Journal of Cereal Science 79 (2018) 469–476

Contents lists available at ScienceDirect

Journal of Cereal Science

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

Do ancient types of wheat have health benefits compared with modern bread wheat?

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ARTICLE INFO

Article history:
Received 12 October 2017
Accepted 18 November 2017
Available online 20 November 2017

Keywords:
Ancient wheat
Health benefits
Allergy
Intolerance

ABSTRACT

A number of studies have suggested that ancient wheats have health benefits compared with modern bread wheat. However, the mechanisms are unclear and limited numbers of genotypes have been studied, with a particular focus on Kamut® (Khorasan wheat). This is important because published analyses have shown wide variation in composition between genotypes, with further effects of growth conditions. The present article therefore critically reviews published comparisons of the health benefits of ancient and modern wheats, in relation to the selection and growth of the lines, including dietary interventions and comparisons of adverse effects (allergy, intolerance, sensitivity). It is concluded that further studies are urgently required, particularly from a wider range of research groups, but also on a wider range of genotypes of ancient and modern wheat species. Furthermore, although most published studies have made efforts to ensure the comparability of material in terms of growth conditions and processing, it is essential that these are standardised in future studies and this should perhaps be a condition of publication.

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1. Introduction

Wheat is the dominant crop and major staple food in temperate

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https://doi.org/10.1016/j.jcs.2017.11.010
0733-5210/

countries, with the mean global production over the period 2010 to 2014 being about 690 million tonnes (http://www.fao.org/faostat/en/#data). It contributes between 20% and 50% of the total calories in wheat-producing countries but the consumption of wheat is also increasing in countries where it is not climatically adapted, including parts of Sub-Saharan Africa, and particularly in countries undergoing urbanisation (Mattei et al., 2015). Although wheat is often regarded mainly as a source of calories, it also contributes essential amino acids, minerals and vitamins, beneficial phytochemicals and dietary fibre components to the human diet (NDNS, 2014; Shewry and Hey, 2015a). However, wheat products are also at the centre of concerns about the relationship between the western diet and lifestyle and health outcomes, and particularly the increasing prevalences of obesity, type 2 diabetes, allergy and food intolerances. These concerns have been propagated by the popular press and social media and have generally not been substantiated by detailed scientific review (Brouns et al., 2013; Shewry and Hey, 2016). Similarly, although it has also been suggested that modern bread wheat differs in its composition and health benefits from traditional types of wheat (Morris and Sands, 2003), such differences have not been identified by detailed analyses (Shewry et al., 2011; Ribeiro et al., 2016) with the exception of a decreased content of mineral micronutrients (reviewed by Shewry et al., 2016, 2017).

The concerns about the consumption of bread wheat have been accompanied by the promotion and increased consumption of ancient forms of wheat, based on perceived health benefits. However, genotypes of wheat vary widely in composition while ancient wheats may be grown and processed differently to modern bread wheats. It is therefore necessary to consider whether effects observed relate to intrinsic differences between wheat species or to variation between genotypes or to the impacts of differences in cultivation and processing.

1.1. What are ancient wheats?

Wheat was first cultivated about 10,000 years ago, as part of the "Neolithic Revolution", which saw the transition from hunting and gathering of food to settled agriculture. The earliest cultivated forms were einkorn and emmer, which are diploid (genome AA) and tetraploid (genomes AABB) species, respectively. Both species probably originated from the south-eastern part of Turkey (Dubcovsky and Dvorak, 2007) with emmer being derived from the spontaneous hybridization of the ancestor of einkorn with a related species of wild grass. Thus both species arose from the domestication of natural populations and wild wheats related to both still grow in the Middle East. Modern durum (pasta) wheats have developed from the same wild ancestor as emmer and both emmer and durum are now regarded as forms of the same species (*Triticum turgidum*). By contrast to einkorn and emmer, bread wheat has only existed in cultivation, having arisen about 9000 years ago by hybridization of cultivated emmer with wild "goat grass" (*Triticum tauschii*). Hence, it is a hexaploid species with three genomes (AABBDD) each comprising 7 pairs of chromosomes.

Crop domestication is associated with the selection of a range of genetic traits, which are called the "domestication syndrome". In wheat these traits include a change from hulled forms, in which the glumes of the flower adhere tightly to the grain and are not removed by threshing, to free-threshing forms in which the naked grain is released on threshing. Consequently, whereas most forms of einkorn and emmer are hulled, bread wheat is free-threshing. However, hulled forms of bread wheat do occur and are termed "spelt". Because the free-threshing character is controlled by mutations at only two genetic loci (Dubcovsky and Dvorak, 2007) bread wheat and spelt are regarded as forms of the same species (*Triticum aestivum*). Bread wheat and spelt are readily inter-bred, which has resulted in many modern types of spelt containing genetic material from bread wheat which has been incorporated to improve their performance.

Although bread and durum wheats together account for the vast majority of global wheat production, einkorn (*Triticum monococcum*), emmer and spelt ("ancient wheats") continue to be produced in small amounts (mainly for traditional foods) and increases in production, particularly of spelt, have occurred in recent years to satisfy the increasing demand for the health food market. These hulled wheats are often together called "*farro*" in Italy.

A further type of "ancient" wheat, called Kamut®, has been actively promoted over the past two decades (Abdel-Aal et al., 1998). Kamut seed was originally obtained from Egypt in the late 1940s, described as "mummy wheat" from an Egyptian tomb (see Moshenska (2017) for a discussion of "mummy wheat"). However, it is more likely to have been purchased from a street trader (http://www.kamut.com/en/discover/the-story). It is known to be a genotype of Khorasan wheat, a form of *T turgidum* related to emmer and modern durum wheats. Kamut® is a registered trademark of Kamut International Ltd and is only grown on certified organic farms. Similarly, 'the tetraploid Italian wheat Graziella Ra® is also purported to be derived from an Egyptian tomb (http://www.girolomoni.it/en/cat0_18828_18856-graziella-ra.php). Comparative analyses show that Graziella Ra and Kamut are related but distinct (Colomba and Gregorini, 2011; Colomba et al., 2012).

2. Factors affecting the composition of wheat grain

It is logical to expect that these different types of wheat exhibit genetically-determined differences in composition which may result in different impacts on diet and health. However, the composition of the grain is also affected by environmental factors, and the interactions of these with the genotype, and it is therefore necessary to briefly consider the relative effects of these factors.

2.1. Genetics

Bread wheat spread rapidly from the Middle East across temperate zones of the world, reaching China by 3000 years ago and being introduced into the New World in the 16th century and Australia in the late 18th century (Feldman, 2001). This migration was facilitated by the ability of wheat to adapt to local environments, resulting in vast genetic diversity in modern bread wheat. In 2001 Feldman (2001) noted the existence of 25,000 different cultivated forms of bread wheat and it is likely that the total current number is at least twice this estimate. These types not only differ in their adaptation to local environments, but are also likely to differ in their compositions, including their contents and compositions of "bioactive" components. Although large scale detailed comparisons are lacking, an indication of this diversity is given by the study initiated as part of the EU Healthgrain programme (2005–10). This included analyses of phenolics (phenolic acids, alkylresorcinols), terpenoids (sterols, stanols, tocols), folates and dietary fibre components in a collection of 150 bread wheat lines of diverse type, geographical origin and date of release. The concentrations of phytochemicals in wholemeal varied widely, by 3.6-fold for phenolic acids, 2.9-fold for tocols, 2.8-fold for alkylresorcinols, 2.4-fold for folates and 1.4-fold for sterols, with the content of arabinoxylan (the major dietary fibre fraction) in white flour also varying by over two-fold (Ward et al., 2008; Shewry et al., 2010). This is discussed in more detail by Shewry et al. (2013, 2017).

2.2. Environment

Grain composition is affected by both the environment and