2002—from 52 500 tonnes in 1996 to 3900 tonnes in 2002.
- Burkina Faso, Guatemala, Mexico, Nigeria, Pakistan, Sudan, Tanzania, Venezuela and Vietnam export a relatively high proportion of their production.

With the exception of Venezuela and the United States, there was a decline in the export prices received for sesame seed between 1996 and 2002 (see Figure 4.5).

Figure 4.5 Sesame seed: export price, selected countries, 1996 to 2002



Source: UN Food and Agriculture Organization.

A number of other features are also noteworthy:

- Venezuela exports a large quantity of sesame seed—albeit with large variations between years—and consistently receives the highest export prices. In 2002 it received an average FOB price of US\$1352 per tonne.
- The relatively small exporters Turkey and the United States receive high prices—in 2002, US\$1143 a tonne and US\$865 a tonne respectively.
- There is a clear second tier of prices—between US\$600 and US\$800 a tonne—paid for sesame seed from Guatemala, China and India.
- The consistent and sizeable exporters Pakistan, Burkina Faso, Sudan, Myanmar and Nigeria receive between US\$300 and US\$500 a tonne.

4.6 Sorghum

Sorghum (*Sorghum bicolor*) is also called kaf, kafir corn, durra, milo, great millet, millo maize, American broom corn, Egyptian corn, African millet, Black Indian millet, and Guinea corn. In a number of the health stores the authors visited in Australia and North America the terms ‘millet’ and ‘sorghum’ were being used synonymously.

There are a number of sorghum types:

- *Sweet sorghum*. This refers to the sweet juice found in the stalk, which can be boiled down into sorghum syrup. The leaves and stalk are then used for silage and animal feed. Sweet sorghum is quite tall, growing to more than 3 metres.
- *Grain sorghum*. These types produce grain that is used as feed for all types of livestock and is consumed by humans. The grains can be red, brown or white.
- *Grass sorghum*. These types are called Sudan grass, Tunis grass or Johnson grass and are used as summer pasture and for forage.
- *Broom corn*. This name derives from the use to which this type of sorghum’s matured branches are put.

Health attributes

Sorghum has high levels of insoluble fibre, and its protein and starch are more slowly digested compared with other grains. This is generally a good attribute in terms of health, especially for diabetics.

Uses

Sorghum can be cooked whole or hulled and ground into flour either by traditional means or with machinery. The flour from sorghum is considered the best general gluten-free flour.

The basic range of foods for which sorghum can be used is as follows:

- Breads. These can be unfermented (for example, *roti* and *dhosa* in India) or fermented (for example, *kisra* and *dose* in Africa). Tortilla is an unfermented flat bread that can be made from whole or hulled sorghum; Mexico, the home of the tortilla, is the world's fourth-biggest sorghum producer.
- Porridges. *Sangati* is an Indian stiff porridge and *ambali* is a thin one. Thick porridges are common in Kenya, Tanzania and Uganda (where they are uniformly called *uguli*), Burkina Faso and Niger (*to*), Nigeria (*tuwo*), Sudan (*aceda*), Botswana (*bogobe*, *jwa ting*) and Zimbabwe (*sadza*). Thin porridges are called *uji* in Kenya and Tanzania, *ogi* in Nigeria and Ghana, *edi* in Uganda, *rouye* in Niger and Senegal, *nasha* in Sudan, and *bota* in Zimbabwe. The porridges can also be fermented to improve their shelf life.
- Steamed products, the main form being couscous.
- Boiled products.
- Beverages—such as the African sweet beers *burukutu dolo* and *pito* and the sour, opaque beers *marisa*, *busaa*, *urgwaga* and *utshwala*.
- Snack foods—*pelapindi* is an Indian popped whole grain snack.

Grain sorghum also produces an edible oil, and starches, dextrose and commercial enzymes can be extracted from the grain.

Hard, small grains are specifically grown for processing into foods that are used as a substitute for rice.

Production

Sorghum is an important grain crop. In the decade to 2003 world production tended to remain at about 80 million tonnes a year. Eleven countries in Africa, the Americas, Asia and Oceania produce over 1 million tonnes each. This wide geographic spread of production militates against massive global variations in output. Table 4.11 shows the world's largest sorghum producers.

Table 4.11 Sorghum: production of the 10 largest producers, 2003

Country	Production (million tonnes)
United States	10.4
India	8.5
Nigeria	8.1
Mexico	6.4
Sudan	4.3
Argentina	2.8
China	2.8
Brazil	1.7
Ethiopia	1.6
Burkina Faso	1.5

Source: UN Food and Agriculture Organization.

Trade

Around 10 per cent of global production is traded internationally. This figure stayed relatively stable during the decade to 2002 (see Appendix I). The United States consistently provides nearly 90 per cent of the world's sorghum exports. Excluding Australia in drought-affected years, the only other two exporters of note are Argentina (413 000 tonnes in 2002) and France (208 000 tonnes). France exports at least 50 per cent of its production.

Marketing

Proprietary promotional material makes the following claims in relation to the healthy attributes of sorghum:

- high in insoluble fibre
- protein and starch slow to digest.

4.7 Teff

Teff (*Eragrostis tef*) is an oddity in that until quite recently it was grown and consumed as a cereal in virtually just one region—Ethiopia and Eritrea. Its primary use there is as a cereal, but it is also used as livestock forage. It is grown as a forage crop in other parts of Africa and India⁴⁷, Australia, the United States and South America.

Another unusual thing about teff is that, although the literature makes frequent reference to its being an important staple food in Ethiopia and Eritrea, the grain's low yield and highly labour intensive method of production result in it being quite expensive. Staple foods are rarely expensive.

Product description

Strictly speaking, teff is a grass, and its grain is exceptionally small. The name 'teff' is derived from the Amharic *téf*, which means lost—a reference to the grain's small size. On average, 1000 seeds weigh just 0.3–0.4 grams; put another way, 150 grains of teff weigh as much as one grain of wheat.

There is great diversity in seed colour—from pale white to ivory and from light tan to deep brown. The lighter coloured grains have a milder taste, probably because the darker ones have a higher iron content. The lighter coloured teffs are also more expensive because they are grown under more rigorous climatic conditions.

⁴⁷ This seems to be a result of action in 1886 by the Royal Botanic Gardens at Kew in England, which distributed teff to India as well as other colonies.

Health attributes

Although there is some debate about the precise nutritional value of teff, it is generally accepted that the grain is highly nutritious. The debate concerns the grain's high proportion of bran and germ as a result of its small size. Because of the difficulty of gristing such a small grain in order to separate the germ, bran and endosperm, the grain is treated as a whole and one consequence of this is that it has a very high fibre content compared with the other grains—15.3 grams of fibre per 120 grams of flour. Another debated question concerns the iron content, which has been estimated at 62.7 milligrams per 120 grams (Piccinin 2002). Some attribute this high level to the dust and dirt that cling to the grain and cannot be gristed off. Table 4.12 provides details of teff's nutritional profile; Table 4.13 shows its amino acid levels.

Table 4.12 Teff: nutrient profile of a 45 gram serving

Nutrient	Amount
Calories	160.0
Calorie from fat	5.0
Total fat (g)	1.0
Saturated fat (g)	0.0
Cholesterol (mg)	0.0
Sodium (mg)	10.0
Total carbohydrate (g)	33.0
Dietary fibre (g)	6.0
Sugars	–
Protein	6.0 ^a
Niacin (mg)	2.5
Vitamin C (mg)	88
Calcium (mg)	159
Chloride (mg)	13
Magnesium (mg)	170
Manganese (mg)	6.4
Phosphorus (mg)	378
Potassium (mg)	401
Sodium (mg)	47
Zinc (mg)	2

– Zero

a. Figures as high as 14–15 per cent have been estimated (OIA 2003).

Source: Bob's Red Mill. (On the basis of observations in stores across the United States and discussions at the Natural Produce Expo in Anaheim, California, in March 2004, Bob's Red Mill is arguably the largest of the smaller millers in the country. It has one of the widest range of grain products.)

Table 4.13 Teff: amino acid levels

Amino acid	Level
Cystine	1.9
Lysine	2.3
Methionine	2.1
Phenylalanine	4.0
Threonine	2.8
Tryptophan	1.2
Tyrosine	1.7

Source: OIA (2003).

The following has been said about teff's nutritional value:

Very high calcium content and contains high levels of phosphorous ... copper, aluminium, barium and thiamine ... high in protein, carbohydrates and fibre. (Railey n.d.)

... teff contains more lysine than barley, millet and wheat and slightly less than rice or oats ... many times the amount of calcium, potassium and other essential minerals found in an equal amount of other grains. (Piccinin 2002)

Uses

Traditionally teff is ground into flour, fermented and made into *enjera*, or *ingera*, a flat bread.⁴⁸ There are two types of *enjera*, sweet and sour. The sweet type results from a short fermentation process, whereas longer fermentation produces a sour bread that can be stored for longer. Stallknecht et al. (1993) note that the fermentation process can affect the supply of nutrients: the shorter process that produces the sweeter *enjera* results in less loss of amino acids when the liquid is removed from the dough compared with the longer process. Teff is also eaten as a porridge and is an ingredient in home-brewed alcoholic drinks.

Outside Ethiopia and Eritrea, teff's market was initially limited to emigrant communities from those countries—for example, in Washington DC, New York, Seattle, Los Angeles, London, Rome, Tel Aviv⁴⁹ and Frankfurt. Once teff was introduced, however, the local host community seems to have become interested.

Because the grain is so dense, a small volume of teff easily displaces a much larger volume of other products. As a result, it is used as a part substitute for seeds, nuts and other small grains. Because of its gelatinous nature, cooked teff is used as a thickener in soups, stews, sauces, casseroles and puddings.

Teff's amino acid properties combined with its thickening properties have prompted food manufacturers to explore using the grain in the functional food and ingredients market. Further, the ability to use teff in *enjera*-type applications is a positive attribute. Tortillas can be made with teff. If teff can be used to improve the elasticity of such products, that would open up a huge market, including 'wraps'.

Production

Recent growth in teff production outside Ethiopia and Eritrea has been based on its being a cereal rather than a forage crop. Production occurs in a wide range of environments, from drought-stressed country to water-logged land. Teff prefers altitudes between 1700 and 2200 metres and relatively dry conditions (450–550 millimetres a year); its preferred temperature is 10–27°C with 12 hours of sunlight.

Ethiopia remains the centre of production, producing about 900 000 tonnes in 1995 (OIA 1996). There has been a steady increase in the area planted. Teff production for cereal, rather than as a forage crop, is known to occur in the Kenya, Malawi, South Africa, the United States, Yemen and India.

Because of the grain's small size, teff poses production challenges: any gaps in the mechanical harvesting system will result in lost grain; worse, contamination with soil is a serious problem since it is virtually impossible to separate the soil from the grain.

Marketing

Proprietary promotional material makes the following health-related claims for teff:

- rich in calcium, protein and iron
- a sweet, malty flavour.

It is commonly promoted as one of the newly discovered 'lost' or 'ancient' grains⁵⁰, with all the positive attributes these grains are said to possess.

Australia

It was not possible to establish whether teff is grown in Australia.

⁴⁸ Strictly speaking, *enjera* is not a flat bread but a puffy product that is half way between a true flat bread and a Western-style loaf. The rising is unusual because of the absence of gluten.

⁴⁹ Israel's Volcani Centre is conducting research into teff.

⁵⁰ Domestication appears to have begun about 4000 BC.

5 The future demand for health grains

Current growth in the demand for gluten-free products is estimated at about 10–20 per cent a year. This estimate is based on the authors' discussions with manufacturers of gluten-free products and retailers that stock these products. Demand is not even across all gluten-free products, however, with the higher growth rates being associated with the newer markets because they are starting from a low base.

This chapter discusses the future demand for gluten-free products and thus the identified health grains. The two basic determinants of future demand are the size of the potential market segment seeking gluten-free products and identification of the attributes sought by that market segment.

5.1 The market

The client base for gluten-free products has three components:

- coeliacs
- people seeking healthy alternatives
- people following various dietary fads.

Coeliacs

It is unlikely that the proportion of coeliacs in the population will increase. Epidemiological studies suggest the figure will probably not exceed about 1.5 per cent of the population.

The incidence of coeliac disease is under-reported at present because of limitations in our knowledge about the disease and the limitations of the current methods of detection. The high growth rates noted by interviewees are essentially a result of the number of 'covert' coeliacs becoming 'overt'. The extent of this change from covert to overt is, however, finite, being determined by the estimated incidence of coeliac disease in the population.

Current demand for gluten-free foods tends to be skewed towards the food types sought by older age groups in the population because diagnostic techniques favour these age groups. As knowledge of coeliac disease expands and detection methods improve, it is probable the demand for such foods will change.

Thus, there will not be a significant increase in total demand, but the nature of what is sought will change. Put simply, there will be a demand for baby foods and foods for adolescents and young adults, as well as foods for the older age groups.

People seeking healthy alternatives

People seeking gluten-free foods for reasons of choice, rather than out of necessity, will be the major source of increased demand for health grains and the products derived from them. Moreover, the demand will not be specifically for the gluten-free properties of the grains: it will be for a range of attributes, of which the absence of gluten is but one. As noted in Chapter 4, the seven grains that are the subject of this report are promoted as having the following combinations of 'health' properties, as opposed to being simply gluten free:

- amaranth
 - superior nutrition
 - rich in lysine and high-quality protein
 - nutty, slightly spicy and sticky, gelatinous texture
 - pops like popcorn
 - strong, sweet, spicy, nutty-flavoured flour
 - strong moisture retention
 - high in fibre

- buckwheat
 - high in all eight essential amino acids
 - high in calcium and vitamins E and B
 - mild flavour
- millet
 - alkali free
 - rich in lysine
 - high-quality protein
 - rich in vitamin B
- quinoa
 - high in calcium, iron and fibre
 - a complete source of vegetarian protein
 - contains all eight essential amino acids
 - packed with nutrition
 - high in lysine
 - contains an ideal-quality protein compared with wheat
 - has more iron, phosphorus, vitamins A, B and E, and more calcium and fat than other grains
 - the flour contains twice the protein of corn and rice
- sorghum
 - high in insoluble fibre
 - protein and starch slow to digest
- teff
 - rich in calcium, protein and iron
 - a sweet, malty flavour.

During the fieldwork for this project it became apparent that promotion of any product on the basis of the single attribute of being gluten free is rare. The attributes can be categorised as follows:

- *Attributes relating to the production of the raw grain.* In the main, this relates to organic production. A variety of claims relating to the ‘organic-ness’ of the production method were noted; they can be viewed as a continuum.

conventional production

produced with minimal pesticides

no chemical residues

grown in accordance with Codex standards

grown organically

grown in accordance with organic principles

grown on an organic farm

certified organic—no certifier identified

certified organic—certifier identified

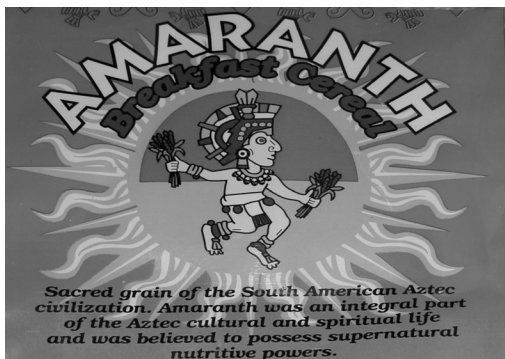
fully organic

In relation to the two ‘certified organic’ categories, it was noted that in the United States the association with the US Department of Agriculture and its ‘USDA Organic’ imprimatur seems to be perceived as having greater marketing appeal than an association with a specific certifier: although such certifiers are identified, they are given far less prominence than the ‘USDA Organic’ logo.



A less frequently observed goodness-by-association claim was ‘Recognised by the Food and Agriculture Organization of the United Nations’. Another production-based health attribute was ‘Not grown with sewerage water/sewerage sludge’, although this was not common.

- *Attributes relating to the raw grain itself.* Two attributes can be associated with the raw grain:
 - *Antiquity.* With amaranth, quinoa and teff much is made of their links with the past, the assumption being that because it is old it is good. Words such as ‘ancient’, ‘lost’ and ‘rediscovered’ are common. Links with the Aztecs, the Incas, the Mayans and ancient Egypt are used to invoke images of food for the warrior class.
 - *‘Indigenous-ness’.* The links between production of the grain and indigenous communities are also used to invoke notions of naturalness.



- *Attributes seen as benefits of the raw grain.* These attributes are usually expressed in the form ‘contains ...’ and generally relate to nutrition, protein, amino acids and fibre.⁵¹
- *Attributes associated with converting the raw product to the end product.* In the main, these attributes are associated with the method of processing and the end product itself.
 - *The method of processing.* Here, the emphasis is on the processing facility. For the milling or gristing stage, statements relating to isolation and steps taken to prevent contamination are made.⁵²
 - *The end product.* It is rare that a gluten-free product contains solely gluten-free grains.⁵³ As a result, health claims made in respect of the product tend to relate to the other ingredients in the product. In the main, the identification is expressed by the phrase ‘Does not contain ...’ Commonly identified in such claims are ‘wheat free’, ‘yeast free’, ‘eggs free’, ‘dairy free’, ‘fat

⁵¹ Strictly speaking, there is duplication in some of these terms: ‘nutrition’ can encompass ‘protein’ and ‘amino acids’.

⁵² ‘We have a dedicated room where *ONLY* gluten free products are milled’ (emphasis in original document)—from arguably one of the United States’ most diverse millers of whole grain natural foods. Product from this miller was seen in the United States, Canada, the United Kingdom, Hong Kong and Australia.

⁵³ The two obvious exceptions are breakfast cereals and muesli.

free' (or at least a defined percentage of freedom from fat), 'cholesterol free', 'salt free' or 'low in salt'⁵⁴, 'sugar free' and 'additive free'.

If the gluten-free grains and their derived gluten-free products adopt the additional health-related attributes just noted, the demand for these products will come from two primary groups of consumers: coeliacs and other gluten-intolerant consumers; and that proportion of the population seeking healthy foods that, among other attributes, are gluten free.

As noted, there are limits to growth in this sector of the population. It is estimated that the sector's size will approximate that of the organic sector—that is, between 5 and 10 per cent of consumers. Since there is likely to be a coincident demand from people seeking a number of the additional health attributes and people seeking organics, the figure will probably be closer to 5 per cent than 10 per cent.

A final comment

All the proponents of health grains provided information about the nutritional benefits of their product. However, their bases for measurement varied. Not surprisingly, the standard chosen is the one that presents the particular grain in the best possible light. The following standards were seen:

- per imperial measurements
- per metric measurement
- per cup
- per packet
- against some objective standard such as 'assuming milk to be 100, then ...'

In one instance observed, the nutritional value of a large number of gluten-containing and gluten-free grains was compared on a common basis. Although this was not as detailed as the analysis provided for specific grains, at least it used a common standard (see Appendix J).

Dietary fads

The West's obsession with obesity and 'wellbeing' (however defined) has led to an obsession with dietary fads. This is particularly evident in North America⁵⁵, the United Kingdom and, to a lesser extent, Australia. (It would appear that dietary fads are less of a preoccupation in Europe.) The various fad-based diets make a host of recommendations for and against the consumption of various foods and food groups. The fact there are so many diets is indicative of their short-lived nature. The impact of dietary fads should therefore be ignored when estimating the likely future demand for gluten-free products.

5.2 Determinants of demand

Three factors will determine the future demand for gluten-free products:

- knowledge
- manufacturers' initiatives
- supermarkets.

⁵⁴ In the United States the term 'sodium' was more common than 'salt'.

⁵⁵ 'More than half of American adults are trying to lose weight'—*Natural Grocery Buyer*, winter 2004.

Knowledge

The knowledge of three sets of actors will play a major role in boosting the demand for gluten-free products:

- *Health workers.* This includes doctors, nutritionists, dietitians and nursing staff. An increase in the number of known coeliacs is dependent on health workers' ability to recognise the plethora of symptoms that constitute coeliac disease. They must also have the knowledge to teach coeliacs what are acceptable products.

Various organisations⁵⁶ provide educational materials for the health sector. They also recommend suitable foods: Coeliacs UK has a database of 12 000 food items that are deemed gluten free and/or wheat free.⁵⁷ Philosophical differences between the various organisations can, however, affect their recommendations in relation to acceptable foods. For example, in the United States the main coeliac groups exclude whisky because it is made from malt that comes from the gluten-containing grain barley, whereas in Canada the main coeliac group does not make such a recommendation because, in its view, the amount of alcohol that would have to be drunk for the volume of barley to have a coeliac effect would be such that the drinker would have well and truly passed out before drinking the requisite volume.

- *Store staff.* Apart from information provided by the various organisations representing coeliacs, a common reference point for many coeliacs searching for gluten-free products is store staff. Formal and informal interviews were held with more than 70 retailers in Australia, Canada, France, Ireland, Switzerland, the United Kingdom and the United States. The following sums up those interviews:
 - There is enormous variation in the extent of the knowledge of store staff.
 - Generally, the larger the store the more limited the knowledge. Staff knowledge in the conventional chain store retailers in Australia, Canada, the United Kingdom and the United States was generally poor, although there were exceptions to this.
 - Staff knowledge among the chain-based specialist retailers was much better.
 - At the lifestyle stores staff knowledge was excellent.
 - Staff knowledge at the health food specialist stores was poor.
- *Consumers.* Coeliacs' demand for gluten-free foods is limited to a large extent by their own lack of knowledge. There are two aspects to this:
 - *Raw products.* For many coeliacs the health grains are unknown products. If more were known about how to use the raw products, use of the products would increase. Demand would move beyond the narrow existing range if the products were accompanied by recipes. This does occur to some extent, but greater effort is needed.
 - *Processed products.* There is much confusion about what is gluten free and what is wheat free. Gluten-free products are not readily identified. There is a logo—the 'crossed grains' symbol—but its use is not universal. Nor, indeed, is the logo itself always the same, as the examples here demonstrate. Use of the logo was seen in Australia, Canada, France, Switzerland and the

⁵⁶ Coeliac societies in Australia are the Coeliac Society of Australia, the Coeliac Society of NSW Inc., the Coeliac Society of Victoria, the Queensland Coeliac Society, the Coeliac Society of South Australia, the Coeliac Society of WA, and the Coeliac Society of Tasmania. In the United States, the major groups are the Gluten Intolerance Group of North America, the Celiac Sprue Association, the Celiac Disease Foundation, Raising our Celiac Kids, Celiac.com, and Gluten Free and More. The authors made contact with two such groups in Australia, three in the United States, and the national organisations in the United Kingdom, Canada and Switzerland.

⁵⁷ The website of the Coeliacs Society of Australia lists the following suppliers of gluten-free products: Freedom Foods, Rosita's Australia, Nu-Vit, Meriram, Sunsol Products, Soy Products, Roma Food Products, Massel International, Food Care, Gluten-Free Pantry, Gluten Solutions, Liv-N-Well, Menu Direct and Because You're Special.

United States. Coeliacs UK claims that the ‘crossed grains’ logo is trademarked to it, but it does not apply it on a licence basis.⁵⁸



In the United Kingdom legislation requires that products containing wheat must be so identified. Comparable legislation is mooted for the United States.⁵⁹ If anything, this might be confusing because it could lead to the implication that wheat is the only product that contains gluten. As noted in Chapter 3, a number of other grains contain gluten. To simply say that a product does not contain wheat does not mean the product is free of gluten. Coeliacs will continue to be reluctant to try other products.

Manufacturer’s initiatives

Two types of manufacturer’s initiatives were observed in connection with gluten-free products. With one, the manufacturer works from the basis of developing new gluten-free products; this is a long-term approach. With the other, the manufacturer observes what gluten-containing products are available and sets about producing the same thing with gluten-free grains; this is by far the speedier approach. As Chapter 3 points out, there is a vast array of gluten-free products, and many of them seem to have originated as a result of a manufacturer taking this second approach.

Supermarkets

Supermarkets are a mixed blessing for coeliacs and others seeking gluten-free foods. On one hand, they represent the ultimate in shopping convenience. They stock a huge array of products and their buying power ensures that those products are available at very competitive prices. If a manufacturer of gluten-free foods can have its product marketed through a supermarket, that ensures significant exposure for the product. On the other hand, there are distinct disadvantages of marketing through a supermarket:

- *Product shelf life.* Whilst the time varies between supermarket chains, products generally have about six months to prove themselves and meet a precise sales expectation. If they fail they are removed from the shelves.
- *Supplier numbers.* Supermarkets usually want two or three suppliers of a specific product. Moreover, they usually require a number of products from a single supplier, rather than a single product from each of a number of separate suppliers.⁶⁰ This is in the interest of their internal accounting, reducing the overall number of accounts they must run. Supermarkets also like to have each product presented in a series of sizes, thus giving consumers a choice between sizes rather than a simple yes–no choice. Combined, the numerous products from a single supplier and the numerous sizes for each product result in the supermarkets’ ‘breadth and depth’ policy.
- *Real estate.* Supermarkets are actually real estate agents, selling shelf space to food suppliers. It is common for supermarkets to charge the supplier for the rent of the space, over and above any commission they make on the sale of the product. This rent can be demanded up front and can relate to the term of the product’s life on the shelf—that is, six months.

⁵⁸ These examples were taken directly from packages of gluten-free food. The first appears to be a photographic inverse of the second one. This may have been done to avoid any licensing problems with Coeliacs UK, even though that organisation has stated that it will not pursue litigation against those who use the logo—pers.comm., London, May 2004.

⁵⁹ Gluten Intolerance Group of North America—pers. comm., Los Angeles, March 2004.

⁶⁰ This phenomenon was particularly evident with the supply of herbs—see Vinning and Hemphill (2001) and Vinning (2001b).

- *Cooperative advertising.* This refers to the charge supermarkets apply when they promote their products in the media. Such promotions can be weekly specials in the newspapers or more elaborate pieces in national magazines and on radio and television. In the end, even though it is the retailer's banner that heads the advertisement, it is the supermarket suppliers that pay for the advertisement.
- *Store-wide supplies.* Supermarkets are chain stores. They like all their stores to stock the same product.⁶¹ This places a heavy volume demand on a potential supplier.

Thus, although it might suit consumers to obtain their gluten-free products from a supermarket, there are a number of reasons why suppliers of gluten-free products might be reluctant to become involved. The financial commitment to a supermarket must be considered, in addition to the manufacturer's requirement to educate the public about the benefits of its product.

Conclusion

In sum, the determinants of demand for gluten-free products are as follows:

- people who seek gluten-free food for health-related reasons
- the provision of coeliac-related information by coeliac organisations, health workers and store staff
- the choice of retail outlet by the manufacturers of gluten-free products. Ideally, the best exposure will come with placement in the chain-sized specialist health stores
- an assured, universally recognised system of identification of a product being gluten free. The two best ways of achieving this are through compulsory, non-confusing labelling clearly identifying the product as being gluten free—not merely wheat free—and the use of a logo. As an intermediate step, something in the nature of the following phrase, used by a whole-grain miller in the United States, might be introduced: 'Gluten-free property confirmed by use of ELISA gluten assay test'.

5.3 The future size of the market

The current rates of growth in demand for gluten-free products will continue in the near future—that is, growth of 10–20 per cent a year. This growth will not, however, continue indefinitely. It will stall when the market reaches about 5 per cent of the population.

The rate of annual increase will start to decline in the next few years and will decline considerably within five years. After that, growth in demand will parallel growth in the general population.

Finally, given the relative size of the coeliac population and the estimated growth in the demand for gluten-free products, the basic determinants of demand will be the combination of health attributes, rather than reliance on the gluten-free attribute alone.

⁶¹ This is despite some chains having a policy that store managers can stock specific products that may be in demand because of the store's location in a specific area.

6 The future supply of health grains

Chapter 4 looks at the current global supply of the seven identified health grains. This chapter analyses the likely future supply of the grains using three criteria:

- what is likely to be grown overseas
- what is likely to be grown in Australia
- what is likely to be the supply situation for the products that are derived from the seven grains.

This framework recognises that, whilst it is the raw grain that is grown, in virtually all cases it is the processed products made from the raw grain that are sought.

6.1 Overseas production

Interestingly, production of the seven health grains largely occurs in countries where the population is not predisposed to coeliac disease:

- amaranth—Andean countries, India
- buckwheat—China, eastern Russia, Ukraine
- millet—India, West Africa, Sahelian Africa, China, parts of the former Soviet Union, other subcontinent countries
- quinoa—Andean countries
- sesame—China, India
- sorghum—United States, India, Nigeria, Mexico, Sudan
- teff—Ethiopia, Eritrea.

Amaranth

Detailed production data for amaranth are not available. Movements in production in the Andean countries are likely to be in response to changes in local demand for amaranth as well as competition with other grains. Demand for amaranth will be determined by local conditions and customs.

Some effort is being made to expand amaranth production in the United States.⁶² The people involved must, however, contend with the government assistance given to the mainstream grain crops. It is therefore difficult to envisage any significant increase in amaranth production in the near term.

Buckwheat

China and eastern Russia are the main sources of buckwheat. Chinese production is essentially directed at the Japanese market; production in Russia and the Ukraine tends to be for stockfeed. Unless Japan reverses its pricing policy towards China (see Vinning 2001a), Chinese production is expected to continue its downward trend.

The UN Food and Agriculture Organization puts annual production in France and the United States at 75 000 tonnes and 65 000 tonnes respectively. These figures seem unreasonably high, despite the fact that the FAO data are based on information supplied by member countries.

- *France.* Buckwheat products do not seem as common in France as the production data would suggest.⁶³ This is in contrast to Japan, where it is difficult to escape the presence of buckwheat soba. Japan's annual consumption of buckwheat is around 120 000 tonnes, supplied by local production and imports, overwhelmingly from China. This is nearly double France's attributed production level. But France's population is around half that of Japan, so the two factors should

⁶² Nu-World Amaranth Inc., Illinois, pers. comm., March 2004.

⁶³ Based on observations in France in 2004 and detailed observations in stores in Geneva, which by location and inclination is Francophile.

even each other out. No one in the trade mentioned France as a major producer.⁶⁴ France is a country susceptible to coeliac disease, so a reasonable level of production can be considered to be consumed internally.

- *United States and Canada.* Detailed discussions in the United States⁶⁵ and Canada⁶⁶ put the combined production of buckwheat at less than half the FAO figure. Moreover, buckwheat production is struggling to maintain its current level. There appears to have been a negligible response to a specific coeliac-based demand. Long-term trends suggest that, at best, production will remain at the current level. A conclusion from the Vinning (2001a) study, that a potential trigger for expanded production could be demand for the nutraceutical properties of buckwheat, was confirmed in interviews at the Natural Products Expo.

The most likely scenario for the overall supply of buckwheat is maintenance of the current supply. Japan will have to increase the price it pays China to combat the likely reduction in production and thus exports to Japan. No specific response to coeliacs is expected.

Millet

Millet is a widely produced grain. With the exception of the United States, and to a much smaller extent Australia, production is based in countries where the people are not prone to coeliac disease. Supply will thus be in response to local and traditional factors. The millet is used for both animal feed and human consumption.

Although trade in millet accounts for only about 10 per cent of production, there is considerable seasonal variation in volumes and prices. The world's leading exporter is the United States, although US exports have declined by nearly 50 per cent in the past five years. Since trade tends to be for the animal feed market, the supply of millet for human consumption will be largely determined by the overall supply of animal feed grains.

The most likely scenario for the supply of millet is a continuation of the current situation. There is an adequate supply to meet any coeliac-induced demand, despite the likelihood of there being changes in the composition of the various types of millet to meet specific demands, especially from coeliacs.

Quinoa

Like most of the other specified health grains, quinoa is produced in countries where the inhabitants are not predisposed to coeliac disease. Quinoa does, however, seem to be a grain for which supply is influenced by demand from coeliacs. In all six countries where interviews were conducted with manufacturers and retailers of gluten-free foods, reference was made to the supply of quinoa from, variously, 'South America', Ecuador, Peru, Chile and Bolivia.⁶⁷

There have been some efforts made to increase the supply of quinoa in the United States, Canada, France and Denmark, all of which are prone to coeliac disease. There have also been efforts made to increase the production of quinoa in countries with favourable climatic conditions.

Sesame

Sesame production occurs mainly in countries that do not have a problem with coeliac disease, so future supply of the grain will be determined by local factors. Even if the supply were suddenly to

⁶⁴ Based on trade interviews associated with the collection of data for the 2001 study (Vinning 2001a) and trade interviews at the Natural Products Expo in the United States in March 2004.

⁶⁵ See Vinning (2001a). Confirmed by interviews at the Natural Products Expo. Specifically, Food For Life Baking Co., GEF Inc., Kashi Company, Nature's Path Foods Inc., Nu-World Amaranth Inc., and US Mills Inc.

⁶⁶ See Vinning (2001a). Pulse and special crops analyst, Market Analysis Division, Ag Canada, Winnipeg, pers. comm., March 2004.

⁶⁷ No references were made to Colombia and Argentina, both of which produce quinoa.

increase by 10 per cent in response to coeliac-led demand, this would still only approximate the seasonal variations that typify global production.

The international trade in sesame supplies two distinct markets—the dipping-sauce market in Japan and Korea (the world’s largest importers) and the tahini and halva market in the Middle East. The seed’s high oil content tends to limit its use in many of the foods made from gluten-free grain.

Overall, it is not expected that the supply of sesame seed will be affected by demand from coeliacs.

Sorghum

With the exception of the United States, none of the world’s major suppliers of sorghum have a domestic coeliac problem. Variations in production will be in response to local conditions as well as movements in the overall market for feed grains. The supply of sorghum for human consumption will depend on traditional factors.

Sorghum production in the United States is primarily aimed at the animal feed market. It is possible that some highly specialised varieties could be produced for the coeliac market. Given the size of total production—10.4 million tonnes in 2003—it is highly unlikely that demand from coeliacs will have an impact on total production.

Overall, there is an adequate supply of sorghum to meet any demand from coeliacs.

Teff

As noted in Chapter 4, teff has some unique properties. It is made almost exclusively into enjera, which is consumed almost exclusively by Ethiopians and Eritreans.⁶⁸ Despite its gluten-free properties, teff will probably not move beyond this confine. From a production point of view, the teff grain’s minute size makes it extremely difficult to handle. Even in Ethiopia and Eritrea it is expensive.

It is unlikely that the supply of teff will expand beyond the current limited base.

6.2 Australia

Amaranth

Although limited supplies of amaranth are available in Australia, consistency in supply and quality is a problem.

One manufacturer of bakery products reported that amaranth was the only gluten-free grain used.⁶⁹ A manufacturer of pasta noted that the grain’s strong taste tended to reverse the normal pasta ‘formula’, whereby of the two basic ingredients (that is, the pasta and the sauce) the flavour of the sauce was overwhelmed by the flavour of the pasta.⁷⁰ Nearly all manufacturers interviewed noted that the high price of amaranth was another factor limiting their use of the grain.

In the absence of a strong demand imperative it is unlikely that production in Australia will increase in any meaningful way.

⁶⁸ In this regard a parallel can be drawn with *poi*, the unique fermented, pounded form of taro that is consumed almost solely by Hawaiians. Poi consumption is only around 5000 tonnes a year, compared with over 10 million tonnes for the conventional form of taro. See Crippen and Vinning (2003) and Vinning and Young (2003).

⁶⁹ Brits Danish Delight, Brisbane, pers. comm., January 2004.

⁷⁰ Casellari Specialty Pasta, pers. comm., February 2003.

Buckwheat

The Australian buckwheat industry showed quite strong growth in the 1990s. One factor favouring production is that buckwheat is a summer crop that in a number of potential production areas fits in between pasture and winter crops. It can also be grown using conventional equipment.

Despite the impressive increase in production, cultivation of buckwheat has not taken off in a way comparable with that of lentils, even though good buckwheat crops can produce very favourable gross margins (Bluett 2001). Poor yields are, however, more common. The most common cause of poor yields is adverse conditions at the flowering stage. Other factors hampering the industry's expansion are difficulties with harvesting and the critical requirements for the size and colour of the harvested grain. Vinning (2001a) showed that when Australia does get size and colour requirements right the rewards in the Japanese market are good: in the six years from 1995 to 2000 Australian buckwheat received nearly double the price of that from Canada and the United States and triple the price of that from China, the dominant supplier. For China, the six-year average was 29 yen per kilogram, for Canada it was 48 yen per kilogram, for the United States it was 54 yen, and for Australia it was 89 yen.

Production is for the soba market, as raw grain for export to Japan or for delivery to the Haku Baku noodle factory in Victoria. The fact that buckwheat is produced solely for soba means that if the product does not meet the high quality requirements of the soba market there is virtually no other market for it. None of the interviewees noted buckwheat as a raw ingredient for the production of non-noodle products.

The coeliac market could take up some non-soba buckwheat but would not influence total supply.

Millet

Australia exports about 15 000 to 20 000 tonnes of millet each year, mainly to Japan. Because of the considerable variability in yields⁷¹, in some years Australia imports small quantities. Although food manufacturers have expressed some interest in millet for human consumption, the industry is fuelled by the demand for birdseed; it experienced annual growth of about 5 per cent in the 1980s and early 1990s. Previously, the demand was based on smaller birds such as canaries, budgerigars and finches, which require small seeds, whereas the trend now is towards the smaller parrots and wild feeders, which require larger seeds. Overall, production is likely to be static.

In the case of human consumption, there is a demand for millet-based cereals, especially for the elderly. It appears, however, that this demand is for the grain's general health-promoting properties, rather than its gluten-free attribute (Twyford-Jones 1995). Lack of variety in the final product form is also limiting the crop's expansion.⁷²

It is estimated that any coeliac-based demand for millet will have an impact on total supply comparable with the degree of variation in yield.

Quinoa

The authors were unable to establish whether quinoa is grown in Australia. One interviewee said he might explore growing quinoa in Australia but that for the moment he prefers to import it.

Johnson and Ward (1993) noted the following aspects of quinoa cultivation:

- Nitrogen is very influential for yield increases. Current recommendations in South America are for 120 kilograms per hectare of urea.
- Irrigation appears to greatly improve yields.

⁷¹ In one study period, these varied between 0.37 and 2.02 tonnes a hectare—see Twyford-Jones (1995).

⁷² One interviewee was supplying millet flour to a university that was conducting kitchen experiments—Bowdler English and Wheal, Brisbane, pers. comm., December 2003.

- Seeding rates vary. Current US recommendations are for 1 to 1.5 million plants per hectare, whereas South American recommendations are for 8 million per hectare for row cropping and 20 million per hectare for broadcast.
- Weed control has a major impact on yield.
- Quinoa is very salt tolerant, which increases its attraction for arid regions.
- Insects are a concern. In South America *Scrobipalpula* spp. destroys buds, inflorescences and immature and mature grain, and ‘leaf miners’ (*Liriomyza* spp.) destroy leaves and occasionally stacks of quinoa. In Colorado common insects are the leaf miners and aphids usually associated with sugar beet and fat hen.

The keys to increasing quinoa production are as follows:

- low to zero saponin, which would alleviate the post-harvest treatment problem
- varieties that grow at lower elevations
- higher yields
- more uniform plant height, form and seed size, to facilitate mechanical harvesting
- large seed size, which would reduce the proportion of fibrous pericarp in the grain
- white pericarp, which would produce a colourless product and increase food processors’ ability to find further uses for the grain
- greater pest resistance. This is likely to be needed if the saponin content is reduced because saponin discourages birds and other pests.

Sesame

Australian sesame seed production, based in Queensland and the Northern Territory, is so limited it is not included in the UN Food and Agriculture Organization’s database, although the database does record the fact that Australia exports sesame seed. Further, using Bennet’s (1999) estimate of local production, the FAO data show that Australia not only exports a large percentage of its production but is also one of the world’s highest priced exporters. Table 6.1 shows export volumes and values for Australian sesame seed from 1995 to 2002.

Table 6.1 Sesame seed: export volumes and FOB values, Australia, 1995 to 2002

	1995	1996	1997	1998	1999	2000	2001	2002
Export volume (tonnes)	9	9	14	204	5	121	20	19
FOB price (US\$/tonne)	1777	1111	1571	803	3000	1107	950	1157

Source: UN Food and Agriculture Organization.

Bennet has argued that, given the likelihood of sesame seed production becoming threatened in the traditional producing countries, potential exists for Australia to become a producer of sesame (especially the higher quality produce) to compensate. In making his case, he outlines a series of production and harvesting considerations that need to be taken into account if production is to expand.

But production will not expand in response to demand from just the coeliac industry. After all, and despite its exports, Australia currently imports sesame seed in the seed, oil and processed forms to meet the demands of the oil, confectionery, bakery, tahini and halva markets. If this is not enough to encourage higher levels of local production, then it is equally unlikely that production will expand for the same products in gluten-free form.

Sorghum

Australia is a significant sorghum producer: in the six years to 2003 annual production averaged 1.8 million tonnes. Production is destined almost exclusively for the animal feed sector. A few health

food shops in Sydney sell sorghum for human use, but they are the only ones who appear to deal with the product.

Production of sorghum in Australia will not change in response to demand from coeliacs. If there is any response, it will have to be in the form of varieties better suited to human consumption. Again, given the availability of alternatives, the likelihood of this occurring is slim.

Teff

As noted, it was not possible to establish whether teff is grown in Australia.

The minute size of the grain and the requirement for very specific production techniques mean that production of the grain in Australia is unlikely. Nevertheless, Australia is a good candidate for expanding world production because the key to such expansion will be the ability to mechanise harvesting. Over the years Australian agricultural producers have been remarkably innovative when it comes to mechanisation, and these skills could be transferred to teff.

7 Prospects

Demand for gluten-free products will come from coeliacs, people with varying degrees of wheat intolerance, people who for medical reasons are advised to consume gluten-free products, and people who chose to consume gluten-free products. In Australia this market segment will amount to about 1 million consumers.

As elsewhere, in Australia the demand for gluten-free products will continue to exhibit the strong growth currently being experienced. Part of the reason for the strong growth is that demand increases are being measured from a very low base. However, the rates of growth are not even across all gluten-free products. It appears that the higher rates of growth are associated with higher levels of value-adding. The high growth rates also disguise a significant level of substitution.

Again as elsewhere, the annual growth rates seen in Australia will start to level off in the near term—say, five years—as more cases of coeliac disease are identified. This will come about through greater awareness on the part of consumers and improved techniques for detecting the disease. As the number of coeliacs and people who for medical reasons must consume gluten-free foods reaches the estimated absolute number, the rate of growth will slow, eventually approximating the rate of population growth.

The main distribution outlets for gluten-free grains are, in descending order of priority, lifestyle stores, health stores, supermarkets, direct from manufactures and direct from producers.

Of the seven health grains, it is known that four are grown in Australia—amaranth, buckwheat, millet and sorghum. Of these, buckwheat production is oriented towards the Japanese soba market and millet and sorghum production is oriented towards non-human consumption.

For reasons of consistency in supply and quality, the Australian food manufacturers interviewed preferred to import amaranth, quinoa and even buckwheat. There is, however, an inherent preference in Australia for Australian-grown produce so, if the production challenges could be overcome, manufacturers would probably turn to health grains grown in Australia.

Current production of millet and sorghum in Australia is adequate to meet any gluten-free induced demand.

The gluten-free grain with the best prospects is quinoa. In the overseas countries studied, it was most consistently mentioned by retailers as the health grain whose products are most often demanded. Considerable mention was also made of amaranth and buckwheat.

Both amaranth and buckwheat are an enigma when it comes to flavour. A number of Australian interviewees—processors of minimally valued-added products such as pancake and tortilla mixes—remarked positively on the strong, individualistic flavours of the products. In contrast, other interviewees said the flavour was too strong and interfered with the prime item, which in the case of pasta was the sauce.

Finally, in connection with the non-designated health grains, in Australia and the United States a significant number of food manufacturers made positive remarks about the future of spelt.

Australia has a number of ‘pathfinder firms’ that have been successful with gluten-free foods, in both the Australian and the international markets. It must be noted, however, that the majority of these successes have been achieved by using products other than the health grains that are the subject of this study. The pathfinder firms and their successful products are as follows:

- *Amaranth*. Micronised Foods in New South Wales has gained space among mainstream breakfast cereals on the shelves of a major supermarket chain. Amaranth is also now an ingredient of a mainstream glutenous bread, Performax, having been included for its high protein content.
- *Millet*. Kialla Pure Foods in Queensland has combined the gluten-free element with its recognised status as one of Australia’s leaders in organic grain to consistently gain space in the health food sections of the main supermarket chains. Freedom Foods of New South Wales has successfully reproduced in gluten-free form a number of popular mainstream gluten products. It is understood that recipes using others of the seven health grains are being trialled for future products.
- *Buckwheat*. Haku Baku in Victoria exports buckwheat noodles to Japan.
- *Export markets*. In the United Kingdom and Ireland products from Roma Foods, in Victoria, were often sighted in both health food stores and mainstream supermarkets. This success has been achieved in the face of a significant price disadvantage. Most of the products do not incorporate the nominated health grains, but a small volume of millet is involved. Arnotts is another pathfinder, its gluten-free product being seen in Ireland; again, none of the seven health grains was involved.

Most of the gluten-free component of these pathfinder firms comes from rice, corn, soy or potato starch, but the firms’ success does demonstrate that there is a market for gluten-free products.

In the Australian gluten-free food sector there have been failures with products such as arrowroot and psyllium. Nevertheless, the pathfinder firms do demonstrate that success is achievable.

7.1 A warning

Suppliers of health grain products must be sensitive to the fact that there are three gluten-free grains—corn, rice and soy—whose production completely dwarfs the combined production of the seven identified health grains. Additionally, gluten-free starch is extracted from potatoes. More than half the Australian food manufacturers interviewed for this study mentioned their use of at least two of these products. Overall, corn starch and potato starch were the preferred non-health grains sources of gluten-free ingredients.

A statement that a product is gluten free is a declaration of purity. When a consumer looks for a product so labelled, it is with the expectation that the product is indeed free of gluten. If it is not, for people who choose to consume gluten-free products it is a disappointment. For people with a degree of gluten intolerance, inadvertent consumption of a gluten-containing product could be unpleasant. For coeliacs, inadvertent consumption of gluten can lead to illness, even temporary incapacitation. This is why coeliac societies in Australia, the United States, Canada and the United Kingdom are so insistent about labelling.

The requirement for purity means that food manufacturers that deal with both gluten-containing and gluten-free products are very sensitive to the prospect of contamination. Until such manufacturers can isolate the two streams of products and operations, they will not declare their products gluten free, even if they in fact are. In Queensland a franchised bakery operation gave up marketing gluten-free breads because it was unable to guarantee that contamination would not occur.

The authors were advised that the larger food manufacturers that deal with gluten-containing and gluten-free products are particularly alert to the threat of litigation by virtue of their very size inviting litigation. Take breakfast cereals. By any measure this is a massive market. In the United Kingdom in 2000 about 400 000 tonnes of breakfast cereal were sold, with a retail value of £1.1 billion.⁷³ In the United States 48 breakfast cereal companies had combined sales of US\$9.3 billion in 1997⁷⁴; corn flakes accounted for 29 per cent, oats 17 per cent, wheat flakes 16 per cent, and rice 10 per cent. Just

⁷³ <<http://www.nutraingredients.com/marketreport/report.asp?id=1486>>, viewed April 2004.

⁷⁴ *Food and Drink Weekly*, January 2000.

four of the 48 companies—Kellogg, Post, General Mills and Quaker⁷⁵—account for 84 per cent of the ready-to-eat breakfast cereal sold (Price 2000). Their size makes them a tempting target.

Until it is possible to guarantee non-contamination none of the major food manufacturers that deal in both gluten-containing and gluten-free products will declare its products gluten free. An Australian bakery would not even handle bread made with spelt because of the fear of contamination with this near-wheat.

To exacerbate the situation, the concept of liability stretches beyond the actual food manufacturers. If a manufacturer is to be able to give a guarantee of non-contamination, it must be confident that the raw product has also not been contaminated. One Australian manufacturer of gluten-free foods is reluctant to move into oat products (notwithstanding the debate about oats being gluten free) because of the need for assurance that the oats are not grown in the same field as wheat and that different equipment is used in the growing and harvesting processes.

7.2 The way forward

Growth in the demand for the seven health grains will not be based solely on their gluten-free properties. A large number of products can claim gluten-free status, but what those other products usually cannot claim is the same degree of nutritional content. It is the promotion of these nutritional values—rather than reliance on the gluten-free attribute—that will mark the success of the health grains.

The evidence, at least from overseas, is that, although manufacturers of gluten-free foods should state that their product is gluten-free, a host of other attributes should also be declared.

Should these additional health benefits be promoted both by the producers of the health grains and the manufacturers of products derived from them, the potential market captured will greatly exceed the estimated market for the coeliac-based sector alone.

⁷⁵ The Australian equivalents are Kellogg, Sanitarium and Uncle Toby's. The first two companies share their heritage with Battle Creek, Michigan, in the United States. Breakfast cereals as we know them started with the vegetarian Seventh Day Adventists in their Western Health Reform Institute in the 1860s in Battle Creek. The immediate antecedent to this was 'Granula', developed in 1863 by Dr James Jackson of the Dansville sanatorium. His dense cereal nuggets had to be soaked overnight to make them chewable. Another medical practitioner, John Harvey Kellogg, operated the Battle Creek sanatorium. In the 1880s he developed oat and corn meal biscuits. With his brother Will Keith, he serendipitously developed in the 1890s the roasted corn flake as part of an exercise to produce healthy vegetarian food options for his fellow Adventists. Out of this came the Battle Creek Toasted Corn Flake Company in 1906, and from that came the Kellogg Company. Charles Post was a client of the Battle Creek sanatorium who, as a result of consuming the Kellogg roasted corn flake, developed his own breakfast cereal. Today Kellogg and Post are still headquartered at Battle Creek. Battle Creek also saw the origin, in 1938, of Otto Frederick Rohwedder's first commercial slice-and-wrap bread machine. By 1933, 80 per cent of all bread sold in the United States was sliced and wrapped.

Appendix A Australian interviews

The following individuals and representatives of organisations were interviewed in Australia:

Ben Furney Flour Mills, New South Wales	Manildra Group of Companies, Queensland
Bowdler English and Wheal, Queensland	Maryland Produce, New South Wales
Brits Danish Delight, Queensland	Micronised Foods, New South Wales
Brumbies, Queensland	Moore's Bakery, New South Wales
Buckwheat Enterprises, Queensland	Mrs Flannery's, Queensland
Byron Organic, New South Wales	Naturally Good Products, Victoria
Coeliac Society of Australia, New South Wales	O'Brien's Flour, Queensland
Casellari Specialty Pasta, Victoria	Organics at Home
Country Life, Victoria	Philp Brody Grains, Queensland
Deacon Seeds, Queensland	Pure Harvest, Victoria
Doug von Pine, Queensland	Queensland Department of Primary Industries
Eden Seeds, Queensland	R&R Friendly Bakery Products, Queensland
Energy Products, New South Wales	Real Foods, New South Wales
Freedom Foods, New South Wales	Roma Foods, Victoria
Glenmar, Queensland	San Diego Tortilla Factory, Queensland
Gluten Free Bakery and Health Foods, Queensland	Sanitarium Foods, New South Wales
Golden Harvest Specialty Foods, Queensland	Select Foods, New South Wales
Goodman Fiedler, New South Wales	Sol Breads, Queensland
Greens General Foods, New South Wales	Soy Products, Victoria
Haku Baku, Victoria	Specialty Cereals, New South Wales
Hulscher Ingredients, Queensland	Spike Dessert Seed Company, Western Australia
Jensen's Choice Foods, Victoria	Spiral Foods, Victoria
Kellogg, New South Wales	The Lentil Company, Victoria
Kialla Pure Food, Queensland	The VEGE Chip, Queensland
Leda Nutrition, Queensland	University of Queensland, Gatton Campus
Lowan Whole Foods, New South Wales and Victoria	Ward McKenzie, Victoria

Appendix B The Natural Products Expo

Discussions were held with representatives of the following organisations at the Natural Products Expo in Anaheim, California, in May 2004:

AltiPlano Gold Inc.

Bob's Red Mill

Borg Produce Sales

Food For Life Baking Co.

Functional Products (Argentina)

GEF Inc.

Health is Wealth Naturopathy

Inca Organics

InfraReady Products (1998) Limited (Canada)

Innomark Inc.

Kamut Association

Kashi Company

Muliple Organics

Nature's Path Foods Inc.

New Hope Natural Media

Nu-World Amaranth Inc.

Rizopia (Canada)

SunWest Foods

US Mills Inc.

Appendix C Some gluten-free products







Appendix D Codex Alimentarius standard for 'gluten-free foods'

The Codex standard for 'gluten-free foods' was adopted by the Codex Alimentarius Commission at its 11th session in 1976. In 1983 the 15th session adopted amendments to the section on labelling. This standard has been submitted to all member nations and associate members of the UN Food and Agriculture Organization and the World Health Organization for acceptance, in accordance with the General Principles of the Codex Alimentarius. The standard is as follows:

CODEX STAN 118-1981 (amended 1983)

1. SCOPE

1.1 This standard applies to those processed foods which have been specially prepared to meet the dietary needs of persons intolerant to gluten.

1.2 The standard refers only to the specific provisions related to the special dietary purpose for which these foods are intended.

1.3 This standard does not apply to foods which in their normal form do not contain gluten.

2. DESCRIPTION

2.1 Definition

Gluten-free food is a food so described:

(a) consisting of or containing as ingredients such cereals as wheat, triticale, rye, barley or oats or their constituents, which have been rendered 'gluten-free'; or

(b) in which any ingredients normally present containing 'gluten' have been substituted by other ingredients not containing 'gluten'.

2.2 Subsidiary Definitions

2.2.1 For the purpose of this standard, gluten is defined as those proteins, commonly found in wheat, triticale, rye, barley or oats to which some persons are intolerant.

2.2.2 For the purpose of this standard, gluten-free means that the total nitrogen content of the gluten-containing cereal grains used in the product does not exceed 0.05 g per 100 grammes of these grains on a dry matter basis.

3. ESSENTIAL COMPOSITION AND QUALITY FACTORS

3.1 A gluten-free food shall be based on or shall contain:

(a) gluten-containing cereals such as wheat, triticale, rye, barley or oats or their constituents, which have been rendered 'gluten-free' according to Section 2.2.2; or

(b) ingredients which do not contain gluten in substitution for the ingredients containing gluten which are normally used in food of that kind; or

(c) any mixture of two or more ingredients as in (a) and (b).

3.2 Gluten-free foods substituting important basic foods like flour or bread, must supply approximately the same amount of vitamins and minerals as the original foods they replace in accordance with the national legislation of the country in which the food is sold.

4. LABELLING

In addition to the general labelling provisions contained in the General Standard for the Labelling of Prepackaged Foods (CODEX STAN 1-1985, Rev. 1-1991, Codex Alimentarius Volume 1), and any specific labelling provisions set out in a Codex standard applying to the particular food concerned, the following provisions for the labelling of 'gluten-free foods' shall apply:

4.1 The Name of the Food

The term 'gluten-free' shall be given in the immediate proximity to the name of the product.

4.2 List of Ingredients

4.2.1 A complete list of ingredients shall be declared on the label in descending order of proportion except that in the case of added vitamins and added minerals, these shall be arranged as separate groups of vitamins and minerals, respectively, and within these groups the vitamins and minerals need not be listed in descending order of proportion.

4.2.2 The nature and source of the starch or starches shall be declared on the label. In the case of starch prepared from gluten-containing cereal grains the declaration of this starch shall be accompanied by a statement 'containing not more than 0.3% protein in the dry matter'.

4.3 Declaration of Nutritive Value

The label shall include the following nutritional information:

4.3.1 The amount of energy, expressed in calories (Kcal) or kilojoules (kJ), and the number of grammes of protein, carbohydrate and fat per 100 grammes of the food and where appropriate per specified quantity (e.g. one biscuit) of the food as suggested for consumption.

4.3.2 In addition to any other nutritional information required by national legislation, the total quantity in the final product of those vitamins and minerals which have been added in accordance with Section 3.2 shall be declared per 100 g as well as according to the serving size of the food suggested for consumption.

4.4 Date Marking and Storage Instructions

4.4.1 The date of minimum durability (preceded by the words 'best before') shall be declared by the day, month and year in uncoded numerical sequence except that for products with a shelf-life of more than three months, the month and year will suffice. The month may be indicated by letters in those countries where such use will not confuse the consumer. In the case of products requiring a declaration of month and year only, and the shelf-life of the product is valid to the end of a given year, the expression 'end (stated year)' may be used as an alternative.

4.4.2 In addition to the date, any special conditions for the storage of the food shall be indicated if the validity of the date depends thereon.

Where practicable, storage instructions shall be in close proximity to the date marking.

5. CLAIMS

5.1 A food prepared according to Section 3.1 may be called a 'gluten-free food'.

5.2 A food which naturally has no gluten may not be called 'gluten-free'; however, a cereal or a food product containing a cereal which naturally has no gluten, may be labelled to show that it is naturally free of gluten and is suitable for use in gluten-free diet.

6. PACKAGING

6.1 The product shall be packed in containers which will safeguard the hygienic and other qualities of the food.

6.2 The containers including packaging material shall be made only of substances which are safe and suitable for their intended use. Where the Codex Alimentarius Commission has established a standard for any such substance used as packaging material, that standard shall apply.

7. METHODS OF ANALYSIS AND SAMPLING

See Codex Alimentarius Volume 13.

Appendix E Bread

E.1 Bread forms

There is an astounding range of bread forms, all with their own particular names. Adding to the complexity is the fact that there can be regional and local variations of the same bread. Some breads are proprietary brands. The following list, based on country of origin, provides examples; it was developed during the compilation of this report.⁷⁶

- Belgium—pistolet, cramique
- British—Aberdeen buttery rowies, bannock, bara brith, barm brack, batched bloomers, cob, Coburg, pan Coburg, cornbread, Danish, farmhouse, innes, plait, morning rolls, spiral, Vienna batons, walnut, English oatmeal, Cornish saffron cake, cottage loaf, lardy cake, muffins, Lincolnshire plum, Melrose leaf, potato bread, Scotch bread, soda bread, stottie, Staffordshire oatcakes, Welsh cob
- Chinese—man to (steamed buns), chung yau beng (spring onion bread), hwa jwen (sweet buns)
- Eastern Europe—balabusky, blinis, kalach, krendel, Polish and Russian black bread, rossisky, Russian potato bread
- France—baguette, boule de meule, brioche, céréale, croissant, épi, fougasse, pain de campagne, pain aux noix, pain de mie, pain de seigle, pain de Provence, pain poilane, pain polka, pain allemand aux fruits, pain au levain
- Germany—pumpernickel, rye, Vollkornbrot, Weinkeinbrot, Landbrot, pretzels, Stollen, Bauernbrot
- Greece and Turkey—breadsticks, daktyla, pitta, ekmek, simits
- India—bhakris, chapattis, rotis, parathas, puris, naan, poppadoms
- Italy—biova, carta da musica, ciabatta, focaccia, grissini, michetta, mezzaluna, paesana, pane con noci, pane di mais, pugliese, olive bread
- Israel—challah⁷⁷, boulkas, bagel⁷⁸, bailys, sumsums, matzo, Passover rolls, latkes, mandel bread
- Middle East and North Africa—aiysh, khobz, barbari, lavash, mannaeesh, mella, pideh
- Switzerland—Apfelnussbrot, Bangeli, Bauerruch, panis lunatis, sako, Zuppe, Gippelteig, Wegglitag
- Scandinavia—rye, kernebrod, tresse, smorrebrod, limpa, rogbrod, knackerbrod, halkaka, rieska.

E.2 Bread trade

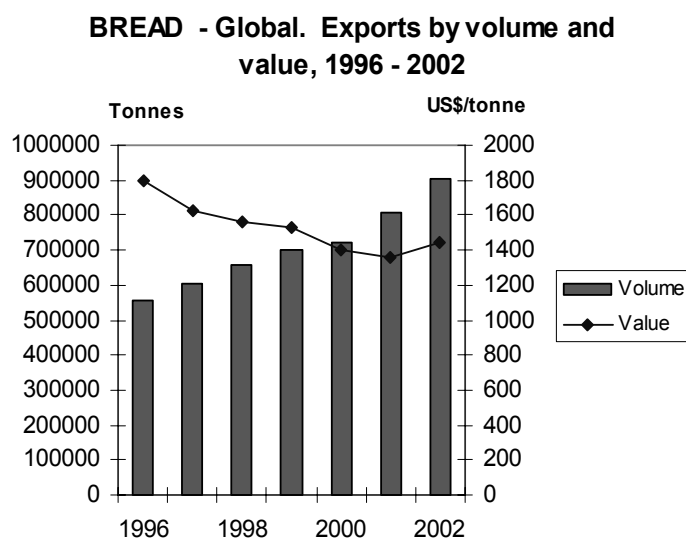
A huge volume of bread is traded throughout the world, and it has steadily increased during the past decade. The per-unit value of bread traded has declined but the rate of decline in value is commensurate with the rate of increase in the trade; that is, bread is holding its value (see Figure E.1).

⁷⁶ The assistance of Ingram and Shapter (2004) is acknowledged.

⁷⁷ ‘Cholla’, according to the Federation of Bakers, London.

⁷⁸ Most writers on bread types say that bagels are so widely consumed it is inappropriate to associate them singularly with Jewish cuisine.

Figure E.1 Bread: global exports, by volume and value, 1996 to 2002



Source: UN Food and Agriculture Organization.

As is to be expected, the trade comes primarily from Canada and European producers (see Table E.1).

Table E.1 Bread: global exports, by major sources, 1998 and 2002

(tonnes)

Country	1998	2002
Canada	107 920	203 249
France	124 588	135 778
Germany	66 092	112 430
United Kingdom	76 396	86 486
United States	61 601	57 722
Belgium ^a	27 112 ^b	56 081
Netherlands ^a	32 949	37 307
Denmark	26 013	34 408
Italy	19 277	30 993
Sweden	29 186	30 799

a. Production volumes in Belgium and the Netherlands allow the two nations to be treated as traders in their own right.

b. At that stage 'Belgium-Luxembourg'.

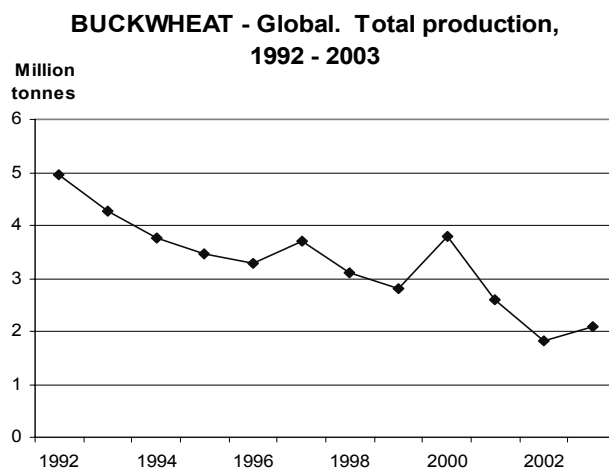
Source: UN Food and Agriculture Organization.

Appendix F Buckwheat

F.1 Production

Between 1992 and 2002 global buckwheat production decreased (see Figure F.1).⁷⁹

Figure F.1 Buckwheat: global production, 1992 to 2003



Just five countries supply about 90 per cent of the world's buckwheat (see Table F.1).

Table F.1 Buckwheat: global production, 2003

(metric tonnes)

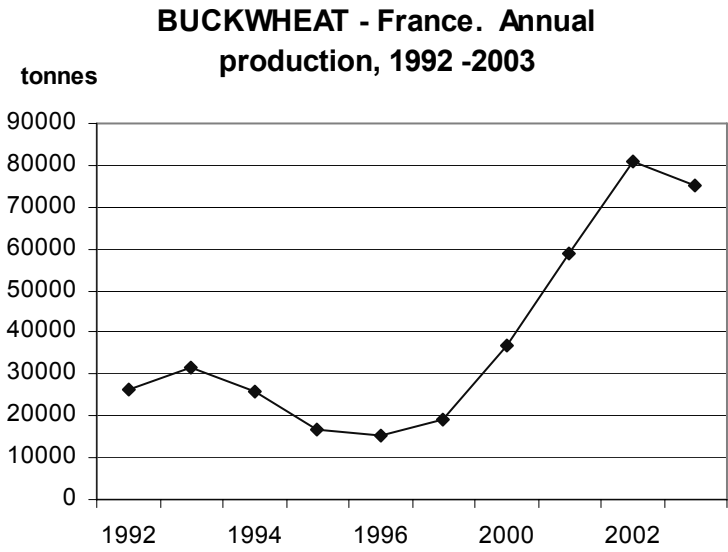
Country	Production
China	1 000 000
Russia	525 000
Ukraine	231 000
France	75 000
United States	65 000

In the 10 years to 2003 China's production declined most in absolute terms, from 3.1 million tonnes to 1.0 million tonnes. In relative terms, however, the decline in Kazakhstan was much greater, from 220 000 tonnes to just 25 000 tonnes. The indications are that global production has levelled off. A number of factors support this claim:

- In the three years to 2003 Chinese production fluctuated around 1 million tonnes.
- Production in Russia appears to have stabilised at about 500 000 tonnes, albeit with considerable seasonal variation.
- Although the United States is the smallest of the big five producers, after a period of decline annual production has reached a steady 65 000 tonnes.
- France is one of the few countries where production has been increasing. Production in 2003 was three times that in 1992 (see Figure F.2).

⁷⁹ All data are drawn from the UN Food and Agriculture Organization.

Figure F.2 Buckwheat: annual production, France, 1992 to 2003

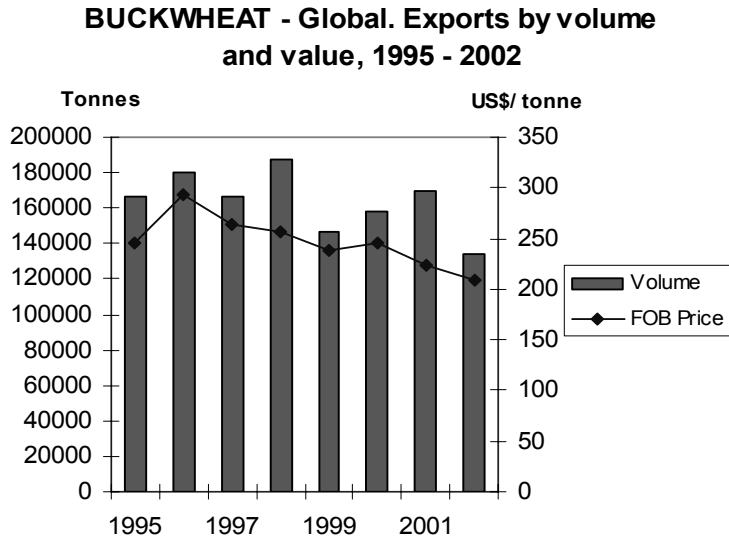


F.2 Trade

Exports

Global exports of buckwheat are declining in both volume and value (see Figure F.3).

Figure F.3 Buckwheat: global exports, by volume and value, 1995 to 2002



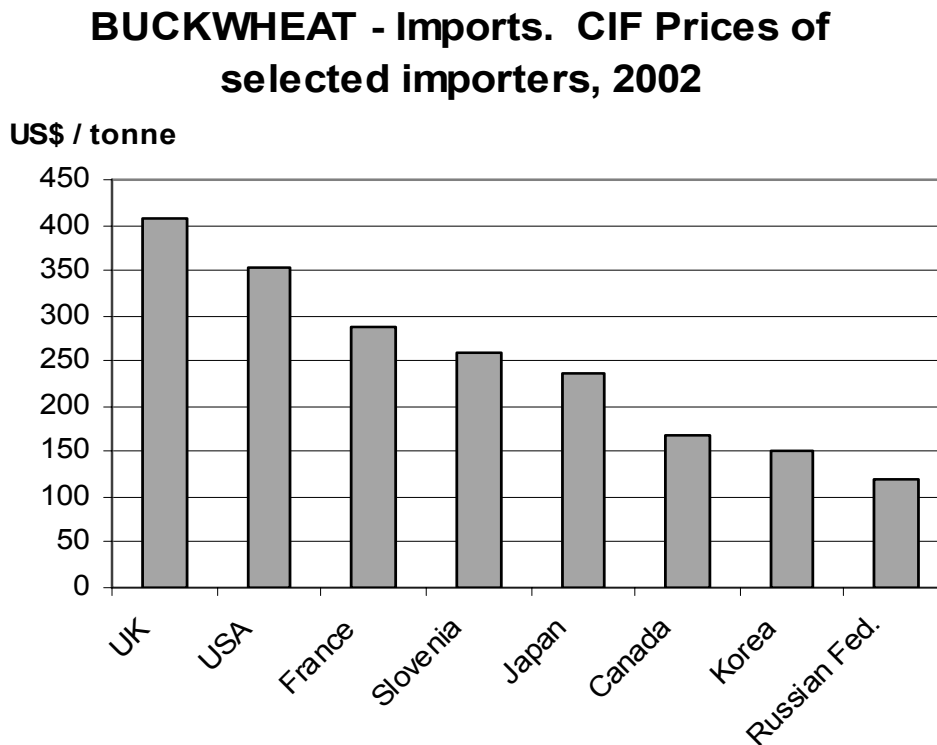
China accounts for at least 65 per cent of the world’s exports; the other main suppliers are the United States, the Ukraine, Canada, Poland and Russia. In terms of value, China is the low-end supplier.

Imports

Japan is the largest importer of buckwheat—90 659 tonnes in 2002. It regularly accounts for about half of all buckwheat imports. Other notable importers are France (8175 tonnes), Korea (3700 tonnes), Russia (3375 tonnes), the United States (2917 tonnes) and Moldova (2169 tonnes).⁸⁰

Although Japan, as the largest importer, pays a good price for its product, it is the smaller importers of the United Kingdom, the United States, France and Slovenia that pay the higher prices (see Figure F.4).

Figure F.4 Buckwheat: import, CIF prices, selected importers, 2002



⁸⁰ Imports by Belgium and the Netherlands are ignored because of their entrepot roles, but it must be recognised that the 12 948 tonnes these two countries imported in 2002 is consistent with imports in the past five years and represents a considerable proportion of total imports. The more than 100 000 tonnes imported by Papua New Guinea between 2000 and 2002 is not recognised. Imports of this level would be noted by the trade, but they do not appear in the FAO data. The data are therefore treated as non-operative.

Appendix G Millet

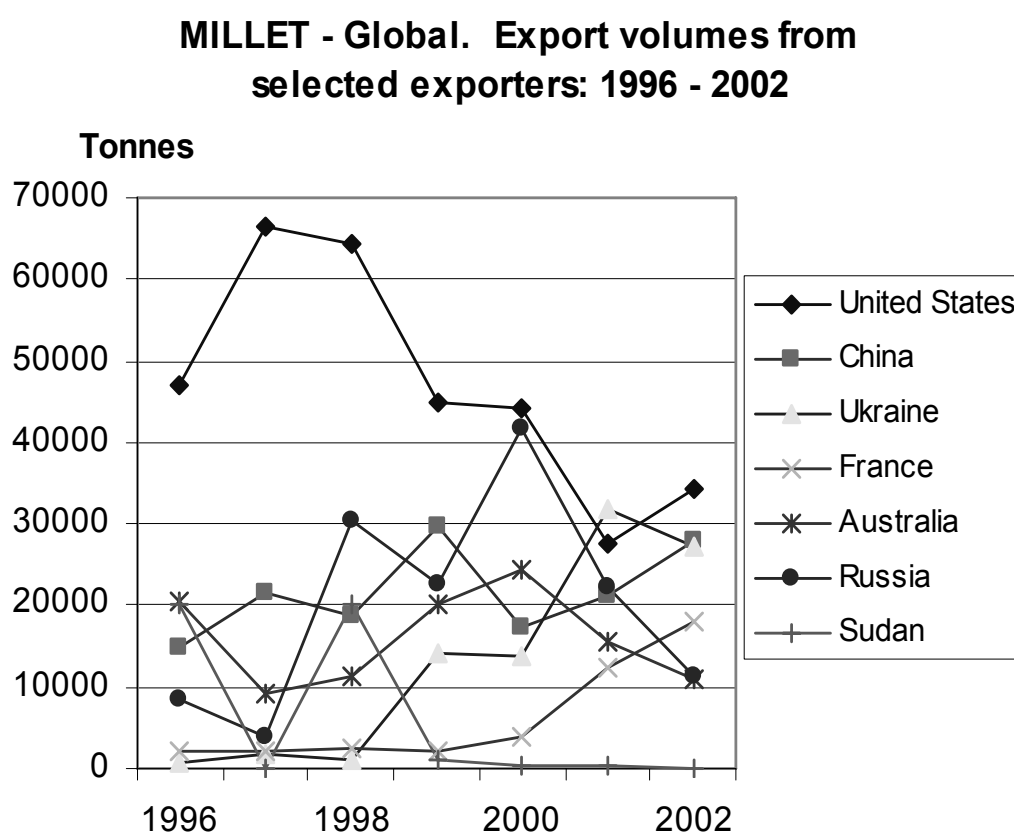
International trade in millet tends to account for a constant 10 per cent of global production.⁸¹

G.1 Exports

Volumes

Despite the overall picture of comparatively static exports, there is considerable change in the volumes exported by the main exporting countries (see Figure G.1). The result is that no single country dominates exports.

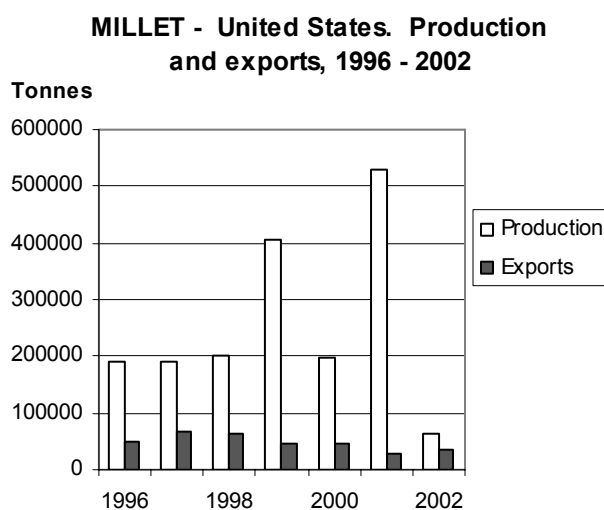
Figure G.1 Millet: export volumes, selected exporters, 1996 to 2002



In the seven years to 2002 the United States was consistently the biggest exporter, even if erratic. There appears to be little relationship between growth in local production and exports (see Figure G.2), and the implication is that local consumption expanded dramatically during the period in question.

⁸¹ All data are drawn from the UN Food and Agriculture Organization.

Figure G.2 Millet: production and exports, United States, 1996 to 2002

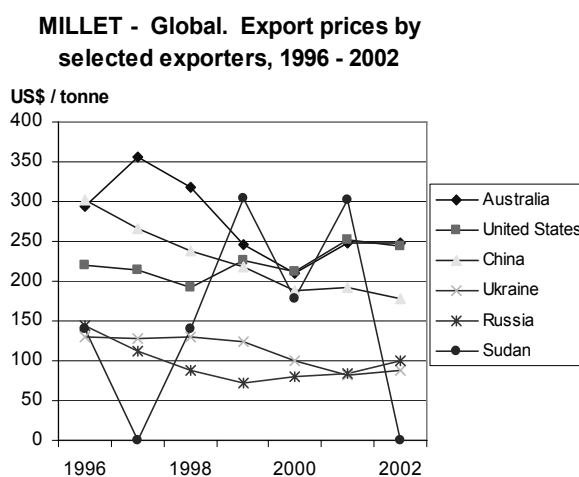


Exports from Russia and the Ukraine are very erratic, regularly varying by more than 100 per cent. China and India export only a small proportion of their total production. Although in Africa there is cross-border trade between countries, official exports from that continent are minute compared with total production. Mali and Sudan are the two biggest exporters, although the dramatic variation in Sudan's reported exports gives cause for suspicion about the veracity of the data.

Prices

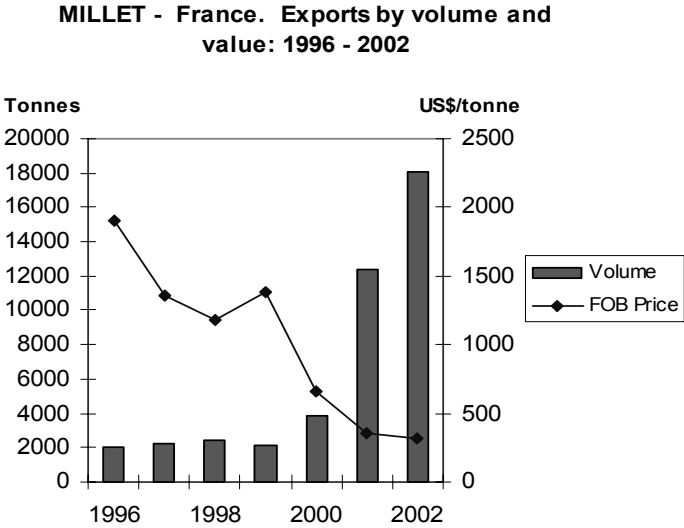
With the exception of Sudan, the fluctuating export volumes are not matched by fluctuating export prices (see Figure G.3).

Figure G.3 Millet: export prices, selected exporters, 1996 to 2002



France is treated separately from the foregoing analysis because the extremely high prices it received in the mid-1990s for its product—more than US\$1000 a tonne for each of the four years to 1999—distort the illustration of the other prices. France has experienced an inverse relationship between the growth of its exports and the FOB price it has received (see Figure G.4).

Figure G.4 Millet: exports, by volume and value, France, 1996 to 2002



What makes the French case even more interesting is that the FAO data do not record production in France, yet field observations confirm that production does occur.

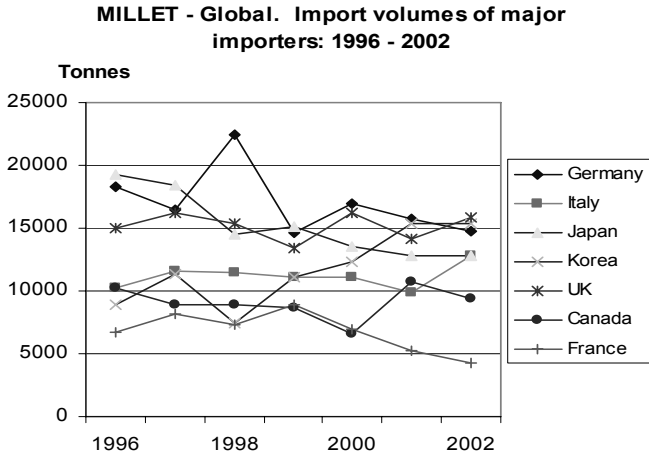
G.2 Imports

Volumes

A large number of countries import millet—well over 100, according to the FAO data. The two biggest importers are Belgium–Luxembourg and the Netherlands. They are excluded from this analysis because their entrepot roles make it difficult to establish domestic consumption.

Overall, Europe is the biggest importer. This is a reflection of millet’s use as a feed grain in Europe, rather than for human consumption. Apart from imports into Japan and Korea, and with the noticeable exception of Africa, imports tend to be evenly demanded throughout the world (see Figure G.5).

Figure G.5 Millet: imports, major importers, 1996 to 2002



Prices

Even though import volumes are steady, import prices are gradually declining (see Figure G.6). Compared with European importers, Australia pays a premium (see Figure G.7). The difference appears to be greater than would be accounted for by transport costs.

Figure G.6 Millet: imports, by volume and price, 1992 to 2002

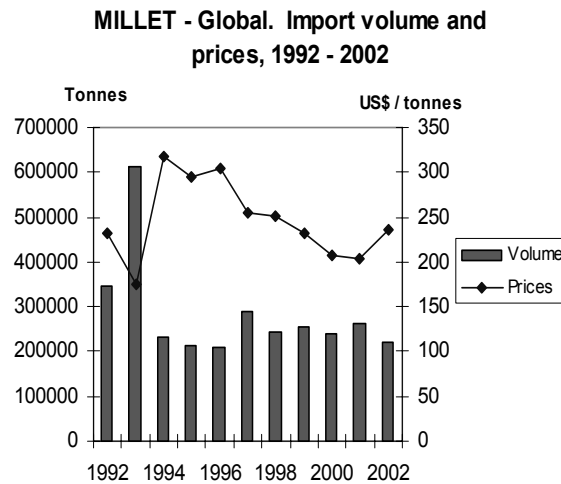
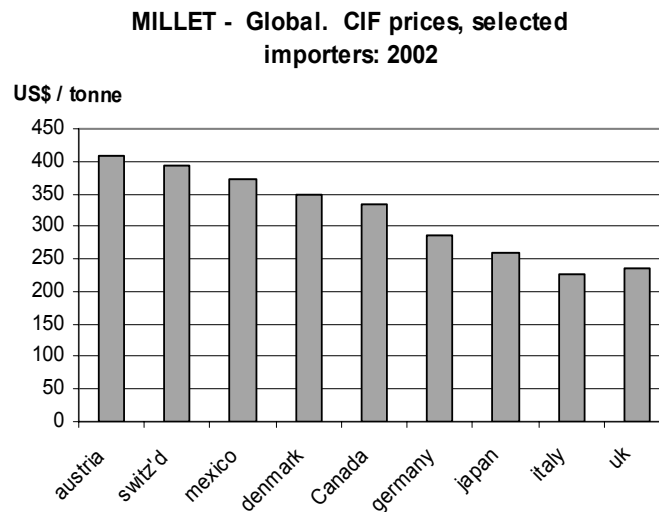


Figure G.7 Millet: CIF prices, selected importers, 2002



The United States and France are special cases in that they are both notable exporters and notable importers. However, the United States pays a premium compared with other importers: for it, the annual average CIF price was US\$580 a tonne in 2002, compared with US\$408 a tonne for Australia.

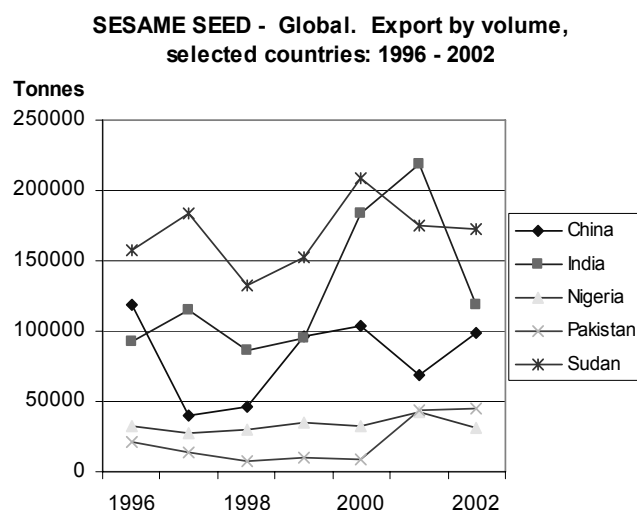
Appendix H Sesame

H.1 Exports

Volumes

India and China are large exporters of sesame seed (see Figure H.1).⁸²

Figure H.1 Sesame seed: export volumes, selected exporters, 1996 to 2002



An analysis of the data on export volumes reveals several facts of interest:

- Exports from India and China account for only a small proportion of each country's total production.
- Sudan is not only the biggest exporter but also the most consistent.
- Exports from Myanmar fell dramatically between 1996 and 2002, from 52 500 tonnes to 3900 tonnes.
- Burkina Faso, Guatemala, Mexico, Nigeria, Pakistan, the Sudan, Tanzania, Venezuela and Vietnam export a relatively high proportion of their domestic production.

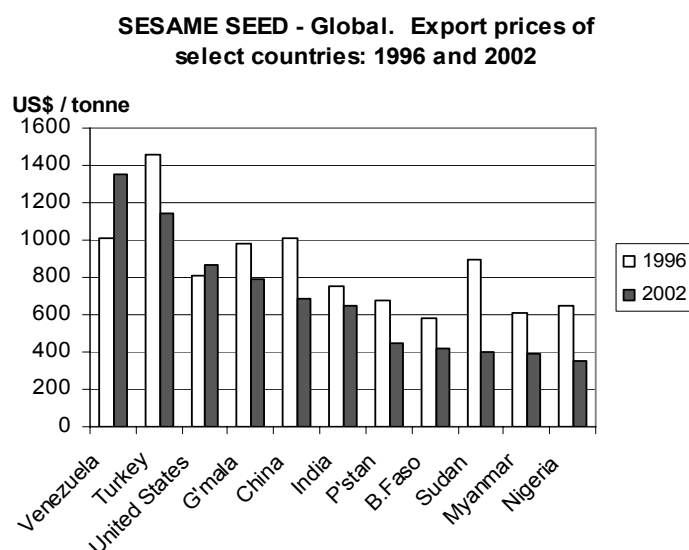
Ethiopia is excluded from the analysis because the export data it submitted to the UN Food and Agriculture Organization are incompatible with its production data in that for the seven years to 2002 it exported a total of 217 000 tonnes yet produced only 128 000 tonnes.

Prices

With the exception of Venezuela and the United States, between 1996 and 2002 there was a consistent decline in export prices for sesame seed (see Figure H.2).

⁸² All data are drawn from the UN Food and Agriculture Organization.

Figure H.2 Sesame seed: export prices, selected exporters, 1996 to 2002



Venezuela exports a large volume—an annual average of 18 076 tonnes between 1996 and 2002, albeit with large variations between years—and consistently gains the highest export prices (see Table H.1).

Table H.1 Sesame seed: export volumes and prices, Venezuela, 1996 to 2002

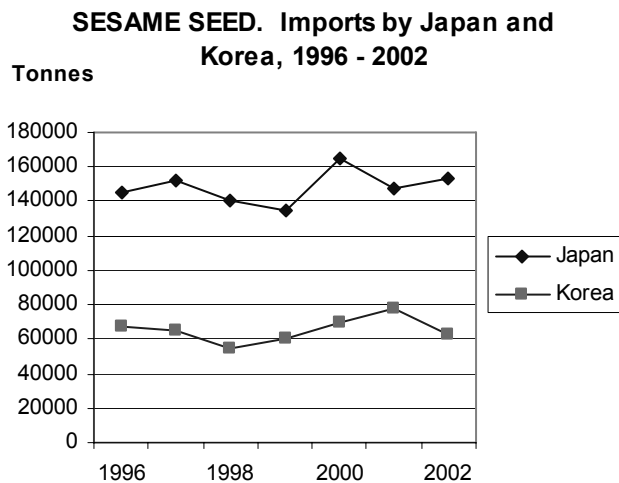
	1996	1997	1998	1999	2000	2001	2002
Volume (tonnes)	9 962	25 750	18 658	24 030	24 301	17 354	6 580
Price (US\$/tonne)	1 012	1 342	1 351	1 378	1 354	1 270	1 352

The relatively small exporters of Turkey and the United States receive high prices—in 2002, US\$1143 a tonne and US\$865 a tonne respectively. Turkey exported an annual average of 3270 tonnes in the seven years to 2002, at an average price of US\$1289 a tonne; in the same period the United States exported an annual average tonnage of 2106 tonnes, at an average price of US\$985 a tonne. There is a clear second tier of prices—US\$600–800 a tonne—for Guatemala, China and India. Pakistan, Burkina Faso, Sudan, Myanmar and Nigeria receive about US\$300–500 a tonne.

H.2 Imports

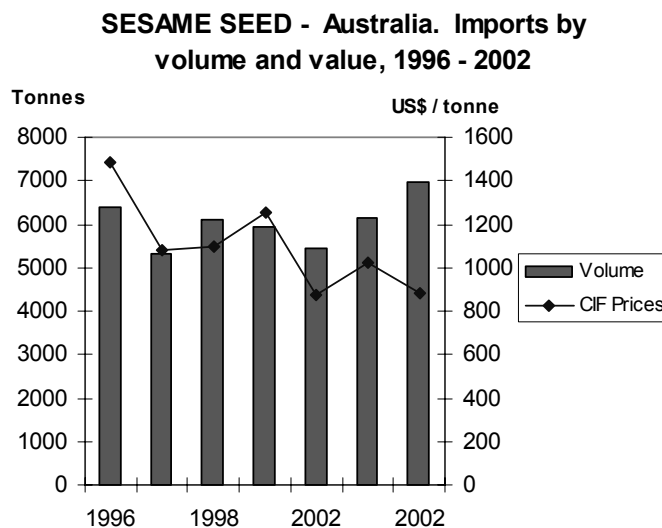
Japan is the world's largest individual importer of sesame seed: in 2002 it imported 153 019 tonnes, a volume that was relatively constant between 1996 and that time (see Figure H.3). The second biggest individual importer is Korea: in 2002 its imports amounted to 63 093 tonnes, again a level that remained relatively constant from 1996.

Figure H.3 Sesame seed: imports, Japan and Korea, 1996 to 2002



The Middle East is the largest importing block: in 2002 Egypt, Iran, Israel, Jordan, Lebanon, Saudi Arabia, Syria and Turkey imported a total of 223 092 tonnes. China, the world's largest producer, is also a significant importer: its average imports for 1996 to 2002 amounted to 39 000 tonnes a year. Another importer of note is the United States—46 299 tonnes in 2002 and a seven-year annual average of 46 000 tonnes. Australia is a consistent importer of sesame seeds, importing 6983 tonnes in 2002 (see Figure H.4). The volume imported has hovered around 6000 tonnes, but there has been a persistent decline in the CIF price. In the seven years to 2002 prices nearly halved.

Figure H.4 Sesame seed: imports, by volume and value, Australia, 1996 to 2002

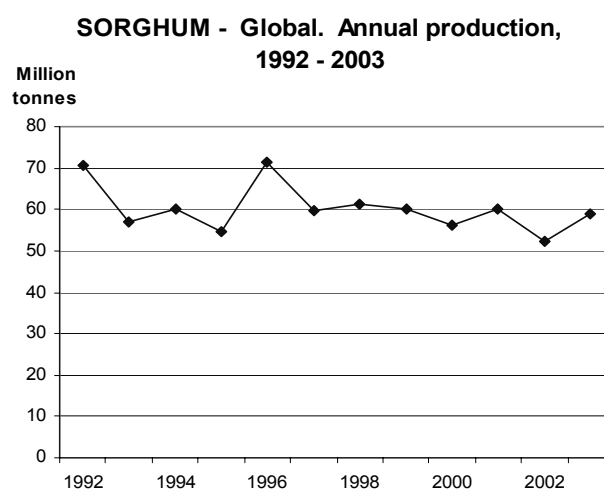


Appendix I Sorghum

I.1 Production

Sorghum is a major grain crop. In the decade to 2002 global production remained at about 60 million tonnes (see Figure I.1).⁸³

Figure I.1 Sorghum: global production, 1992 to 2003



Eleven countries produce over 1 million tonnes each. The geographic spread of production is broad, which militates against seasonal variations causing massive global variations in production. Table I.1 shows the largest producers.

Table I.1 Sorghum: the 10 largest producers, 2002

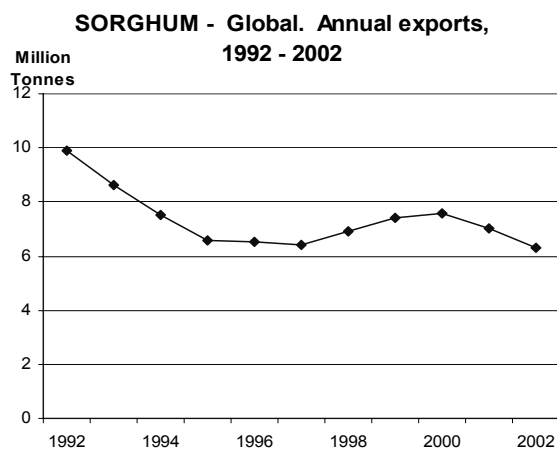
Country	Volume (million tonnes)
United States	10.4
India	8.5
Nigeria	8.1
Mexico	6.4
Sudan	4.3
Argentina	2.8
China	2.8
Brazil	1.7
Ethiopia	1.6
Burkina Faso	1.5

⁸³ All data are drawn from the UN Food and Agriculture Organization.

I.2 Trade

About 10 per cent of global production is exported. The amount exported stayed relatively stable in the decade to 2002 (see Figure I.2). The United States consistently provides almost 90 per cent of all exports. The other two exporters of note are Argentina (413 000 tonnes in 2002) and France (208 000 tonnes). The data show that France consistently exports at least 50 per cent of its production. Australia is a very large exporter, but the volume exported is greatly limited during drought conditions.

Figure I.2 Sorghum: global exports, 1992 to 2002



Appendix J Nutritional properties

Table J.1 shows the nutritional properties of selected cereals, flours and grains.

Table J.1 Nutritional properties of selected cereals, flours and grains

Grain or product	Water (g)	Food energy (kcal)	Protein (g) (Nx5.85)	Total lipids (g)	Carbohydrate (g)	Crude fibre (g)	Ash (g)
Amaranth	9.84	374	14.45	6.51	66.17	3.77	3.04
Arrowroot flour	11.37	357	0.30	1.1	88.15	–	0.08
Barley	9.44	354	12.48	2.3	73.48	2.85	2.20
Barley—pearl, raw	10.09	352	9.91	1.16	77.72	0.74	1.11
Buckwheat	9.75	343	13.25	3.4	71.5	–	2.1
Buckwheat groats—roasted, dry	8.41	346	11.73	2.71	74.95	1.76	2.2
Buckwheat flour—whole groat	11.15	335	12.62	3.1	70.59	–	2.54
Bulgur	9.0	342	12.29	1.33	75.87	1.78	1.51
Corn	10.37	365	9.42	4.74	74.26	2.90	1.20
Corn flour—whole grain	10.91	361	6.93	3.86	76.85	–	1.45
Couscous—dry	8.56	3.76	12.76	0.64	77.43	0.58	0.62
Farina—dry	10.5	369	10.6	0.5	78.0	0.20	0.40
Millet—raw	8.67	378	11.02	4.22	72.85	1.03	3.25
Oats	8.22	389	16.89	6.90	66.27	–	1.72
Oat bran—raw	6.55	246	17.30	7.03	66.22	2.17	2.89
Oats—rolled, dry	8.8	384	16.0	6.30	67.0	1.10	1.90
Quinoa	9.30	374	13.10	5.80	68.90	–	2.90
Rice—brown, long grained, raw	10.37	370	7.94	2.92	77.24	1.32	1.53
Rice—white, long grained, raw	11.62	365	7.13	0.66	79.95	0.30	0.64
Rice flour—brown	11.97	363	7.23	2.78	76.48	1.29	1.54
Rye	10.95	335	14.76	2.50	69.76	1.50	2.02
Rye flour—dark	11.07	324	14.03	2.69	68.74	–	3.47
Semolina	12.67	360	12.68	1.05	72.83	–	0.77
Sorghum	9.20	339	11.30	3.30	74.63	2.40	1.57
Tapioca—pearl, dry	10.99	341	0.19	0.02	88.69	–	0.11
Triticale	10.51	336	13.05	2.09	72.13	2.60	2.23
Triticale—whole-grain flour	10.01	338	13.18	1.81	73.14	1.50	1.85
Wheat—hard red winter	13.10	327	12.61	1.54	71.18	2.29	1.57
Wheat—soft red winter	12.17	331	10.35	1.56	74.24	1.72	1.68
Wheat—hard white	9.57	342	11.31	1.71	75.90	–	1.52
Wheat—soft white	10.42	340	10.69	1.99	75.36	–	1.54
Wheat—durum	10.94	339	13.68	2.47	71.13	–	1.78
Wheat flour—whole grain	10.27	339	13.70	1.87	72.57	2.10	1.60

Note: Gluten-free products are shown in bold.
Source: Oregon State University (2004).

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