Journal of Cereal Science 58 (2013) 209–215

Contents lists available at SciVerse ScienceDirect

Journal of Cereal Science

journal homepage: www.elsevier.com/locate/jcs

Review

Does wheat make us fat and sick?

Fred J.P.H. Brouns [a,*], Vincent J. van Buul [a], Peter R. Shewry [b]

[a] Maastricht University, Faculty of Health, Medicine and Life Sciences, Department of Human Biology, Health Food Innovation Management, P.O. Box 616, 6200 MD Maastricht, The Netherlands
[b] Rothamsted Research, Plant Biology and Crop Science, West Common, Harpenden, Hertfordshire AL5 2JQ, United Kingdom

ARTICLE INFO

Article history:
Received 5 February 2013
Received in revised form
27 May 2013
Accepted 3 June 2013

Keywords:
Whole-wheat
Risk-benefit
Gluten-free diet
Celiac disease

ABSTRACT

After earlier debates on the role of fat, high fructose corn syrup, and added sugar in the aetiology of obesity, it has recently been suggested that wheat consumption is involved. Suggestions have been made that wheat consumption has adverse effects on health by mechanisms related to addiction and overeating. We discuss these arguments and conclude that they cannot be substantiated. Moreover, we conclude that assigning the cause of obesity to one specific type of food or food component, rather than overconsumption and inactive lifestyle in general, is not correct. In fact, foods containing whole-wheat, which have been prepared in customary ways (such as baked or extruded), and eaten in recommended amounts, have been associated with significant reductions in risks for type 2 diabetes, heart disease, and a more favourable long term weight management. Nevertheless, individuals that have a genetic predisposition for developing celiac disease, or who are sensitive or allergic to wheat proteins, will benefit from avoiding wheat and other cereals that contain proteins related to gluten, including primitive wheat species (einkorn, emmer, spelt) and varieties, rye and barley. It is therefore important for these individuals that the food industry should develop a much wider spectrum of foods, based on crops that do not contain proteins related to gluten, such as teff, amaranth, oat, quinoa, and chia. Based on the available evidence, we conclude that whole-wheat consumption cannot be linked to increased prevalence of obesity in the general population.

1. Introduction

Wheat is the most widely cultivated cereal grain worldwide, being grown in temperate climates from Scandinavia in the north to Argentina in the south, including upland regions in the tropics. It is third among the cereals, behind maize and rice, in total global production, which was 704 million tons in 2011. The demand for wheat for human consumption is also increasing globally, including in countries which are climatically unsuited for wheat production, due to the adoption of western-style diets. Wheat is relatively rich in micronutrients, including minerals and B vitamins, and supplies up to 20% of the energy intake of the global population (Cummins and Roberts-Thomson, 2009).

About 95% of the wheat that is grown and consumed globally is bread wheat (*Triticum aestivum*). Bread wheat is a relatively new species, having arisen in southeast Turkey about 9000 years ago (Feldman and Millet, 2001). It is hexaploid with three related genomes (termed A, B and D) and probably arose by spontaneous hybridization between a cultivated form of tetraploid wheat (*Triticum turgidum*) and a related wild grass species (goat grass, *Aegilops tauschii*). Most of the remaining 5% of the wheat crop is tetraploid durum wheat (also called pasta wheat) (*T. turgidum* var *durum*) which is more adapted to the dry Mediterranean climate. However, small amounts of "primitive" wheats are also grown, mainly for specialist health foods: einkorn (diploid *Triticum monococcum*), emmer (tetraploid T. *turgidum* var *dicoccon*) and spelt (hexaploid *T. aestivum* var *spelta*). The latter essentially differs from bread wheat in that the hull is not removed by threshing; resulting in a higher fibre content when consumed as whole grain.

Although wheat is a young species, it is immensely diverse, with forms adapted to a wide range of local environments and selected for different end uses. Feldman et al. (1995) estimated that at least 25,000 genetically distinct forms occur, but this is undoubtedly an underestimate with previously unreported diversity being described in recent years in countries such as China. Determination of the full genome sequence of bread wheat has been hindered by the massive genome size (17 gigabases, which is 40 times the size of

Abbreviations: ATIs, amylase-trypsin inhibitors; CD, celiac disease; GI, glycemic index; IBS, irritable bowel syndrome.

* Corresponding author. Tel.: +31 (0) 433 88 14 66; fax: +31 (0) 433 67 09 76.
E-mail addresses: fred.brouns@maastrichtuniversity.nl (F.J.P.H. Brouns), v.vanbuul@maastrichtuniversity.nl (V.J. van Buul), peter.shewry@rothamsted.ac.uk (P.R. Shewry).

0733-5210 © 2013 The Authors. Published by Elsevier Ltd. Open access under CC BY license.
http://dx.doi.org/10.1016/j.jcs.2013.06.002

the rice genome and 5 times the size of the human genome) and the hexaploid nature. However, a recent study identified 96,000 to 98,000 genes, many of which were assigned to the three genomes (Brenchley et al., 2012). The large genome size, with a high content of mobile elements, and the hexaploid nature have, however, also resulted in high genome plasticity, which has facilitated rapid adaptation and contributed greatly to the global success of the wheat crop (Dubcovsky and Dvorak, 2007).

The wheat grain contains many hundreds of individual proteins, which may have structural, metabolic, protective or storage functions (as reviewed by Shewry (2009)). They include the gluten proteins, which are the major storage components and may account for up to 80% of the total grain protein (Wrigley et al., 1988). The protein composition of the grain is determined by the genotype, but also strongly influenced by the environment (climate and agronomy). For example, the contents of protective proteins may be greater when the plant is subjected to heat or drought stress while the total content of gluten proteins and the proportions of different gluten protein components are influenced by the availability of mineral nutrients (nitrogen and sulphur) (Shewry, 2011).

Several popular nutritional plants, such as the Paleolithic diet (CBS, 2012; Jönsson et al., 2006, 2005; Rose, 2011) and more recently the proposal of the U.S. cardiologist W.R. Davis, in his recent bestseller book, *Wheat Belly* (2011), have suggested that (whole-)wheat consumption has adverse health effects, based on different and controversial hypotheses. With this, they follow a recent trend to pinpoint the cause of obesity to one specific type of food or food component, rather than to overconsumption and inactive lifestyle in general. Hence, following discussions on the roles of fat, fructose, high fructose corn syrup and added sugar in foods, it seems that it is now the turn of wheat to take the blame for obesity. These discussions fail to take into account that obesity has a multifactorial causation (Grundy, 1998; Keith et al., 2006).

For centuries, there have been populations who consume wheat-based breads and other wheat products as the main source of their energy intake, such as in Turkey, without indices of causing weight gain. Moreover, the consumption of whole grain products, which in the U.S. and Europe are mainly based on wheat, has been shown to be associated with reduced risks of type 2 diabetes, cardiovascular disease, some types of cancer as well as a more favourable weight management (Ye et al., 2012). It is also argued that the current worldwide wheat production consists of "genetically modified" varieties, which contain new components that cause adverse health effects. In reality, the presence of such new components is not supported either by comparative studies of old and recently bred types of wheat (Ward et al., 2008) or by analyses of genomic sequences (Brenchley et al., 2012). Moreover, hard data about adverse effects of wheat, consumed in baked, extruded, and other processed foods, are not available, and there are no grounds to advise the general public not to consume this common dietary staple. Only individuals with a genetic predisposition for celiac disease, or suffering from allergy or other forms of sensitivity to gluten and other wheat proteins, will benefit from excluding wheat and related cereals from their diet.

2. Materials and methods

To ensure the quality of the research, and to obtain transparent and reproducible results, we made use of certain guidelines. In our search strategy, we used several databases of controlled scientific articles. All articles are referred to in the text and are available in English. We discuss most the relevant articles and critically evaluate the data. We also consider the scientific evidence for possible mechanisms based on recent literature.

3. Discussion

In a recent interview (CBS, 2012), the cardiologist W.R. Davis discussed his recent bestselling book: *Wheat Belly*: *Lose the Wheat, Lose the Weight, and Find Your Path Back to Health* (Davis, 2011). The author stated that the wheat that we eat these days is "created by genetic research in the 60s and 70s" leading to the inclusion of an unnatural protein in our "modern wheat" called gliadin. When coming to a conclusion, Davis explained that everybody is 'susceptible' to this gliadin protein as "gliadin binds into the opiate receptors in your brain and in most people stimulates appetite, such that we consume 440 more calories per day, 365 days per year".

In this light, it should be noted that gliadins are present in all wheat lines and in related wild species (Goryunova et al., 2012). In addition, seeds of certain ancient types of tetraploid wheat (e.g.; Graziella Ra, Khorasan wheat/Kamut) have even greater amounts of total gliadin than modern accessions (Colomba and Gregorini, 2012). Moreover, although the genetic engineering of wheat is technically possible, it has only been used in research programs and "GM wheat" has not been marketed or grown commercially in any country. However, it could be argued that wheat has been "genetically modified" by plant breeding in the same way that other crops and livestock species have been improved by selective breeding. Because bread wheat arose in cultivation, rather than from domestication of a wild species, it has probably been subjected to selection for the whole of its 9000 year history, initially subconsciously by early farmers and later (over the past century) by the application of scientific breeding. This has exploited variation controlled by endogenous wheat genes, resulting particularly from the high genome plasticity, with the limited use of related species to transfer useful traits. The main traits selected have been high yield, good resistance to pests and pathogens and good processing properties (for bread, cookies, noodles and, in durum wheat, pasta). There is no evidence that selective breeding has resulted in detrimental effects on the nutritional properties or health benefits of the wheat grain, with the exception that the dilution of other components with starch occurs in modern high yielding lines (starch comprising about 80% of the grain dry weight) (Shewry et al., 2011). Selection for high protein content has been carried out for bread making, with modern bread making varieties generally containing about 1–2% more protein (on a grain dry weight basis) than varieties bred for livestock feed when grown under the same conditions (Monaghan et al., 2001; Snape et al., 1993). However, this genetically determined difference in protein content is less than can be achieved by application of nitrogen fertilizer (Godfrey et al., 2010).

We consider that statements made in the book of Davis, as well as in related interviews, cannot be substantiated based on published scientific studies. For the sake of brevity, we focus on four of these arguments which we consider are most relevant to the present discussion (other critical remarks are listed by Jones (2012)), while further expanding on sound nutritional and cereal science.

> "*The proliferation of wheat products parallels the increase in waist size*"

This statement implies that a correlation between two variables can be interpreted as a true causal relationship. It is certainly true that the increase in wheat sales has a parallel with an increase in obesity. However, there are also parallel increases in the sales of cars, mobile phones, sports shoes and the average speed of winners of the Tour de France. Similarly, a correlation between the national consumption of chocolate and the number of Nobel Prize winners has been reported (Messerli, 2012).