Quality of Organically Produced Wheat from Diverse Origin

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Cover: Spikes (right), grains (left) of diverse wheat genotypes and CLSM image (centre) of wheat dough (Green color shows high molecular weight glutenins (2, 5, 10 and 12), red – gliadins and sharp red are bran particles.
(Picture by Hans Larsson and Abrar Hussain)

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Abstract

The health benefits of organically grown whole grain wheat are derived from various nutritional compounds such as dietary fibre, minerals, vitamins and phytochemicals, while baking quality is influenced by the protein content and composition. Genetic improvement and production of wheat to increase the amounts of the nutritional compounds therefore enhance the health benefits. Also, the baking quality of organic wheat can be improved by increasing protein quality of the grain. This study screened a large collection of organically grown winter and spring wheat genotypes from six groups (selections, old landraces, primitive wheat, spelt, old cultivars and cultivars) for different nutritionally relevant compounds such as, minerals, tocochromanols (vitamin E) and heavy metals. The genotypes were also screened for protein quality related to bread-making performance.

There was a wide variation in grain concentrations of minerals, total tocochromanols, heavy metals and protein fractions between the six genotype groups, indicating that there is a great potential to use genotypes for the production and the development of specific wheat genotypes with health-promoting and bread-making properties for future breeding programmes.

Primitive wheat had higher amounts of most minerals studied, a higher percentage of tocotrienols in total tocochromanols (74%) and a lower amount of cadmium in the wheat grain than the other genotype groups.

Around 70% of the recommended daily intake (RDI) of most minerals and up to 24% of the RDI of vitamin E could be obtained by consuming the organically produced whole grain wheat genotypes tested. Tocochromanol content and vitamin E activity are known to be lowered by heating, so organically produced wheat might be a good source of minerals and tocochromanols since organically produced wheat is more commonly consumed as whole or sprouted grain as compared to conventionally produced wheat.

There was also a wide variation in the amount and size distribution of polymeric proteins (ASPP), mixing parameters and structural properties between the six genotype groups investigated. Genotypes with a high protein concentration and a high percentage of unextractable polymeric proteins in total polymeric proteins (%UPP) might be helpful in improving the bread-making quality of organic wheat.

Keywords: Organic wheat genotypes, nutritionally relevant compounds, minerals, vitamin E, tocochromanols, heavy metals, protein polymerisation, mixing behaviour

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Dedication

To my parents who strongly believed that their prayers are always with me.

And

To all those, who live in my mind, my soul and in my heart throughout the whole span of my life and are nearest, dearest, and deepest to me.

Allah said about those who believed and acquired knowledge:

"Allah will raise up, to (suitable) ranks and (degrees), those of you who believe and who have been granted knowledge. And Allah is well-acquainted with all you do." (Qur'an, Al-Mujadilah 58:11)

Contents

List of Publications

This thesis is based on the work contained in the following papers, referred to by Roman numerals in the text:

I Abrar Hussain, Hans Larsson, Ramune Kuktaite & Eva Johansson (2010). Mineral composition of organically grown wheat genotypes: Contribution to daily mineral intake. *International Journal of Environmental Research and Public Health* 7: 3442-3456.

II Abrar Hussain, Hans Larsson, Ramune Kuktaite & Eva Johansson (2012). Concentration of some heavy metals in organically grown primitive, old and modern wheat genotypes: Implications for human health. *Journal of Environmental Science and Health, part B,* 47 (7) (In press).

III Abrar Hussain, Hans Larsson, Marie E. Olsson, Ramune Kuktaite, Heinrich Grausgruber & Eva Johansson (2012). Is organically produced wheat a source of tocopherols and tocotrienols for health food? *Food Chemistry* 132: 1789-1795.

IV Abrar Hussain, Hans Larsson, Ramune Kuktaite & Eva Johansson (2012). Healthy food from organic wheat: Choice of genotypes for production and breeding. *Journal of Science of Food and Agriculture (*Accepted*)*.

V Abrar Hussain, Hans Larsson, Ramune Kuktaite, Maria Luisa Prieto-Linde & Eva Johansson (2009). Protein content and composition in organically grown wheat: Influence of genotype. *Journal of Agronomy Research* 7 (2): 599-605.

VI Abrar Hussain, Hans Larsson, Ramune Kuktaite, Maria Luisa Prieto-Linde & Eva Johansson (2012). Amount and size distribution of monomeric and polymeric proteins in the grain of organically produced wheat: Influence of genotype and location. *(Manuscript)*.

VII Abrar Hussain, Hans Larsson, Ramune Kuktaite, Maria Luisa Prieto-Linde & Eva Johansson (2012). Towards the understanding of bread-making quality in organically grown wheat: Dough mixing behaviour, protein polymerisation and structural properties. *(Manuscript)*

Papers I-V are reproduced with the permission of the publishers.

The contribution of Abrar Hussain to Papers I-VII was as follows:

I Planned the experiment together with supervisor, collected samples, threshed and milled samples, carried out all experimental work, evaluated data, analysed data and wrote manuscript with the input of co-authors.

II Planned the experiment together with supervisor, collected samples, threshed and milled samples, carried out all experimental work, evaluated data, analysed data and wrote the manuscript with the input of co-authors.

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Abbreviations and symbols

ANOVA	Analysis of Variance
ASPP	Amount and Size Distribution of Polymeric Proteins
AT	Average Exposure Time
BCF	Bio-concentration Factor
CA	Cluster Analysis
Ca	Calcium
Cd	Cadmium
CDI	Chronic Daily Intake
CLSM	Confocal Laser Scanning Microscopy
Co	Cobalt
Cr	Chromium
Cu	Copper
EC	European Commission
ED	Exposure Duration
eLMP	Extractable Large Monomeric Proteins
eLPP	Extractable Large Polymeric Proteins
eSMP	Extractable Small Monomeric Proteins
eSPP	Extractable Small Polymeric Proteins
FAO	Food and Agriculture Organization
Fe	Iron
Hg	Mercury
HMs	Heavy Metals
HMW-GS	High Molecular Weight Glutenin Subunits
HPLC	High Performance Liquid Chromatography
HQ	Hazard Quotient

ICP-MS	Inductively Coupled Plasma Mass Spectrometry
ICP-OES	Inductively Coupled Plasma Atomic Emission Spectrometry
IFOAM	International Federation of Organic Agriculture
IR	Ingestion Rate
K	Potassium
LM	Light Microscopy
LMP	Large Monomeric Proteins
LMW-GS	Low Molecular Weight Glutenin Subunits
LPP	Large Polymeric Proteins
Mg	Magnesium
MPC	Maximum Permitted Concentration
Na	Sodium
Ni	Nickel
NP-HPLC	Normal Phase High Performance Liquid Chromatography
P	Phosphorus
Pb	Lead
PCA	Principal Component Analysis
RDI	Recommended Daily Intake
RfDo	Reference Dose
S	Sulphur
SDS-PAGE	Sodium Dodecyl Sulphate-Polyacrylamide Gel Electrophoresis
Se	Selenium
SE-HPLC	Size Exclusion High Performance Liquid Chromatography
SMP	Small Monomeric Proteins
SPP	Small Polymeric Proteins
TBS-T	Tris-Buffered Saline -Tween
TFA	Trifluroacetic Acid
TOTE	Total SDS-Extractable Proteins
TOTU	Total SDS-Unextractable Proteins
uLMP	Unextractable Large Monomeric Proteins
uLPP	Unextractable Large Polymeric Proteins
USDA	United States Department of Agriculture
uSMP	Unextractable Small Monomeric Proteins
uSPP	Unextractable Small Polymeric Proteins
Zn	Zinc

1 Introduction

1.1 Organic agriculture

The movement towards organic agriculture in the world started in the 1930s-1940s as an alternative to the increased intensification of agriculture, mainly due to the increased use of synthetic nitrogen fertiliser. Synthetic nitrogen became available after World War 1, when the infrastructure for explosives manufacturing, based on the Haber-Bosch process for fixation of nitrogen, was converted to nitrogen fertiliser production (Morrison, 1937). The term 'organic farming' was first used by Lord Northbourne in 1940 in his book *Look to the Land* (Scofield, 1986). Northbourne used the term not only for the maintenance of soil fertility by organic materials, but also to describe the organic farming system by integrating soil, crops, animals and society (Lotter, 2003).

Today, the general definition of organic farming is similar all over the world. The main focus is on ecological principles as the basis for crop and animal production. However, a range of specific definitions of organic farming have been produced by various international organisations, as described below:

- *Food and Agriculture Organization (FAO):*

"Organic farming is a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using, where possible, agronomic, biological, and mechanical methods, as opposed to using synthetic materials, to fulfil any specific function within the system" (FAO, 1999).

- *International Federation of Organic Agriculture (IFOAM):*

"Organic farming is a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic farming combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved" (IFOAM, 2007).

- *United States Department of Agriculture (USDA):*

"A production system that excludes the use of synthetically produced fertilizers, biocides, growth regulators, and livestock feed additives such as antibiotics and growth hormones" (USDA, 1980).

The formation of IFOAM in 1972 brought social and political organic movements into one forum (Kristiansen & Merfield, 2006). The mission of IFOAM is to lead, unite and assist organic movements all over the world (Woodward & Vogtmann, 2004). According to IFOAM, organic farming should be based on four principles: health, ecology, fairness and care (IFOAM, 2007).

1.1.1 Organic agriculture in the world

Organic agriculture has developed rapidly and it is now practised in more than 160 countries of the world (Willer, 2011). Beyond the industrialised countries of Europe and North America, a large expansion in the area under organic agriculture has also taken place in other parts of the word (Kristiansen & Merfield, 2006). According to an IFOAM and FiBL survey of organic farming in the world, about 37.2 million hectares were managed organically in 2009 (Willer, 2011). The regions with the largest areas under organic agriculture are Oceania, Europe and Latin America according the latest survey carried out by FiBL and IFOAM (Fig. 1). The market for organic foods is also different in different parts of the world. The European organic food market comprises almost half of the global organic food market, valued at 26 billion US dollars (Sahota, 2011). Although the demand for organic food products has been increasing, there are two challenges for the organic industry to overcome. The first of these is the perception that organic food is expensive and the second is how to manage the supply-demand imbalance in organic food production (Sahota, 2011).

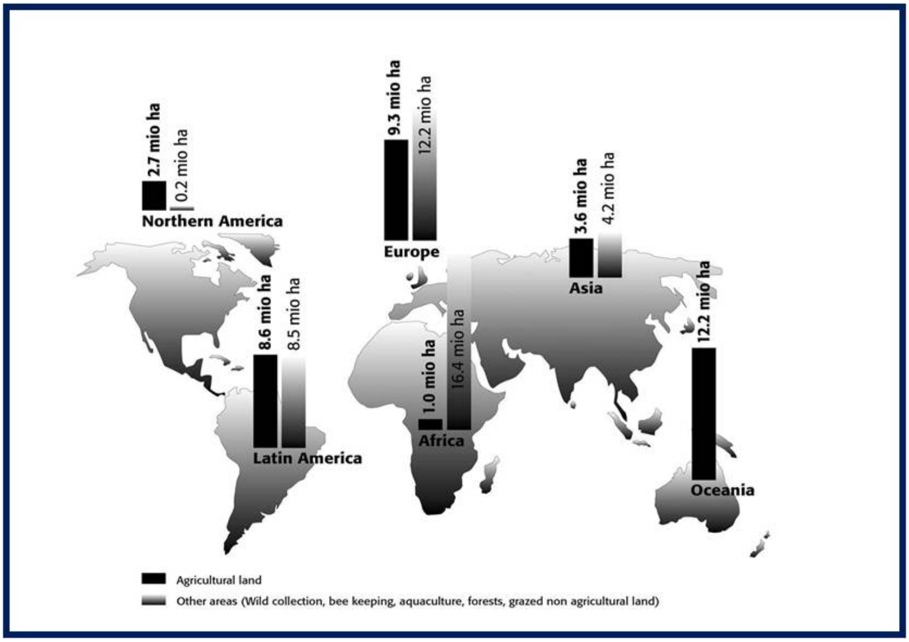

Figure 1. Area of organically managed agricultural land and other organic areas in different continents of the world [reproduced by the permission of Willer, (2011)].

1.1.2 Organic agriculture in Sweden

There are about 2.8 million hectares of arable land in Sweden, which represents about 7% of the total land area (Källander, 2000). Due to structural developments in Sweden, intensification and specialisation of agriculture has taken place in the past few decades. In 1995, Sweden became the member of the EU and consequently part of the Common Agricultural Policy (CAP). Thus, EU membership has influenced the economic development of agriculture in Sweden (Källander, 2000).

The organic production area of Sweden is about 392 thousand hectares, which represents 1.3% of the global total (FiBl & IFOAM, 2011). There has been an increase in organic production area in Sweden in recent years, most likely due to the increase in consumption of organic food. In 2009, the market for organic foods in Sweden was 698 million Euros and *per capita* consumption was 75 Euros (Schaak *et al.*, 2011). Cereals such as wheat, oats and barley are among the main crops grown in organic agriculture in Sweden and amounted to 232 thousand tons of grain in 2009 (SCB, 2009). More than 4% of the total cereals produced in Sweden are organically grown (SCB, 2009). The production of organic spring and winter wheat during the last few years is presented in Figure 2 (SCB, 2009).

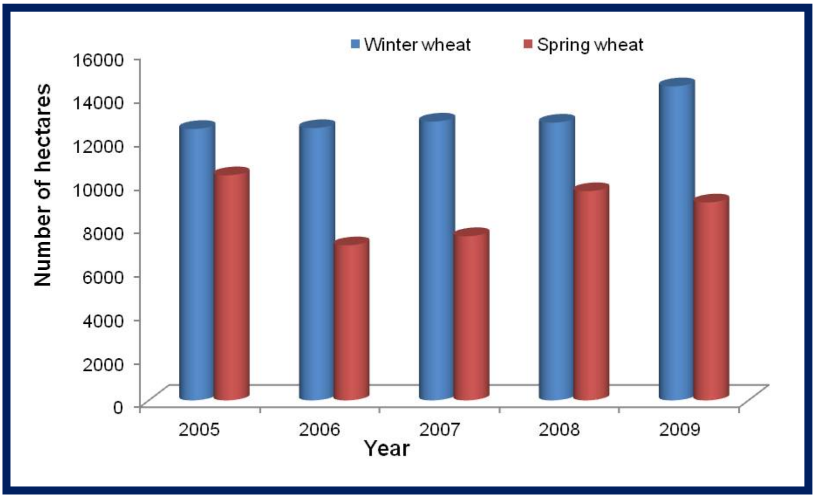

Figure 2. Production area of organic spring and winter wheat in Sweden, 2005-2009 (SCB, 2009).

1.2 Wheat

Wheat is the most important cereal crop world-wide, with annual production amounting to more than 651 million tons (FAO, 2010). It can grow in a wide range of environments, from 67°N in Scandinavia and Russia to 45°S in Argentina, including the tropical and sub-tropical regions of the world (Feldman, 1995). The domestication of wheat started about 10,000 years ago, as part of the Neolithic Revolution, through a transitional period when humans changed from hunting and gathering of food to settled agriculture (Shewry, 2009). The earliest cultivated forms of wheat were einkorn wheat (diploid, genome AA) and emmer wheat (tetraploid, genome AABB), which was grown in south-eastern Turkey (Heun *et al.*, 1997). Bread wheat, which is consumed as a variety of products today, is hexaploid (genome AABBDD), with six groups of seven chromosomes in each group (*i.e.* 2n=42). Emmer wheat (*Triticum turgidium* ssp. *dicoccum*) was developed through hybridisation of *T. urartu* (AA) and *Aegilops speltoides* (BB) (Fig. 3). Later, hexaploid wheat was produced by hybridisation of emmer wheat with goatgrass (*T. tauschii*) with genome DD (Fig. 3) (Shewry, 2009).

In modern agriculture the cultivated species of wheat are: bread wheat or common wheat (*T. aestivum*), durum wheat (*T. durum*) and spelt wheat (*T. spelta*). Bread wheat is widely grown all over the world and accounts for 95% of the total wheat, while the remaining 5% consists of durum and spelt wheat (Shewry, 2009). Currently, a total of around 4000 bread wheat varieties are cultivated in the world, with a spring or winter growth habit (Posner, 2000). Durum wheat is used mainly for pasta and its yield is generally lower than that of bread wheat (Bushuk, 1997), although in some regions, *e.g*. Mexico and Syria, yield of durum wheat can exceed that of bread wheat (Rattey & Shorter, 2010). Spelt wheat is grown on a small scale in some parts of Europe in organic cultivation because it needs less nutrient inputs, which is beneficial when producing organic bakery products (Vasil & Vasil, 1999).

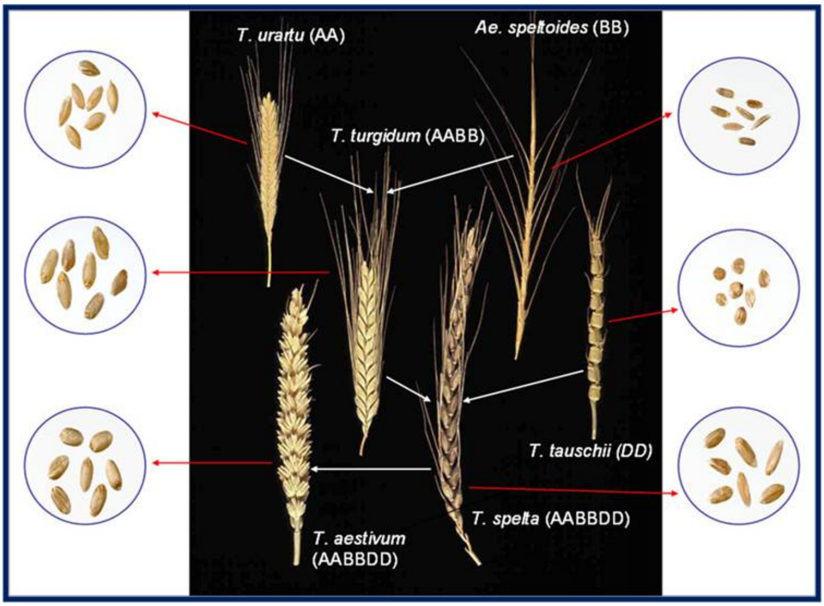

Figure 3. Evolution and genome relationship between bread wheat, durum wheat and einkorn wheat, showing spikes and grains as example [reproduced with kind permission of Shewry, (2009)].

1.2.1 Categorisation of genetic resources

Genetic resources of crops have been categorised by the Food and Agriculture Organization of the United Nations Commission on plant genetic resources (FAO, 1998) and by Frankel (1977). According to these categorisations, the genetic resources of the crop can be subdivided as follows:

- *Modern Cultivars*
  Including the cultivars that are currently used in farming.
- *Obsolete cultivars*
  This category includes cultivars of the past, together with those found in pedigrees of modern cultivars.
- *Landraces*
  Landraces are defined as dynamic populations of a cultivated plant with a distinct identity and associated with a traditional farming system.
- *Wild relatives of crops*
  These include wild and weedy forms of crop plant species.
- *Breeding lines*
  This category is comprised of the genetic material selected for breeding purposes.

Plant genetic resources are also commonly classified according to the gene pool concept, which reflects the ease of use of these genetic resources for future plant breeding (Harian & Wet, 1971). The primary gene pool is comprised of different biological species such as cultivated, wild and weedy types of the crop species of interest. The use of genetic resources of crops from the primary gene pool occurs mainly through the utilisation of modern cultivars and breeding lines (Harlan, 1975). A total of 640 000 accessions of wheat, including *Triticum* spp., *Aegilops* spp. and Triticale spp., was reported to exist throughout the world in 2001 (Skovmand *et al.*, 2002). The genetic diversity of spikes of some of the wheat genotypes used in this thesis is depicted in Figure 4.

Figure 4. Spikes of different wheat genotypes used in this thesis (photos by Hans Larsson).

1.3 Nutritional composition of wheat

The nutritional value of wheat is of key importance, since wheat is the world's largest food crop in terms of amount after rice and maize, thereby it contributes more calories and nutrients to the human diet than any other cereal crop (Abdel-Aal *et al.*, 1998). Wheat is consumed as bread, pasta, noodles, biscuits and many other confectionary products (Kumar *et al.*, 2011). Wheat is nutritious, easy to transport and store and it is a good source of protein, dietary fibre and vitamins (Shewry, 2007; Simmonds, 1989). The nutritional components of wheat are described below.

1.3.1 Proteins

Proteins are considered an essential component of the human diet, as manifested by the origin of the name, from the Greek *proteios,* meaning primary. The primary function of protein in nutrition is to supply the amino acids needed by the human body (Friedman, 1996). There are two categories of amino acids, essential and non-essential. Essential amino acids cannot be synthesised in the human body and therefore must be obtained via the diet. Thus the amount of proteins present and their specific amino acid composition determine the nutritional value of food (Friedman, 1996). Wheat is a good source of proteins since it is a major component of the daily diet and since it contains 8-20% proteins. However, the amino acid composition of wheat proteins could be improved in relation to the nutritional needs of humans. In particular, the amount of essential amino acids provided by wheat is rather low (Jiang *et al.*, 2008).

The classification of wheat proteins is based on different properties such as solubility, genetics, amino acid composition, *etc*. (Loponen *et al.*, 2004). Osborne was the first to classify wheat proteins on the basis of their solubility into albumins, globulins, gliadins and glutenins (Osborne, 1924) (Fig. 5).

The gliadins and glutenins are present in the starchy endosperm cells of the grain. Rough endoplasmic reticulum is the site of synthesis for the polypeptides and after synthesis these polypeptides are translocated into the lumen (Shewry *et al.*, 2002). In the lumen, disulphide bonding and protein folding take place. This is followed by final deposition of the proteins, which depends on the protein type and the growth stage of the plant tissue. Some proteins are transported via the Golgi apparatus to the final deposition place, *i.e.* the vacuole (Shewry, 1999).

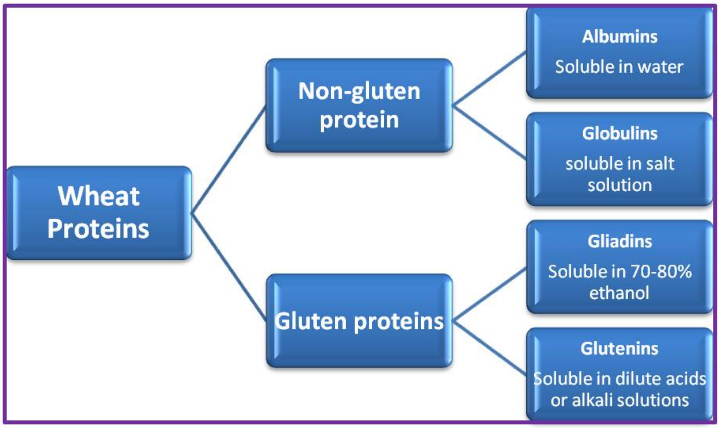

Figure 5. Classification of wheat proteins on the basis of solubility, as described by Osborn (1924).

Albumins and globulins

Albumins are soluble in water and globulins in salt solution. They have enzymatic activity and are responsible for *e.g.* starch breakdown. Albumins are mainly metabolic protein. Many albumins perform enzymatic activity, *e.g.* α-amylases, β-amylases, proteolytic enzymes, *etc*. (Matz, 1991). At the germination stage of the seedling, the enzymes make nutrients and energy available by their hydrolytic and proteolytic activity (Stone & Savin, 1999). The albumins and globulins have been found to play a minor role in protein interactions relating to the gluten proteins, but they are considered to be less significant in this respect than the gliadins and glutenins (Wrigley *et al.*, 2006). The globulins are further classified into two groups, 7S and 11S globulins, on the basis of sulphur-containing amino acids. These globulin groups are composed of multiple subunits (Shewry *et al.*, 2000).

Gluten

Gluten is the elastic, rubbery substance formed after washing the flour. The washing removes the soluble fractions and leaves a substance with elastic and stretching properties (Shewry *et al.*, 2002). Gluten is reported to consist to 80-85% of protein, plus some other compounds such as lipid and starch in minor amounts (Wieser, 2007; Wall, 1979). The gluten proteins are comprised of two groups, the gliadins and the glutenins. All of the gluten proteins are also known as prolamins because they are soluble in alcohol-water mixtures and because of their high contents of proline and glutamine (Madgwick *et al.*, 1992; Shewry *et al.*, 1986). The glutenins are further divided into high molecular weight glutenin subunits (HMW-GS), sulphur-rich proteins (*i.e.* low molecular weight glutenins, LMW-GS), γ-gliadins, α-gliadins and sulphur-poor proteins (ω-gliadins), depending on their molecular weight amino acid composition (Shewry *et al.*, 2000; Madgwick *et al.*, 1992; Miflin *et al.*, 1983). Gluten proteins play a major role in bread-making quality (MacRitchie, 1984). The viscoelastic properties of the dough are due to interactions of gliadins and glutenins and the other components of the gluten, *i.e.* lipids, minor amounts of carbohydrates and soluble proteins (Pomeranz, 1968).

- *Gliadins*

Gliadins are monomeric proteins and constitute more than 40% of total flour protein content. Gliadins have been found to play a role in the gluten network, although they have a low content of charged amino acids leading to the formation of intra-molecular disulphide bridges (Wieser, 2007). The amount of proline and glutamine is high in gliadins and they are classified into *α*-, *β*-, *γ*- and *ω*-gliadins in order of decreasing mobility in gel electrophoresis (Pomeranz, 1988; Mitrofanova, 1976). The role of α- and γ-gliadins in gluten polymer formation is minor, but their disulphide bonds play a role in maintaining the folding structure of proteins (Wrigley *et al.*, 2006; Shewry *et al.*, 2000). Hydrated gliadins are less elastic than glutenins and play a role in the viscosity of dough systems (Wieser, 2007). Gliadins may associate with glutenins through hydrophobic interactions and by hydrogen bonding (Veraverbeke & Delcour, 2002).

- *Glutenins*

The glutenins are comprised of polymeric proteins characterised by interpolypeptide cross-linking through disulphide bonds. Reductions of the glutenins result in two groups of proteins based on sodium dodecyl sulphate-polyacrylamide gel electrophoresis (SDS-PAGE). These groups are high molecular weight-glutenin subunits (HMW-GS) and low molecular weight-glutenin subunits (LMW-GS) (Wang *et al.*, 2006). The distribution of HMW-GS and LMW-GS has been found to have a strong correlation with bread-making quality. Glutenins also confer elastic properties to the gluten and constitute the largest protein polymers, with molecular weights of more than 10 million (Wieser, 2007; MacRitchie, 1992). HMW-GS and LMW-GS constitute up to 40% of gluten protein (Wieser & Kieffer, 2001; Halford *et al.*, 1992).

Wheat cultivars have been found to have six HMW-GS genes, although not all of these are expressed in all cultivars. About 2% of total seed proteins are contributed by each expressed gene and the combined proportion of HMW-GS varies from about 6 to 10% of the total (Shewry, 1999). The HMW-GS and LMW-GS genes are present on the 1A, 1B and 1D chromosomes of hexaploid wheat and are designated *Glu-A1*, *Glu-B1* and *Glu-D1*, respectively (Gianibelli *et al.*, 2001; Payne *et al.*, 1984). Furthermore, each locus is reported to have two genes encoding subunits, *i.e.* x-type and y-type (Veraverbeke & Delcour, 2002).

1.3.2 Starch

Starch is the most important carbohydrate and a major component of wheat grain, which contains about 63-66% starch (Toepfer *et al.*, 1972). Starch is stored in plant tubers and seed endosperm in the form of granules and the quantitative size of these granules varies with the botanical origin. Wheat starch granules are classified into three groups regarding their size; A- type , B-type and C-type granules (Fig. 6). The A-type granules have a lenticular shape and a diameter greater than 15 µm, while the B-type (5-15 µm) and C-type (less than 5 µm) granules are spherical (Peng *et al.*, 1999; Bechtel *et al.*, 1990) (Fig. 6). The components that make up wheat starch granules are amylose and amylopectin, the relative proportions of which differ between starches. Wheat starch normally contains 25-28% amylose and 72-75% amylopectin (Shibanuma *et al.*, 1994). The content of amylose in wheat flour plays an important role in the quality, because the ratio of amylase to amylopectin can affect the physicochemical properties of starch (texture, stability and viscosity of processed foods) (Morita *et al.*, 2002).

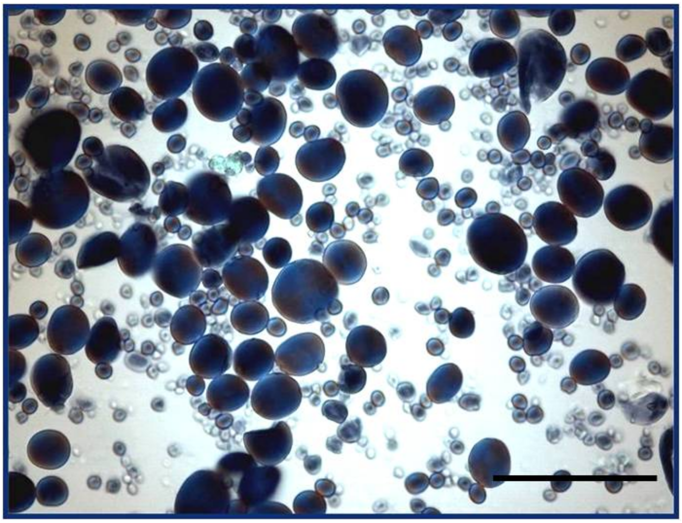

Figure 6. Structure of wheat starch as seen under a light microscope, showing the larger, lenticular A-type granules, spherical B-type granules and smaller C-type granules. Bar indicates 50 μm.

1.3.3 Minerals

Microelements play an important role in the biochemical and physiological functions of any biological system. It is estimated that more than three billion people worldwide are suffering from microelement malnutrition, often called 'hidden hunger' (Welch & Graham, 1999; Golden, 1991). Microelement malnutrition can result in low working efficiency, high rate of premature death of infants, permanent impairment of cognitive abilities and increased healthcare costs (Welch & Graham, 2004). The populations in developing countries are particularly at risk because many cannot afford to buy foods such as meat, poultry, fish, fruits and vegetables, all of which have high amounts of micronutrients (Welch & Graham, 1999).

Wheat grain and its products are considered an important source of minerals for both humans and animals (Iskander & Morad, 1986). Wheat grain contains 1.6% minerals (Fujino *et al.*, 1996). The important minerals in wheat grain and their role in human health are described below.

- *Calcium (Ca)*

Ca is an essential mineral for human health, as it has been found to participate in the biological functions of a number of tissues, *e.g.* the musculoskeletal, nervous and cardiovascular system, teeth, bones and parathyroid glands (Morgan, 2008; Huskisson *et al.*, 2007). It is also involved in the maintenance of mineral homeostasis and general physiological performance (Morgan, 2008).

- *Magnesium (Mg)*

This essential mineral acts as a cofactor in many enzymes that participate in muscles and nerve excitability (Huskisson *et al.*, 2007). It also plays a role in energy metabolism by the release of neurotransmitters. Intake of Mg also helps in reducing chronic diseases such as diabetes and metabolic syndrome (Bo & Pisu, 2008).

- *Potassium (K)*

Potassium has been found to play a role in maintaining the balance of the physical fluid system and it helps in nerve function by transmitting the impulse. Intake of K also helps heart muscle contraction (Lambert *et al.*, 2008; Sobotka *et al.*, 2008).

- *Sodium (Na)*

The role of Na in human health is to control the balance of physiological fluids, *e.g.* blood pressure, kidney, nerve and muscle functions (Sobotka *et al.*, 2008).

- *Phosphorus (P)*

The human body needs P in order to produce energy (ATP, GTP), which regulates the activity and functions of different proteins by means of phosphorylation reactions (Sobotka *et al.*, 2008). It also plays a role in bone and teeth formation and other metabolic actions in the human body, *e.g.* kidney functions, cell growth and contraction of the heart muscle (Martinez-Ballesta *et al.*, 2009).

- *Copper (Cu)*

The primary function of Cu is to act in enzymatic functions, *e.g.* the cytochrome C oxidase family of enzymes. It is also necessary in connective tissue development and iron metabolism (Huskisson *et al.*, 2007).

- *Iron (Fe)*

Fe is an important mineral in wheat grain and its function in the human body is to synthesise haemoglobin and myoglobin and to produce energy (Huskisson *et al.*, 2007).

- *Selenium (Se)*

Selenium is a major constituent of Se-lenoproteins, which play an important role in antioxidant reactions (Martinez-Ballesta *et al.*, 2009). Selenium has also been found to have an inhibitory effect on several types of cancer cells (Combs, 2004).

- *Zinc (Zn)*

Zinc is an important constituent in the structure and activity of more than 100 enzymes (Huskisson *et al.*, 2007). It is also necessary for the synthesis of nucleic acids and proteins, for glucose use and insulin secretion (Martinez-Ballesta *et al.*, 2009).

The amounts of essential elements vary between different milling fractions of the wheat grain. The amounts of K, P and Se in grain cortex are high, while S (sulphur), Mg and Ca are present in lower concentrations. Wheat bran has been found to have high amounts of P, K and Mg and low amounts of Se, S, Ca and Fe (Dikeman *et al.*, 1982).

1.3.4 Heavy metals

While essential elements are present in the wheat grain, some non-essential elements, heavy metals (HMs), may also be present. Heavy metals such as cadmium (Cd), cobalt (Co), chromium (Cr), mercury (Hg), lead (Pb) and nickel (Ni) can be dangerous to humans when they are ingested in certain amounts (Bradl, 2005). These metals enter the soil and the environment as a result of improper use of industrial effluents, sewage sludge and inorganic fertilisers containing HMs (Järup, 2003). They pose a hazard to human health when foods made from crops cultivated on HM-contaminated soils are consumed.

The health risks of HMs (Cd, Cr and Hg) include disruption of the physiological functions of endogenous hormones. Other human health problems caused by HM intake include kidney, neurological, cardiovascular and bone disorders (Dyer, 2007; Järup, 2003).

1.3.5 Antioxidants

Intake of whole wheat grain is associated with potential health benefits, including a reduced risk of coronary heart disease and several forms of cancer (Truswell, 2002). These beneficial effects of wheat grain on human health are due to the presence of bioactive compounds in the grain such as nondigestible carbohydrates and phytochemicals (Box 1) (Flight & Clifton, 2006). Antioxidants (Box 1) are low molecular weight phytochemicals that are present in the wheat grain (Yu, 2008). These antioxidants prevent biologically significant molecules, *e.g*. DNA, proteins and membrane lipids, from oxidative damage by free radicals (Zhou *et al.*, 2004). Free radicals, *i.e*. reactive oxygen species (Box 1), are produced by oxidation reactions in the human body and can start reacting with living cells and cause damage to them. Antioxidants provide a defence to the body by terminating free radical reactions and chelating transition metals (Bonoli *et al.*, 2004). A number of groups of compounds, such as vitamins (A, C and E), beta-carotene and some minerals (Cu, Mg, Se and Zn) act as antioxidants. Some phenols and many other non-nutrients in plants may also have antioxidant properties (Stanner *et al.*, 2004).

In plants, antioxidants have also been found to play a role in the prevention of damage by certain external factors, such as UV light and severe oxygen stress (Tominaga *et al.*, 2005). Resistance of wheat to fusarium head blight has been found to be linked to the presence of phenolic compounds (Atroshi *et al.*, 2002; Abdel-Aal *et al.*, 2001). The most important antioxidants in wheat grain and its fractions are vitamin E (tocochromanols) and carotenoids (Cheng *et al.*, 2006).

Box 1: Definitions of the terms used:

Antioxidant: "Any substance that delays or prevents oxidation also when the antioxidant is present in low concentrations compared with those of the oxidizable substrate" (Halliwell & Gutteridge, 2007).

Bioactive compound: "Extra nutritional constituents that typically occur in small quantities in food" (Kris-Etherton *et al.*, 2002).

Free radical: "A species that possesses one or several unpaired electrons in the outer shell, and is thus very reactive" (Halliwell & Gutteridge, 2007).

Phytochemical: "A plant-derived substance that is nutritionally, medicinally or physiologically highly active." (Harborne & Baxter, 1993).

Reactive Oxygen Species (ROS): "ROS are generally very small molecules and are highly reactive because of free radicals" (Yu, 2008).

- *Vitamin E (tocochromanols)*

The natural vitamin E family consists of eight lipid-soluble antioxidants: α-, β-, γ- and δ-tocopherol; and α-, β-, γ- and δ-tocotrienol. The tocopherols and tocotrienols together are also known as tocochromanols. The structure of tocochromanols is comprised of a polar chromanol head group with a phytyl side chain consisting of isoprenoid units (Fig. 7). Methylation at different positions are present on the polar chromanol head group, giving different compounds with antioxidant activity (Liu, 2007). The only difference in the structure of tocopherols and tocotrienols is that the phytol side chains of tocopherols are saturated, while tocotrienols have three carbon-carbon double bonds as shown in Fig. 7. Many foods including wheat grain contain tocochromanols. In the wheat grain, the tocochromanols are found in the germ fraction. Examples of foods containing high levels of tocochromanols are oils, nuts, fruits and berries (Tiwari & Cummins, 2009).

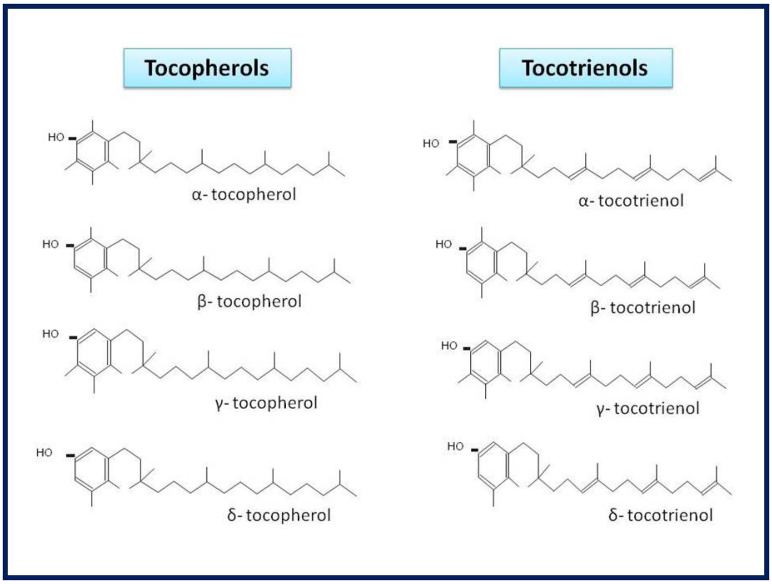

Figure 7. Structure of tocopherols and tocotrienols (tocochromanols).

High intake of vitamin E is associated with decreased incidence of cardiovascular disease in both males and females (Yu, 2008). Tocopherols have also been found to prevent the oxidation of membrane phospholipids and maintain cell membrane integrity (Liu, 2007).

All forms of vitamin E are accumulated in the adipose fat tissue of the human body (Cuthbertson *et al.*, 1940). High concentrations of *α*-tocopherol in the human body can be found in the mitochondria, endoplasmic reticulum and plasma membranes in the adipose fat tissues. Tocopherols are translocated to the blood via the lymph, where they form chylomicrons by combination with plasma proteins (Liu, 2007).

➢ *Carotenoids*

Carotenoids have yellow, orange and red colour and are lipid-soluble antioxidants, produced by most photosynthesising organisms. Carotenoids are grouped into two types, carotene and xanthophylls, on the basis of the number of hydrocarbons and their oxygenated derivatives (Liu, 2007). About 600 different types of carotenoids have been identified in plants, microorganisms and animals (Liu, 2007). The biological properties of the carotenoids are related to their structure. The basic structure consists of an isoprene unit, which is a hydrocarbon with a double bond that is soluble in organic solvents. The presence of single and double bonds in the polyenic chain determines the antioxidant properties of the carotenoids, together with the presence of polar groups associated with membrane interactions (Britton, 1995).

The function of carotenoids in plants is to collect light and to protect against photosensitisation in chloroplasts. Humans and animals cannot synthesise carotenoids but obtain them by consumption of carotenoid-containing foods. The human body needs α- and β-carotenes for the biosynthesis of vitamin A, which is required for normal development of embryo and foetus, visual functions, *etc*. (Zile, 1998).

1.4 Nutritional quality of organic foods

Due to growing awareness of the environment and health among the general public, interest in consumption of organically grown food has increased (Dangour *et al.*, 2009).

Generally, all types of food products differ from each other in terms of nutritional composition and content of other nutritionally relevant substances (Dangour *et al.*, 2009). The nutritional composition may also vary within the same product due to differences in the crop cultivars used. Differences in nutritional composition may also arise due to the fertilisers and pesticides used, growing conditions and other factors (Dangour *et al.*, 2009). The nutritional quality and toxicological value of organically grown foods has long been a matter of interest and debate (Lairon, 2009). During the past few decades, many studies have examined the nutritional quality of organic foods (Dangour *et al.*, 2009; Lairon, 2009; Magkos *et al.*, 2003; Bourn & Prescott, 2002; Worthington, 2001; Woese *et al.*, 1997). However, studies on the nutritional quality of organically grown wheat grain are limited (Ryan *et al.*, 2004; Brandt *et al.*, 2000; Shier *et al.*, 1984). As regards protein levels, some studies have shown that the protein content in organic wheat grain is comparable to that found in conventionally produced wheat grain (Mason *et al.*, 2007). However, in general organically grown wheat is believed to have low grain protein content compared with conventionally produced wheat (Gooding *et al.*, 1993). To compensate, the genotypes selected by organic farmers are mostly high protein types. Moreover, a 25-30% increase in the lysine content of organically grown wheat grain has been achieved in previous studies (Brandt *et al.*, 2000; Wolfson & Shearer, 1981). Organically grown crops have been found to have 21% more Fe and 29% more Mg than conventionally grown crops (Rembialkowska, 2007).

1.5 Effect of genotype and environment on grain nutrition

The nutritional composition of crops is influenced by a number of factors, including genotype and growing environment (climate, soil type, structure and microorganisms, management practices) (Hornick, 1992). The concentration of protein in wheat grain is also reported to be influenced by genotype and environment (Bnejdi & El Gazzah, 2010; Baenziger *et al.*, 1985; Kramer, 1979). Studies on protein composition and polymerisation (amount and size distribution of protein polymers) in the wheat grain have confirmed the significance of genotype and environment (Johansson *et al.*, 2001; 2002; 2003; 2008; Johansson & Svensson, 1998). For example, one recent study showed that the interactive effect of genotype and environment (temperature and nitrogen regime) is of critical importance in determining the amount and size distribution of polymeric proteins (ASPP) (Malik *et al.*, 2011).

The concentrations of minerals such as Fe, Zn, Se, P, Mg, K, *etc*. in wheat grain are also influenced by the genotype (Zhao *et al.*, 2009; Liu *et al.*, 2007; Graham *et al.*, 1999), as well as the growing environment and soil characteristics (Spiegel *et al.*, 2009; Graham *et al.*, 1999). Furthermore, genetic variations between wheat genotypes, farming conditions (organic or conventional) and geographical location have a significant effect on HM concentrations (Cd, Co, Hg, Pb) in wheat grain (Jamali *et al.*, 2009; Al-Najar *et al.*, 2005; Oliver *et al.*, 1995). For example, growing sites with acidic soil have been found to transfer more Cd to plants than less acidic soils (Oborn *et al.*, 1995).

Furthermore, the tocochromanol concentration in the wheat grain of diverse genotypes is reported to vary (Hejtmankova *et al.*, 2010; Lampi *et al.*, 2008; Panfili *et al.*, 2003). The effect of geographical location on the concentration of tocochromanols in conventionally produced wheat grain has been investigated in the EU project 'HEALTHGRAIN' (Lampi *et al.*, 2010).

1.6 Role of mixing in dough development

Mixing of dough is the first step in the bread-making process. The mixing process performs the functions of blending the flour and water into a homogeneous mass, imparting gas-retaining properties to the dough and making the dough viscoelastic (Dobraszczyk & Morgenstern, 2003; Naeem *et al.*, 2002). There are also changes in the gluten protein composition in the dough as a result of the mixing process (Skerritt *et al.*, 1999). Most rheological studies have shown that changes in specific gluten protein fractions, *i.e.* polymers, occur during mixing and resting of the dough (Kuktaite *et al.*, 2004; Dobraszczyk & Morgenstern, 2003). Different dough mixers such as mixograph and farinograph are used to monitor the development of the gluten network during the mixing process (Goesaert *et al.*, 2005).

Some previous investigations found that the size and amount of HMW glutenins are related to dough strength and amount of proteins in the dough (Lee, 2002). In addition, a higher percentage of large unextractable polymeric proteins (%largeUPP) and total unextractable polymeric proteins (%UPP) was found at minimum and optimum mixing level as compared to overmixing (Kuktaite *et al.*, 2004).

1.7 Microstructure of dough

During dough formation, the molecules of gluten become hydrated and interact to form a three-dimensional structure (Schofield, 1986). This three-dimensional structure determines the rheological properties of the dough (Li *et al.*, 2003). The lightness and evenness of the crumb in bread also depend on the gas-holding capacity of the bread. The strain resistant property of gluten prevents the early rupture of gas cells and increases the gas-holding capacity (Dobraszczyk & Morgenstern, 2003; Singh & MacRitchie, 2001).

Changes in the structure of the dough and its viscoelastic properties have an influence on rheological aspects of the dough. Dough behaviour has been found to be influenced by the composition and microstructure of its components (spatial arrangement of components) (Bloksma, 1990). Dobraszczyk & Morgenstern (2003) found that dough molecular structure (presence or absence of branching in glutenin subunits) and large deformation rheology are correlated. Some previous studies have also indicated that the rheological behaviour of wheat dough at large deformations is greatly influenced by strength of the gluten protein fraction (Dobraszczyk & Morgenstern, 2003; Kieffer *et al.*, 1998).

Studies on the microstructure of dough have shown that proteins make fibrils at atomic level that align side-by-side because of hydrogen bond formation (Mackintosh *et al.*, 2009; Humphris *et al.*, 2000). However, the specific interaction of proteins in the dough may contribute to the formation of fibrils. Morphologically, the glutenins and gliadins are responsible for the formation of fibrils in the dough. An example of the gluten network structure (glutenins and gliadins, with some starch granules and aleurone particles) in organically produced wheat dough is shown in Figure 8. A previous study has shown that the distribution of HMW-GS is continuous and forms the backbone of the gluten network, whereas LMW-GS occurs in clustered structures in the gluten matrix (Lindsay & Skerritt, 2000).

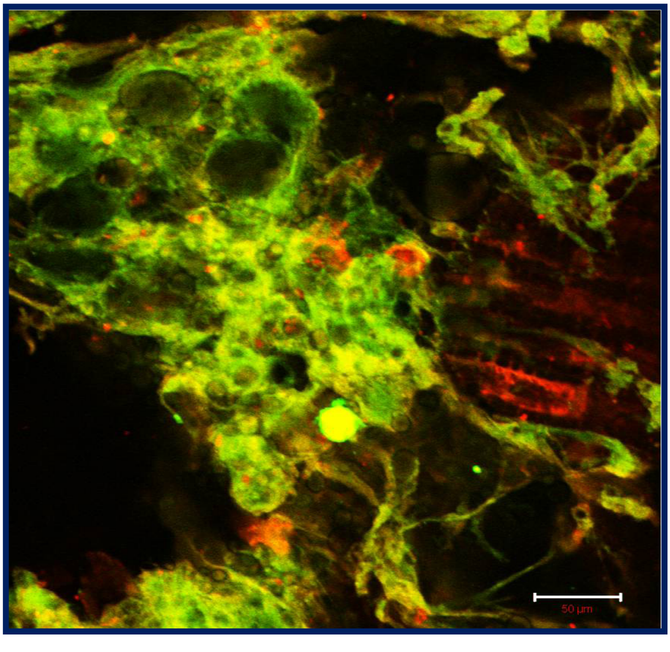

Figure 8. CLSM image of the dough of organically grown wheat. Green colour - high molecular weight glutenins (2, 5, 10 and 12), red colour - gliadins and aleurone (bran) particles, yellow superimposision (overlapping) of red and green fluorescence. Scale bar is 50 µm.

2 Objectives

The overall aim of this doctoral thesis was to study the nutritional composition, mixing behaviour and structural properties of organically grown wheat genotypes in order to develop and improve ways to evaluate and select organic wheat cultivars with desired quality for different end-uses. An additional aim was to evaluate the effects of different growing locations in order to better understand genotype-environment interactions concerning different traits or contents of compounds.

Specific objectives of the studies carried out were to:

- Screen wheat genotypes in organic cultivation systems for nutritionally relevant compounds such as proteins, minerals, antioxidants and heavy metals.
- Evaluate the suitability of wheat from genetically diverse wheat groups in breeding organic wheat with health-promoting properties.
- Assess the risk of different heavy metals to human health through consumption of organically grown wheat grain.
- Identify genotypes with lower propensity to transfer heavy metals from the soil to the grain using the bio-concentration factor (BCF; ratio of metal concentration in wheat grain to that in soil).
- Evaluate whether organically grown wheat is a good source of tocochromanols for human consumption.

- Evaluate and screen for variations in %UPP and TOTE that can be used in selection of genotypes with suitable gluten strength and increased protein content.

- Better understand the background of how to breed for improved bread-making quality in organically produced wheat.

3 Materials and Methods

3.1 Wheat grain samples

In total, 723 wheat grain samples of different spring and winter wheat genotypes were used in the thesis (Appendix 1-4). These genotypes were collected from a project on participatory breeding of wheat for organic agriculture, which started in 1995 and is still ongoing. Most of the varieties were originally obtained from the Nordic Gene Bank, now Nordgen (www.nordgen.org). The participatory breeding project has evaluated the varieties under different climate conditions and the varieties are used by different organic farming groups in an association named Allkorn (www.allkorn.se) and by production groups such as www.wastgotarna.se and www.gutekorn.se (Larsson, 2007; 2006). Many of the spelt wheat varieties were obtained by the participatory breeding project in 1996 from Professor Arnulf Merker, SLU, Uppsala, where they had been used within a PhD project by Peter Nilsson. Other European varieties studied within the participatory breeding project were obtained from some members of the Association of Biodynamic Plant Breeders (www.abdp.org), for example Peter Kunz (www.getreidezuechtung.ch) and Berthold Heyden (www.saatgut-forschung.de).The NordGen number and year of introduction of each genotype are given in Appendix 1.

An aim within the participatory breeding project was to evaluate the genotypes for nutritional quality and adaptation to local climate and organic farming conditions. In this thesis, genotypes included in the participatory breeding project were examined. These genotypes were divided into one of six genotype groups: selections, spelt wheat, old cultivars, primitive wheat, landraces and modern cultivars (for description of genotype groups, see Table

1). These genotype groups were given different names originating from the genetic resources categories described by Frankel (1977) because of genetics and ease of understanding. The genotype group, growing location, type and content of nutritional compounds, *i.e*. minerals, protein fractions and tocochromanols, are presented in Appendix 2-4.

Table 1. *Description of different genotype groups*

Genotype group	*Number of samples (723)*	*Description*
Selections	*53*	*Wheat types selected for the purpose of organic cultivation from old varieties.*
Spelt wheat	*184*	*Spelt wheat varieties from different breeding periods*
Old cultivars	*206*	*Varieties from the 1900-1960 breeding period*
Primitive wheat	*42*	*Accessions of einkorn (Triticum monococcum) and emmer (T. dicoccum) wheat.*
Landraces	*186*	*Traditionally used wheat landraces in organic farming*
Cultivars	*52*	*Varieties released since 1970*

3.2 Growing locations

All the grain samples of the different genotypes were grown organically in one or several locations in Sweden, namely Alnarp (55°39.4N, 13°5.2E), Bohuslän (58°31.6N, 11°34.8E), Gotland (57°36.6N, 18°27.9E) and Uppsala (59°49N, 17°46.6E), during one or several years in the period 2001-2008. The general soil characteristics of each growing location are given in Paper I. After harvesting, the spikes were threshed and the grain obtained was stored at -20 ^{o}C.

3.3 Mineral and HM determination (Papers I, II and IV)

3.3.1 Sample preparation and digestion

A total of 493 grain samples from 321 wheat genotypes were used for mineral and HM analyses. Each grain sample was milled (for 1 min) into whole grain flour using a laboratory mill (Yellow line, A10, IKA-Werke, Staufen, Germany). Microwave digester (Microwave Labstation Mars 5, CEM Corporation, Matthews, NC, USA) was used to digest 0.5 g of each flour sample as described in Papers I and II.

3.3.2 Chemical analysis

Inductively Coupled Plasma Mass Spectrometry (ICP-MS; Perkin-Elmer, ELAN-6000) and Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-OES; Perkin-Elmer, OPTIMA 3000 DV) were used to measure the mineral and HM concentrations in the digested samples. Atomic spectrometry standards from Perkin-Elmer, SPEX, AccuStandard and Merck were used in the analysis. The calibration procedure for ICP-MS and ICP-OES is described in Papers I and II.

The minerals Al, B, Ba, Ca, Cu, Fe, K, Mg, Mn, Na, P, S, Sr, Ti and Zn were estimated by ICP-OES. Heavy metals and some other minerals were measured by ICP-MS using the isotopes as follows; ^{75}As, ^{114}Cd, ^{59}Co, ^{52}Cr, ^{202}Hg, ^{7}Li, ^{95}Mo, ^{58}Ni, ^{208}Pb, ^{121}Sb, ^{82}Se, ^{120}Sn, ^{51}V. Blanks were also used and treated similarly to the samples, as described by Tyler and Olsson (2002). Three replicates of each sample were analysed, as presented in Papers I and II.

3.3.3 Health risk estimation for individual HMs (Paper II)

The risk posed by each HM in wheat grain to human health was estimated following the method described by Huang *et al*. (2008), using the Hazard Quotient (HQ; (US.EPA, 1989) calculated as follows:

$$HQ = CDI/RfDo \qquad (1)$$

$$CDI\ (mg^{-1}kg^{-1}day^{-1}) = (CF \times IR \times EF \times ED) / (BW \times AT) \qquad (2)$$

where CDI is Chronic Daily Intake, *i.e*. mass of HM consumed (mg kg^{-1} body weight day^{-1}); RfDo is the reference dose (mg kg^{-1} body weight day^{-1}) (US EPA, 1989); CF is the mean HM content in wheat grain (mg kg^{-1}); IR is the ingestion rate of a Swedish individual (kg $person^{-1}$ day^{-1}), which is 0.21 according to FAO (2007); EF is exposure frequency, which is 365 days $year^{-1}$; ED is exposure duration for a Swedish adult (71.8 years, which is equivalent to average lifetime) (NationMaster, 2010); BW is body weight, equal to 70 kg for adults (Marti-Cid *et al.*, 2008); and AT is average exposure time for non-carcinogenic effects, calculated by ED x 365 days $year^{-1}$. Values of HQ >1 indicate a health risk. Data on RfDo were taken from a risk-based concentration table for chemical contamination (EFSA, 2011; US EPA, 2000) except for Pb. A previous study was consulted for Pb value (Agusa *et al.*, 2007).

3.4 Tocochromanol determination (Papers III and IV)

3.4.1 Samples

Forty spring and winter wheat grain samples from different genotype groups were selected for tocochromanol determination. The grain samples were freeze-dried and about 6 g of each grain sample were milled to flour (whole grain) and used for tocochromanol extraction (Papers III and IV)

3.4.2 Chemicals

The standards α, β, γ and δ-tocopherols were purchased from Merck (Darmstadt, Germany) and β-tocotrienol from Sigma-Aldrich (Buchs, Switzerland). The procedure used for preparing the stock solutions of standards is described in Papers III and IV. α-tocotrienol was determined by α-tocopherol standard according to the method of Kramer *et al*. (1997) (Papers III and IV).

3.4.3 Saponification of flour samples (Papers III and IV)

Tocochromanols were extracted by the saponification method described by Fratianni *et al*. (2002) with some modifications. A detailed description of this modified saponification method is given in Papers III and IV. In brief, 1 g wheat flour was saponified using 2.5 mL ethanol pyrogallol (60 g L^{-1}), 1 mL sodium chloride (10 g L^{-1}), 1 mL ethanol (95%) and 1 mL potassium hydroxide (600 g L^{-1}). The sample was then transferred to a water bath at 70 °C for 30 min for saponification. Afterwards, the organic layer was collected and evaporated to dryness. The dry residue was dissolved in 2 mL n-hexane and injected into the HPLC (Papers III and IV).

3.4.4 HPLC analysis for tocochromanols (Papers III and IV)

Tocochromanol compounds were separated by normal phase HPLC (NP-HPLC) according to the method described by Panfili *et al*. (2003) with some modifications. The HPLC configuration and mobile phase used are presented in Papers III and IV.

Recovery percentage was determined by adding *α*, *β*, *γ* and *δ*-tocopherols and *β*-tocotrienol to flour sample. The results of recovery percentage indicated that the extraction method used allowed successful determination of tocopherols and tocotrienols (Papers III and IV).

3.5 Protein analyses (Papers V, VI and VII)

3.5.1 Specific protein composition (Paper V)

Total proteins in grain samples of 29 wheat genotypes were extracted in the presence of SDS and fractioned on polyacrylamide gels according to the method of Payne *et al*. (1983). The gels were stained according to Johansson *et al.* (1993) using Coomassie Brilliant Blue solution containing 10% ethanol and 8% trichloroacetic acid (TCA). Afterwards, the gels were destained with 4% TCA water solution for 24 hours in order to get clear bands (Johansson *et al.*, 1993) (Paper V).

3.5.2 SE-HPLC (Papers V-VII)

Amount and size distribution of polymeric proteins were analysed according to Johansson *et al*. (2008) by applying SE-HPLC with a two-step extraction procedure (Gupta *et al.*, 1993). SDS-soluble proteins were extracted in the first step, while SDS-insoluble proteins were extracted in the second step. The extraction procedure is described in detail in Papers V-VII.

Extracted proteins were placed into vials for SE-HPLC analysis and three replicates of each sample were fractionated. Information on the HPLC system and phase used is given in Papers V-VII.

The SE-HPLC chromatograms were divided into four sections according to their molecular size as: (i) large polymeric proteins (LPP), (ii) smaller polymeric proteins (SPP), (iii) large monomeric proteins (LMP) and (iv) smaller monomeric proteins (SMP) (Fig. 11).

Different protein parameters were calculated according to Johansson *et al.* (2008) as follows:

- Total SDS-extractable proteins (TOTE) = eLPP + eSPP + eLMP + eSMP

- Total SDS-unextractable proteins (TOTU) = uLPP + uSPP + uLMP + uSMP
- Percentage of large unextractable polymeric protein in total large polymeric protein (%Large UPP) = uLPP/(uLPP + eLPP) × 100
- Percentage of total unextractable polymeric protein in total polymeric protein (%UPP) = uLPP + uSPP/(eLPP + eSPP + uLPP + uSPP) × 100
- Percentage of large unextractable monomeric protein in total large monomeric protein (%Large UMP) = uLMP/(uLMP + LMP) ×100

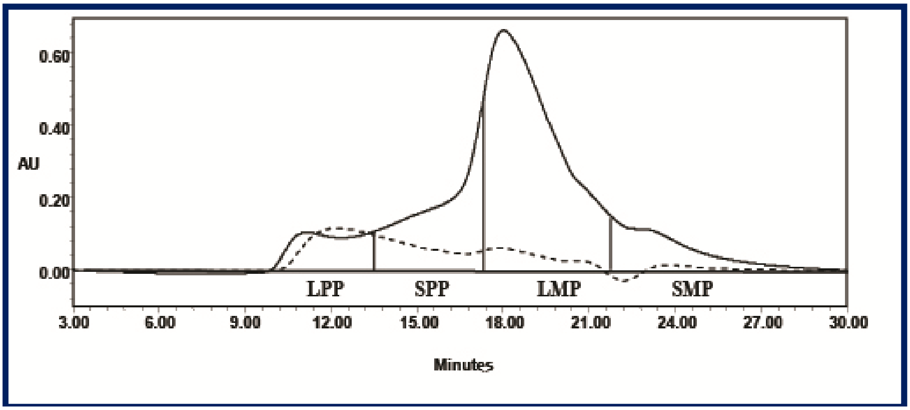

Figure 9. Typical SE-HPLC chromatogram of wheat flour sample, showing SDS-extractable proteins (____) and SDS-unextractable proteins (...........). The chromatogram is divided into four parts: LPP (large polymeric proteins), SPP (smaller polymeric proteins), LMP (large monomeric proteins) and SMP (smaller monomeric proteins).

3.6 Mixing analysis (Paper VII)

On the basis of %UPP in the flours, 51 wheat genotypes were selected for mixing analysis to investigate the effect of mixing on protein polymerisation, network and structure. For dough mixing, 10 g of flour from each sample were mixed with distilled water according to the AACC method (AACC, 2000). All flour samples were mixed at 25 °C using a mixograph (Bohlin). The first mixing continued for 10 min in order to determine dough optimum mixing time (the highest mixing resistance). In addition, two replicate flour samples were mixed until the defined optimum mixing time. The dough samples were used for SE-HPLC analysis. Mixing parameters were also calculated from the mixing curve.

3.7 Microscopy analyses (Paper VII)

Four genotypes were selected for LM and CLSM analysis on the basis of %UPP in flour and dough. These were Agron, with high %UPP in both flour and dough; Extrem, with high %UPP in flour and low %UPP in dough; Intaller, with low %UPP in both flour and dough, and Gammel land vete with low %UPP in flour and medium %UPP in dough. The selected genotypes were milled using a sieve size 0.5 mm in order to decrease the bran particle size and to get homogeneous dough for microscopic analysis. After optimum mixing of the dough, about 1×1 mm of dough samples were smeared on glass slides for LM and CLSM (Paper VII).

3.7.1 LM

The smeared slides were stained using 0.1% Light Green (Sigma, St. Louis, MO, USA) and starch was stained using 50% Lugol solution. The slides were then rinsed with water, immediately mounted and observed with a DMLB light microscope (Leica Microsystems, Bensheim, Germany) as described in Paper VII.

3.7.2 CLSM

CLSM of the dough samples was determined according to the method described by Kuktaite *et al*. (2011) with some modifications. The methodology is described in detail in Paper VII.

3.8 Statistical Analyses

Analysis of Variance (ANOVA) followed by mean comparisons using LSD test and Spearman rank correlation were carried out using Statistical Analysis System (SAS, 2004). Principal component analysis (PCA) and cluster analysis (CA) on the data were carried out using Minitab statistical software (Multivariate, v. 16, Minitab Inc.).

To evaluate the relative influence of genotype and location, the ratio between genetic group and location variance (σ_g^2/σ_l^2) was calculated for each of the minerals and genotype groups analysed, according to the method of Peterson *et al*. (1986) (Paper I).

The bio-concentration factor (BCF) of Cd transfer from the growing medium to the grain of each genotype was calculated according to Huang et *al.* (2008) as:

BCF = Cd concentration in wheat grain/Cd concentration in the soil

4 Results and Discussion

4.1 Mineral concentration in organically grown wheat grain (Papers I and IV)

4.1.1 Variation in grain mineral concentration between genotype groups

There was great variation in the concentration of minerals, *e.g.* B, Cu, Fe, Se, Mg, Zn, Ca, Mn, Mo, P, S and K, in the different genotypes and genotype groups investigated in the thesis (Appendix 2; Papers I and IV). This substantial variation in grain mineral concentration indicates a great genetic potential that can be exploited to enhance the concentrations of minerals in wheat (Papers I and IV).

Of the genotype groups investigated, the primitive wheat group had the highest concentrations of Zn and K. The concentrations of B, Cu, Mg, Ca, P and S in wheat grain were also higher in primitive wheat compared with the other genotype groups. The concentrations of several of the minerals investigated here were higher in primitive wheat, selections and old cultivars than in the cultivars and spelt wheat groups. However, it could not be proven for other minerals that the modern wheat material has lower concentrations than old wheat material (Papers I and IV). One previous study has reported a negative relationship between amount of minerals and more recent cultivars, which was attributed to increased yield of modern cultivars resulting in a dilution effect of the minerals (Fan *et al.*, 2008). The results in Papers I and IV partly confirm findings indicating a decreasing mineral content in wheat over the last 160 years (Fan *et al.*, 2008). In contrast, another recent study showed that mineral concentrations in modern wheat cultivars are no lower than in old cultivars (Nelson *et al.*, 2011).

The differences in grain mineral concentration between the genotype groups might be due to the diverse genetic background of the material evaluated (Papers I and IV). This indicates that genetic differences affect the concentrations of minerals in wheat grain, as also reported in various varietal trials (Nelson *et al.*, 2011; Zhao *et al.*, 2009; Graham *et al.*, 1999; Peterson *et al.*, 1986).

The mean concentrations of most grain minerals were higher in Papers I and IV than in previous studies (Kirchmann *et al.*, 2009; Spiegel *et al.*, 2009; Zhao *et al.*, 2009; Fan *et al.*, 2008; Ryan *et al.*, 2004; Graham *et al.*, 1999), despite a range of different types of wheat and wheat cultivars being included. All the studies cited except Ryan *et al.* (2004) were carried out in conventional farming conditions. Thus, the higher level of minerals in Papers I and IV might be linked to the organic farming system used, although it might also be the effect of the chosen genotypes or of the soil at the different growing locations. A recent Canadian study compared the grain mineral concentrations in spring wheat cultivars under organic and conventional farming systems and found that the organic system gave higher grain Zn, Fe, Mg and K concentrations than the conventional system (Nelson *et al.*, 2011). This variation in mineral concentrations between farming systems may be due to differences in management practices (Ryan *et al.*, 2004).

4.1.2 Variation in grain mineral concentration between locations (Paper I)

Principal component analysis (PCA) was carried out on the concentration of minerals in order to assess the pattern of variation in grain mineral concentration of wheat genotypes grown at different locations. The first four PCs explained 67.2% of the total variation in all genotypes investigated (Table 2). PC1 explained 30.5% of the total variation and the minerals contributing to the variation were Cu, Fe, Se, Mg, Zn and S, while PC2 explained about 15.4% of the total variation between the genotypes and the most important minerals for this variation were Mo, P and K (Table 2).

Table 2. *Proportion of variation in different minerals contributing to PC1-PC4 of organically grown wheat genotypes.*

Minerals	PC1	PC2	PC3	PC4
Variance explained (%)	30.5	15.4	12.7	8.6
Cumulative variance (%)	30.5	45.9	58.6	67.2
B	0.046	-0.163	0.185	-0.854
Cu	0.359	-0.198	0.297	0.106
Fe	0.293	-0.391	-0.207	0.149
Se	0.266	0.23	-0.168	0.083
Mg	0.408	0.127	-0.114	-0.019
Zn	0.382	-0.167	-0.001	0.062
Ca	0.225	-0.276	-0.179	-0.355
Mn	0.008	-0.014	-0.66	-0.162
Mo	0.17	0.447	-0.336	-0.166
P	0.372	0.454	0.046	0.01
S	0.395	-0.252	0.128	0.134
K	0.163	0.372	0.44	-0.169

The score plot of the first two principal components is presented in Fig. 10. The diagram is divided into three groups, indicated by circles, and it is clear that growing the genotypes at different locations gave a large variation in the concentration of grain minerals (Paper I). The genotypes in group I were mainly from Alnarp and showed high concentration of most minerals (Cu, Fe, Se, Mg, Zn, Mo and P) (Fig. 10). Group II contained most of the genotypes grown in Bohuslän and Gotland, which had high amounts of B and K (Fig. 10). The genotypes from Bohuslän and Gotland had low amounts of the other minerals (Paper I). The genotypes in group III were mainly from Uppsala, with some genotypes from Alnarp and Gotland (Fig. 10). These samples were also high in Fe, Zn, Ca and S but low in B, Mo, P and K (Paper I). Growing location has been found to have an influence on mineral levels in grain (Graham *et al.*, 1999). The differences in grain mineral concentrations might depend on the soil characteristics of each growing location (Paper I). Grain samples from Alnarp and Uppsala showed a higher concentration of some minerals than grain from the other growing locations (Paper I). High soil organic matter content and pH at Alnarp and Uppsala might be the reason for the higher mineral concentrations (Paper I). Similarly, previous studies have shown that higher levels of minerals in wheat grain may be linked to high organic matter content and pH in the soil (Spiegel *et al.*, 2009; Murphy *et al.*, 2008).

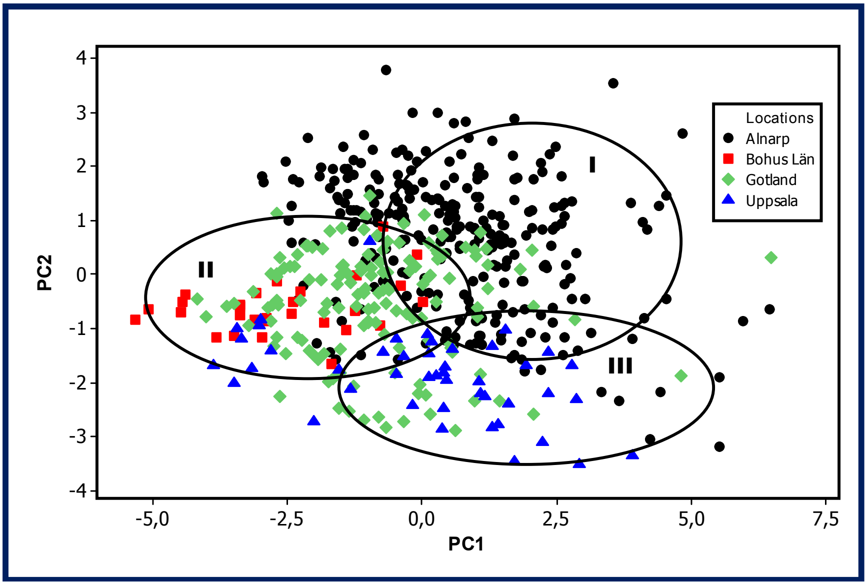

Figure 10. Score plot of PC1 and PC2 of 493 organically grown wheat genotypes based on mineral concentrations (B, Cu, Fe, Se, Mg, Zn, Ca, Mn, Mo, P, S and K) in the grain.

4.1.3 Difference in grain mineral concentrations between spring and winter wheat (Paper I)

The PCA also revealed a large variation in the concentrations of grain minerals between spring and winter wheat genotypes (Fig. 11). The score plot of the first two PCs showed clear grouping of spring and winter wheat genotypes. Group I mainly comprised winter wheat and group II mainly spring wheat (Fig. 11). Most of the spring wheat genotypes (group II) were found to have higher amounts of Cu, Fe, Zn, Ca and S than the winter wheat genotypes (group I) (Paper I). The low concentration of minerals in winter wheat might be linked to the dilution effect, as their yield is higher than that of spring wheat. A negative relationship between mineral concentration and yield was also found (Paper I). Similar findings have been reported in some previous studies (Zhao *et al.*, 2009; McDonald *et al.*, 2008; Garvin *et al.*, 2006). However, there have also been contrasting results showing a positive relationship between yield and mineral concentration in wheat grain (Graham *et al.*, 1999).

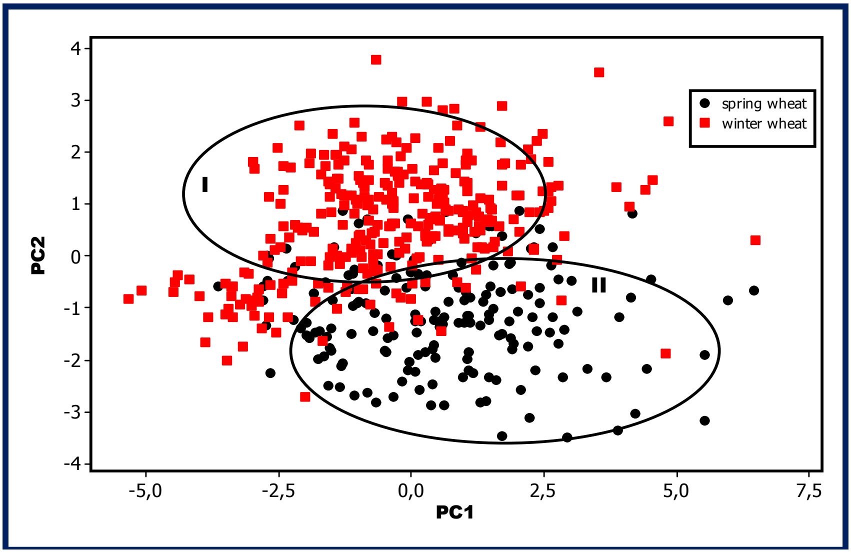

Figure 11. Score plot of PC1 and PC2 of 493 organically grown wheat genotypes based on mineral concentrations (B, Cu, Fe, Se, Mg, Zn, Ca, Mn, Mo, P, S and K) in the grain.

4.1.4 Relative influence of genotype and location on grain mineral concentrations (Paper I)

The relative influence of genotype and location on grain mineral concentrations was calculated using the ratio between their variances (σ_g^2/σ_l^2) (Paper I). For variance ratio >1, the influence of genotype on variation in minerals is greater than that of location (Peterson *et al.*, 1986). Here, the relative importance of genotype and location was found to vary in relation to genotype group and mineral. The primitive wheat genotype group showed a higher influence of genotype compared with location for concentration of B, Cu, Se, Mg, Zn, Ca, P, S and K (Paper I). For the selections genotype group, location was more important than genotype for most minerals studied except Se and Mo. The old cultivars group had a higher influence of genotype compared with location for some minerals (Fe, Mg, Mn and S). Spelt wheat and landraces also varied in relative influence of genotype and location for different minerals in wheat grain. The higher influence of genotype than location for the primitive wheat group provides support for the claim that primitive wheat can be cultivated in organic systems to obtain high mineral concentrations in the grain. However, a study has shown that the relative influence of environment is higher than that of genotype for most wheat minerals (Peterson *et al.*, 1986).

4.2 Heavy metal concentrations in organically grown wheat grain (Papers II and IV)

4.2.1 Variation in grain HM content between genotype groups

There were significant differences between genotype groups and between genotypes within groups as regards the concentrations of Cd, Co, Cr and Pb in the wheat grain (Appendix 2; Papers II and IV). The selections had significantly higher amounts of Cd in grain samples than the other genotype groups. Primitive wheat had the lowest Cd concentration in grain of all genotype groups (Paper II), while Co was significantly higher in the grain of old cultivars than other investigated genotype groups. A higher concentration of Cr was also found in old cultivars compared with selections. Primitive wheat had a higher concentration of Pb than selections, old cultivars, landraces and cultivars. All six genotype groups had statistically similar amounts of Hg and Ni in the grain (Paper II).

The lower concentration of Cd in the grain of primitive wheat compared with the other genotype groups might be linked to differences in genotype. Some previous studies have also reported differences in grain metal accumulation in different genotypes (Jamali *et al.*, 2009; Kirchmann *et al.*, 2009; Spiegel *et al.*, 2009; Stolt *et al.*, 2006). Durum wheat genotypes are reported to accumulate more Cd in grain than bread wheat genotypes (Greger & Löfstedt, 2004).

The concentrations of HMs in the wheat material investigated here were higher than those reported in the Swedish environmental monitoring programme for conventionally grown Swedish wheat (Eriksson *et al.*, 2010). However, the highest concentration of HMs found in any sample within the Swedish environmental monitoring programme exceeded the highest concentration found in Paper II (Eriksson *et al.*, 2010). The differences observed in HM concentration may be due to the differences in wheat genotypes. A large number of old cultivars, spelts and landraces of wheat grown under organic farming were examined in Paper II, whereas the Swedish environmental monitoring programme determined the HM concentration of conventionally grown modern wheat genotypes (Eriksson *et al.*, 2010).

In addition to genetic factors, organic and conventional systems also have an effect on HM concentrations. For example, variation in HM accumulation as a result of conventional versus organic farming has been reported previously (Ryan *et al.*, 2004).

4.2.2 Variation in grain HM accumulation between growing locations (Paper II)

Grain samples from Alnarp had significantly higher amounts of Cd than grain samples from the other three growing locations. High concentrations of Co, Cr and Pb were also observed in grain from Alnarp compared with grain from Bohuslän (Paper II). The lowest concentration of Cd was found in grain samples from Gotland. These differences in HM concentration of grain samples from various locations may be due to differences in soil characteristics at the sites (Paper II). A wide variation with regard to soil characteristics such as pH, cation exchange capacity (CEC), organic matter and clay content and metal concentrations has been reported for arable soils in Sweden (Eriksson *et al.*, 2010). The high amounts of different HMs in grain from Alnarp may be due to the relatively high pH of the soil at this location increasing metal uptake from the soil. Paper II also found a positive correlation between pH and grain concentrations of some HMs. In contrast, a previous study showed that high soil pH lowered metal accumulation in wheat grain (Spiegel *et al.*, 2009). However, pH is not the only factor explaining high HM concentrations in grain. A number of other factors, such as clay concentration, manure applied, soil water concentration, atmospheric deposition, interaction with other trace elements such as Zn, complexes with soil organic matter, pedogenic oxides, redox state *etc*. also play a role in HM accumulation in grain (Andersson, 1976). In Paper II, there was a significant negative correlation between organic matter content and Pb concentration and a significant positive correlation between organic matter content and Ni concentration In contrast, no significant relationship between organic matter and any HM except Cd was observed by Jia *et al*. (2010).

4.2.3 Variation in grain HM content between spring and winter wheat (Paper II)

Grain concentrations of Cr and Ni were significantly higher in spring wheat than winter wheat, while Pb concentrations in grain showed the reverse pattern. There was no significant difference between spring and winter wheat for Cd, Co and Hg concentrations in the grain (Paper II). These findings are in contrast with results by Spiegel *et al*. (2009) showing higher Cd concentrations in spring durum than in winter durum wheat. A negative association between yield and micronutrients has been reported in previous studies (Zhao *et al.*, 2009; McDonald *et al.*, 2008). Introduction of high-yielding genotypes has decreased the amount of different metals in grain, according to Fan *et al.* (2008).

4.2.4 Bio-concentration factor (BCF) of Cd (Paper II)

Cadmium is considered a very harmful compound and its risks to human health are exacerbated by its toxicity and mobility from the soil to the wheat grain (Dyer, 2007). Investigations on the BCF of Cd in different wheat genotype groups in Paper II showed that BCF of Cd was similar in selections, spelts and landraces but significantly higher in selections than in old cultivars, primitive wheat and cultivars. The lowest BCF of Cd was found in primitive wheat. Genetic differences between genotype groups might explain this variance in BCF of Cd. Jamali *et al.* (2009) also found that the BCF of Cd in wheat grain differed between different wheat genotypes. The BCF data presented in Paper II indicate that selections, spelts and landraces are the genotype groups that accumulate the highest amount of Cd, while primitive wheat has the highest resistance to Cd accumulation in the wheat grain.

4.2.5 Comparison of concentrations in high HM genotypes against Maximum Permitted Concentration (MPC) (Paper II)

In Paper II, the mean value of each HM in the grain of the 15 wheat genotypes with the highest HM concentrations from each genotype group was compared against the Maximum Permitted Concentration (MPC) specified by the European Commission (EC, 2006). The results are presented in Fig. 12. The mean grain Cd concentration in the 15 genotypes from each genotype group with the highest concentrations varied between 0.05-0.12 mg kg^{-1} and none exceeded the MPC for Cd set by EU Commission Regulation (EC) No. 1881/2006, which is 0.2 mg kg^{-1} in whole grain.

The MPC for Hg is 0.003 mg kg^{-1} for wheat grain according to Food Standards Australia and New Zealand (2002), and this value was exceeded in the 15 genotypes from old cultivars in Paper II (Fig. 12). This may have been because a few samples of the old cultivars had substantially higher Hg concentrations than all other samples. All grain samples with extraordinarily high amounts of Hg were from the growing location of Bohuslän, which was thus the background of the high Hg values.

The mean Pb concentration in the 15 genotypes with the highest Pb value from each genotype group did not exceed the European MPC (Fig. 12). The mean HM concentrations in the top 15 genotypes with the highest concentration from each genotype group are comparable to those found in a previous study (Jia *et al*., 2010).

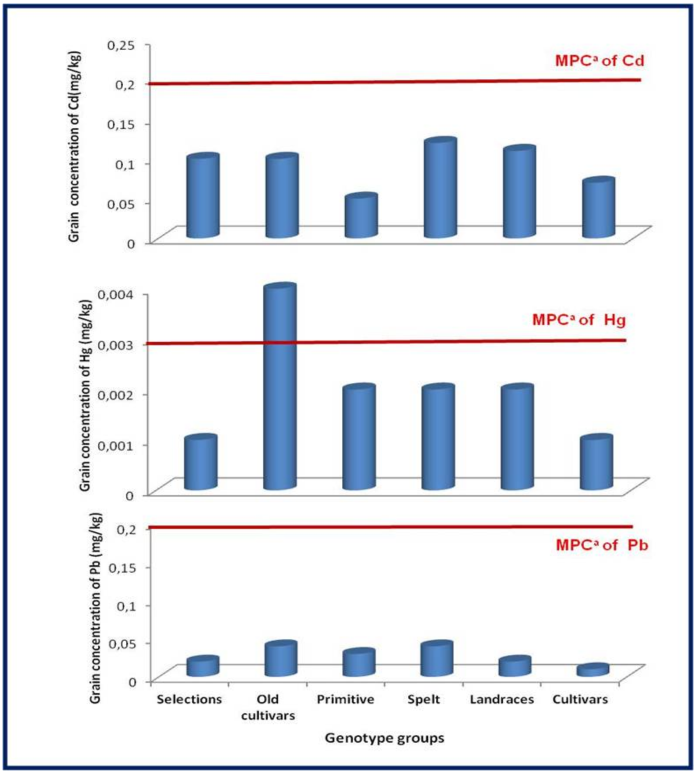

Figure 12. Mean HM concentrations (mg kg^{-1}) in the top 15 genotypes from each genotype group. The red bar indicates the Maximum Permitted Concentration for Cd and Pb set by European Commission Regulation EC (2006) and that for Hg set by Food Standards Australia and New Zealand (2002).

4.2.6 Human health risk of individual HMs

The human health risk of each individual HM was calculated by Hazard Quotient (HQ). All genotype groups investigated here had HQ <1, as shown in Fig. 13. These results show that daily intake of individual HMs through the consumption of organically grown wheat grain would be unlikely to cause adverse health effects in humans (Paper II).

Primitive wheat showed the lowest health risk of Cd of all genotype groups investigated (Fig. 13). The HQ of Cd and Ni was highest of all HMs investigated (Fig. 13).

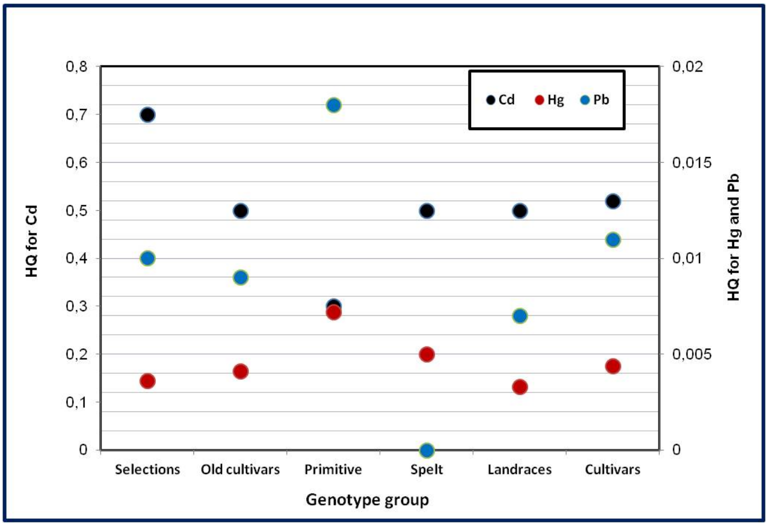

Figure 13. Hazard Quotient (HQ) of individual HM for different genotype groups.

The high RfDo value for Cr (1.5 mg kg^{-1}) could be the reason for its low HQ (Paper II). The lowest HQ for Cr is reported to come from the consumption of vegetables (Wang *et al*., 2005) and wheat grain (Huang *et al*., 2008). The HQ values for Cd, Cr, Hg and Pb found in Paper II are comparable to the values found in vegetables in previous investigations (Zheng *et al*., 2007; Wang *et al*., 2005; Chien *et al*., 2002). However, the HQ values are lower than those found by Huang *et al.* (2008) in wheat grain samples. This difference in HQ might be due to variations in genotype, environmental conditions and probably also the organic cultivation of the wheat in Paper II.

4.3 Tocochromanols in organically grown wheat grain (Papers III and IV)

Tocochromanols were investigated in 40 selected spring and wheat grain samples from various genotype groups (Appendix 3). The major tocochromanols in these samples were α- and *β*-tocopherols and *α*- and *β*-tocotrienols, whereas *γ*-tocopherol was only found in traces in some of the samples.

4.3.1 Variation in tocochromanol content between and within genotype groups (Papers III and IV)

There was great variation between and within genotype groups as regards tocochromanol concentration in the grain (Papers III and IV). The concentration of *α*-tocopherol was statistically similar among landraces, old cultivars and modern cultivars, but significantly higher in these than in spelt and primitive wheat (Papers II and IV)

Primitive wheat had the highest *α*-tocotrienol content, although the level was not significantly different from that in modern cultivars and spelt wheat. Statistically similar amounts of *β*-tocotrienol were found in all genotype groups.

The range of tocochromanol concentrations found within the genotype groups was 27.5-36.5, 23.7-37.3, 32-32.9, 23.1-34.8 and 21.9-35.2 mg kg^{-1} of dry weight for landraces, old cultivars, modern cultivars, spelt and primitive wheat, respectively (Paper III). The ranges of tocochromanol, tocopherol, tocotrienols and tocotrienol/tocochromanol concentrations found here were similar to those reported for conventionally grown wheat in previous studies (Okarter *et al.*, 2010; Lampi *et al.*, 2008; Hidalgo *et al.*, 2006; Zielinski *et al.*, 2001). Thus, the claim that organically grown crops are more healthy and nutritious than conventionally grown crops (Nelson *et al.*, 2004) was not verified here concerning tocochromanol content in wheat grain. To our knowledge, no other study to date has evaluated tocochromanols in organically grown wheat and therefore only comparisons with studies on conventionally grown wheat were possible. Primitive wheat had lower amounts of tocochromanols (Papers III and IV) than those reported by Panfili *et al*. (2003). This variation might be due to differences in genetic, environmental and cultivation practices and conditions and to differences in methods used for extraction and analysis. For example, use of the saponification method for extraction of tocochromanols in cereals has been found to give increased recovery of tocochromanols (Panfili *et al.*, 2003). The caryopsis in primitive wheat and spelt might also have an effect on the tocochromanol content. The primitive and spelt wheat samples used in Papers III and IV were dehulled, which was not the case for those used by Panfili et al. (2003).

4.3.2 Variation in tocochromanol content between spring and winter wheat (Paper III)

Spring wheat had significantly higher concentrations of *α*- and *β*-tocopherols than winter wheat, but lower concentrations of *α*- and *β*-tocotrienols. These results are in agreement with previous studies (Lampi *et al.*, 2008).

4.3.3 Characterisation of genotype groups on the basis of tocotrienols in total tocochromanols (Paper III)

Primitive wheat had the highest percentage of tocotrienols in total tocochromanols, averaging 74.03% (56.9-88.5%), while landraces had the lowest percentage (mean 55.39%; range 42.7-83.1%) (Table 3).

Tocotrienols are the major form of vitamin E and cereals such as wheat, rice and barley are considered an important source of tocotrienols in the human diet (Miyazawa *et al.*, 2009). Previous studies have shown that tocotrienols have a higher antioxidant activity than tocopherols (Serbinova *et al.*, 1991). Tocotrienols have gained increased interest because of their health-promoting properties, which are different from those of tocopherols (Schaffer *et al.*, 2005). In humans, tocotrienols are responsible for lowering cholesterol levels (Miyazawa *et al.*, 2009), preventing neurodegeneration (Sen *et al.*, 2000), reducing oxidative protein damage (Adachi & Ishii, 2000), and promoting the suppression of human breast cancer cells (Nesaretnam *et al.*, 1998). In Paper III, the highest tocotrienol/total tocochromanol ratio was found in primitive wheat, as has also been reported for conventional growing systems (Lampi *et al.*, 2008). Furthermore, primitive wheat had the highest tocotrienol content of all wheat genotype groups investigated, confirming previous findings (Hejtmankova *et al.*, 2010; Lampi *et al.*, 2008; Hidalgo *et al.*, 2006). The percentage of tocotrienols in total tocochromanols of winter wheat (67.75%) was higher than that of spring wheat (53.23%) (Table 3). This variation in tocochromanol content between genotype groups suggests that some genotypes might be a better source of tocotrienols in the human diet than others. Other cereals such as barley, oats, rice and maize also have generally lower *β*-tocotrienol content than wheat (Paper III). Thus, organic wheat grain can contribute a significant amount of tocotrienols to the human diet, providing protection from different diseases.

Table 3. *Characterisation of genotype groups on the basis of tocotrienols in total tocochromanols in organically grown wheat grain*

Tocotrienol content as a percentage of total tocochromanol content		
Genotype group	**Mean**	**Range**
Landraces	55.85	43.1-83.3
Old cultivars	57.84	37.0-70.5
Modern cultivars	61.92	60.1-63.5
Spelt wheat	68.38	51.8-88.4
Primitive wheat	74.28	57.2-88.7
Spring wheat	53.6	37.0-83.3
Winter wheat	68.1	51.8-88.6

4.4 Proportion of recommended daily intake of minerals and vitamin E from consumption of organically produced wheat flour (Papers I and III)

The percentage of recommended daily intake (RDI) of nutritionally relevant compounds was calculated based on values from FAO (2007) for average consumption of wheat flour (200 g person^{-1} day^{-1}), DGE (DGE, 2001) for RDI of different minerals and (EC., 1990) for RDI of vitamin E (10 mg day^{-1} for adults)(EC., 1990). The results showed that about 70% of the daily intake of Cu, Se, Fe, Mg, Zn, Mn, Mo and P could be obtained by consuming organically produced whole grain flour (Paper I; Fig. 14). However, the concentration of minerals in the wheat grain was found to be affected by other factors such as cultivated genotype, environment, farming conditions, *etc*.

The percentage of RDI of vitamin E from the consumption of 200 g of wheat flour was up to 24% (Fig. 14). However, the amount of vitamin E varies among different fractions of wheat grain (Engelsen & Hansen, 2009) and storage time of the grains (Nielsen & Hansen, 2008). Other crops, *e.g*. sea buckthorn berries, have a higher content of vitamin E (Andersson *et al.*, 2008). Furthermore, it has been found that tocochromanols are destroyed by heating, with a reduction in vitamin E activity from 63% to 94% reported for wheat (Zielinski *et al.*, 2001).

Organic wheat is generally consumed as whole and sprouted grain products (less heated products), unlike conventional wheat. A previous study has shown that whole grains of wheat have 10-30% higher content of vitamin E than different white flour fractions (Zielinski *et al.*, 2001). The concentrations of vitamins and minerals are also higher in sprouted wheat grain than in non-sprouted grain (Plaza *et al.*, 2003). This suggests that organically produced whole grain or sprouted products might be a good source of vitamin E.

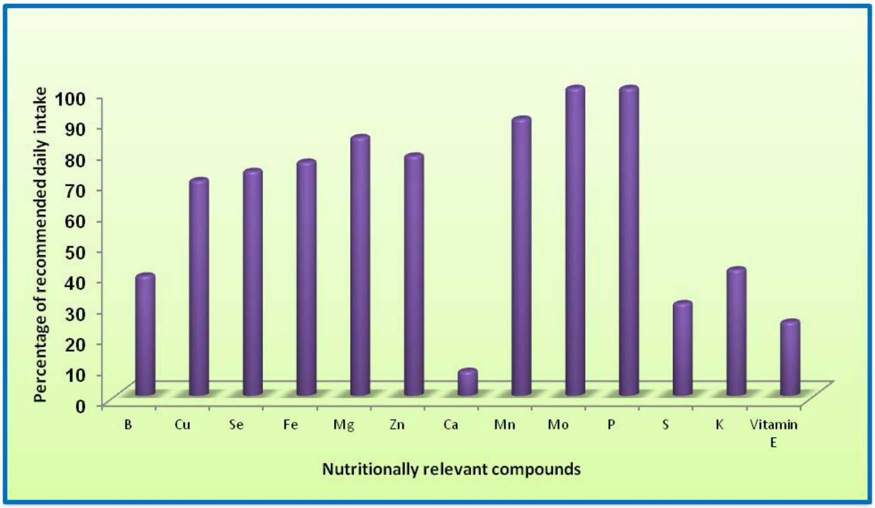

Figure 14. Percentage of recommended daily intake (RDI) of minerals and vitamin E obtained from consumption of 200 g organically produced flour per person and day.

4.5 Opportunities for production and breeding of wheat with high nutritional quality (Paper IV)

Minerals and vitamins are important in different metabolic processes in the human body and inadequate consumption of these elements might lead to malnutrition. Among the compounds investigated here, Fe, Zn and tocochromanols are important in relation to human health (Lampi *et al.*, 2008; Welch & Graham, 2004). Having low amounts of HMs such as Cd and Pb in wheat grain is also important for health (Jarup *et al.*, 1998).

Today, half the world's population is suffering from microelement malnutrition (Welch & Graham, 2004). Among the deficient nutrients, Fe, Zn and tocochromanols (vitamin E) are the most important and women and children in developing countries suffer particularly from Fe and Zn deficiency (WHO, 2002).

Wheat grain and its products are an important source of nutrients in order for people to grow normally and develop a healthy life in many countries (Welch & Graham, 2004). Thus, microelement malnutrition could be solved by producing wheat genotypes with increased contents of minerals, tocochromanols, protein and other vitamins. In this thesis, some genotypes (Rauweizen, Lv. Dalarna 16 vit, Lyshvede brun borst, *Triticum monococcum*, Hjelmqvist 6356 spelt and Schwabenkorn) were found to have higher contents of nutritionally important minerals and tocochromanols, but similar contents of heavy metals or higher contents of Co, than the other wheat genotypes investigated (Paper IV). In particular, *Triticum monococcum* and Hjelmqvist 6356 spelt wheat genotypes might be of interest for healthy food production.

4.6 Specific protein composition of wheat genotypes (Paper V)

In Paper V, grain samples from 29 organically grown spring and winter wheat genotypes were used for determination of specific protein composition. The genotypes showed differences in HMW-GS composition (Paper V). Of the 29 genotypes studied, 15 genotypes had subunit 2*, 12 genotypes had subunit 1 encoded on the locus Glu-A1 and only two genotypes had no subunit (Paper V). Subunit 6+8 on the locus Glu-B1 was present in 23 genotypes. In all, 27 genotypes had subunit 2+12 of Glu-D1, while the 5+10 subunit was present in only two genotypes (Paper V). Variations in HMW glutenin subunit composition between genotypes have also been reported in previous studies (Johansson *et al.*, 1993; Payne *et al.*, 1983).

4.7 Amount and size distribution of polymeric proteins (ASPP) in the grain of organically grown wheat genotypes (Paper V and VI)

4.7.1 Variation in protein fractions between genotype groups (Papers V and VI)

There were significant differences between and within genotype groups in terms of TOTE, %UPP and %LargeUPP (Appendix. 4, Paper VI; Fig. 15). The amount of TOTE in selection, spelt, primitive and landrace genotype groups was statistically similar, although higher than the amount in cultivars (Paper VI; Fig. 15). The cultivar genotype group had the highest %UPP and %large UPP of all genotype groups investigated (Fig. 15). The cultivar group included the cultivars that were mainly bred for getting high yield and quality under conventional conditions (van Bueren *et al.*, 2011; Wolfe *et al.*, 2008). Because of low nitrogen availability under organic conditions the cultivars resulted in low amount of TOTE. Higher amount of %UPP in cultivars as compared to other groups might be result of breeding work to improve the bread-making quality. Negative relationship between protein concentration and gluten strength (%UPP) has been found in previous studies (Johansson *et al.*, 2004).

ASPP has been found to play an important role in bread-making quality of wheat (Johansson *et al.*, 2001; 2003; Gupta *et al.*, 1992). Thus, the large variation in ASPP in the organically grown wheat genotypes studied in this thesis might be of interest when genotypes are to be selected with high protein quality for consumption and future breeding to improve organic bread-making quality. It has been shown that %UPP corresponds to gluten strength, while amount of TOTE is associated with high protein concentration (Godfrey *et al.*, 2010; Johansson, 2002; Marchylo *et al.*, 1989). The differences in the amounts of TOTE, %UPP and %large UPP between the genotype groups might be due to the diverse background of these genotypes (Appendix 4). These results confirm previous findings of differences in TOTE and %UPP between conventionally produced wheat genotypes (Johansson *et al.*, 2003; 2008). Other factors such as nitrogen fertilisation, temperature and maturation time also have an effect on ASPP in wheat (Malik *et al.*, 2011; Johansson *et al.*, 2005).

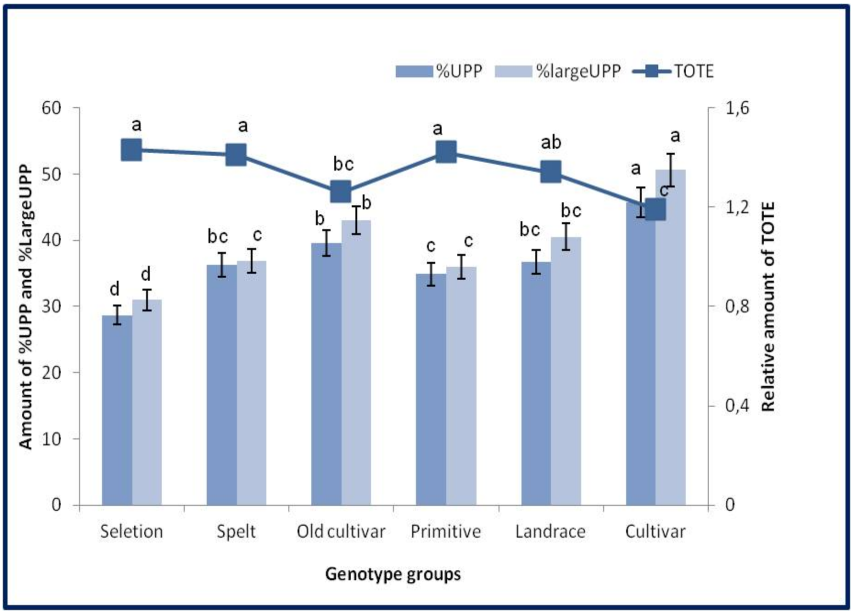

Figure 15. Amount of different protein fractions (TOTE, %UPP and %LargeUPP) in different genotype groups. Bars with different letters indicate significant differences from other genotype groups.

4.7.2 Variation in protein fractions between locations (Paper VI)

Growing location had an effect on protein fractions measured as TOTE, %UPP and %LargeUPP (Paper VI; Fig. 16). Grain samples from Uppsala had significantly higher amounts of TOTE than samples from the other three locations. The amount of TOTE was lowest in grain samples from Bohuslän (Paper V; Fig. 16). Grain samples from Uppsala had high %UPP and %large UPP but these were statistically similar to those in grain samples from Bohuslän (Paper VI; Fig. 16).

One explanation for the differences in TOTE, %UPP and %LargeUPP between growing locations is that the genetic material grown at various locations was different, *e.g.* genotypes grown in Bohuslän were of winter type and genotypes from Uppsala were mostly spring wheat. However, environmental factors, *e.g.* temperature, precipitation and humidity, and soil factors, *e.g.* soil organic matter, pH and clay, are also known to influence the protein fractions in grain (Jia *et al.*, 1996).

Previous studies showed that SDS-extractable and SDS-unextractable protein polymers are significantly influenced by different environments (Johansson & Svensson, 1999; Johansson & Svensson, 1998; Jia *et al.*, 1996; Graybosch *et al.*, 1995). In contrast, Gupta *et al.* (1993) found that the relative size distribution of polymeric proteins was independent of growing environment. According to Zhu and Khan (2001), differences in ASPP of wheat grain result in variations in bread-making quality.

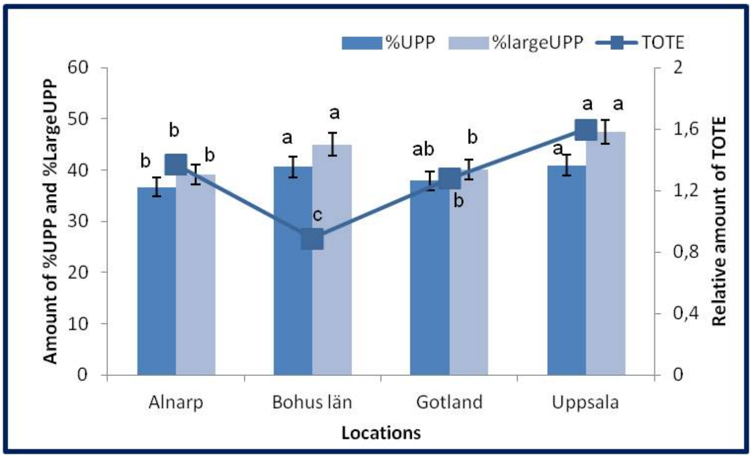

Figure 16. Amount of different protein fractions (TOTE, %UPP and %LargeUPP) in grain from different growing locations. Bars with different letters indicate significant differences from other locations.

4.7.3 Variation in protein fractions between spring and winter wheat (Paper VI)

The grain samples of spring wheat had higher amounts of TOTE, %UPP and %largeUPP than those of winter wheat (Paper VI; Fig. 17), confirming previous findings of higher %UPP in spring wheat than winter wheat (Zhang *et al.*, 2008).

PCA analysis on individual SDS-extractable and SDS-unextractable proteins in spring and winter wheat genotypes also showed a clear grouping (Paper VI). There were higher relative amounts of eSMP, uSPP, eLMP and eSMP in grain of spring wheat than that of winter wheat. The amounts of eLPP, eLMP and uLPP were higher in winter wheat genotypes than in spring wheat genotypes (Paper VI).

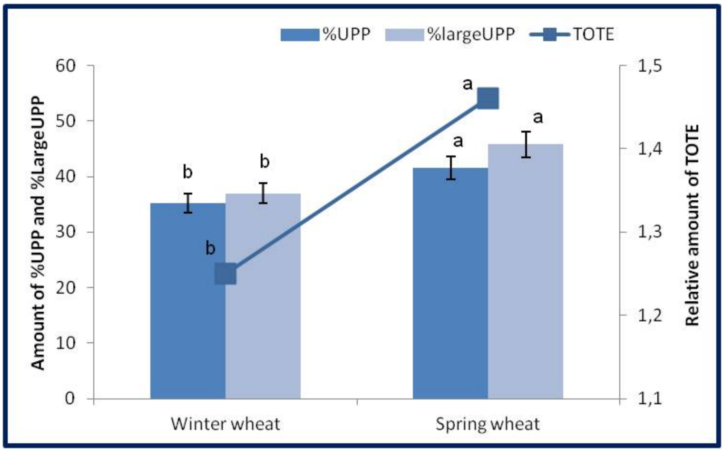

Figure 17. Amount of different protein fractions (TOTE, %UPP and %LargeUPP) in spring and winter wheat. Bars with different letters indicate significant differences from other locations.

4.7.4 Organically grown wheat genotypes have highest TOTE and %UPP content

Only one genotype Kenya has been found among both twenty genotypes with the highest TOTE and %UPP (Paper VI). Thus, the genotype Kenya might be useful for future organic wheat breeding programs. However, among all other genotypes Öland urval 10 lång borst spelt, Brun spelt Alnarp 1027, Fram and Ölands 17 borst spelt have shown the highest amount of TOTE in the grain samples (Paper VI). The genotypes Kulturemmer, Reno, Rollo and Olympia had the highest %UPP content (Paper VI).

Previous studies have shown that %UPP in wheat flour plays an important role in bread-making quality (Zhang *et al.*, 2008; Weegels *et al.*, 1996a; Singh *et al.*, 1990). Thus, genotypes with high amounts of %UPP can be used to produce wheat flour with increased gluten strength. However, the genotypes which showed the highest %UPP in this thesis were not among the genotypes found to be best in terms of nutritionally relevant compounds such as minerals, tocochromanols and heavy metals (Papers I-IV).

4.8 Changes in %UPP in flours and optimally mixed dough of organically grown wheat genotypes (Paper VII)

As mentioned, variations in gluten strength and bread-making quality are largely determined by %UPP in the flour (Zhang *et al.*, 2008; Johansson *et al.*, 2001; Weegels *et al.*, 1996b; Singh *et al.*, 1990). Thus, the bread-making quality of organic wheat can be enhanced by improving %UPP in organically produced wheat flour. Previous studies on organic wheat bread-making quality have focused on the protein content of organic wheat (Mason *et al.*, 2007; Poutala *et al.*, 1994; Feil & Stamp, 1993; Gooding *et al.*, 1993), and not on protein quality. A recent study suggested that improving the protein quality of organic wheat can improve its baking quality (Osman *et al.*, 2012).

There was great variation among the 51 organically grown wheat genotypes examined in this thesis in terms of %UPP in the flours and optimally mixed dough (Paper VII; Table 4). The genotypes with the highest %UPP in the flour were Agron, Krachi 1026/18, Hjelmqvist 6357 blå, Eroica 1026/4 and Hansa brun Ax (Paper VII; Table 4). After dough mixing to optimum level, all the genotypes behaved differently. The highest %UPP in dough at optimum mixing was found in the Agron, Hjelmqvist 6357 blå and Effrada genotypes (Paper VII; Table 4). The other genotypes with less change in %UPP from flour to optimum mixing were Urval Ölands 8, Durum, Lantvete Uppsala 6692, Browichs röd and Hjelmqvist 6356 (Table 4). The wide variation between different genotypes studied as regards %UPP in the flour and optimally mixed dough suggests that the desired bread-making quality of organic wheat can be achieved by selecting genotypes which change less in %UPP from flour to optimum dough mixing.

4.8.1 Ranges of different mixing parameters in organically produced wheat dough (Paper VII)

Different mixing parameters are related to the behaviour of the dough in the bread-making process. There was great variation between the genotypes investigated in thesis in terms of mixing parameters, *e.g.* peak time, peak height, breakdown, initslope and end width. The ranges of the measured mixing parameters were: peak time1-9.87 min, peak height 3.16-8.42, breakdown 0-2.11, initslope 3.87-11.57, end width 0.54-3.90 and protein content 6.89-12.32% (Paper VII).

A long mixing time, high peak resistance, low breakdown, low initslope and high end width are the main characteristics of a strong dough (Leon *et al.*, 2009). Of the genotypes investigated in this thesis, Durum, lantvete Gotland 4496 spelt, Erbe brun and Jacoby 59 utan borst had long mixing time, high peak resistance, high end width and low breakdown. The differences in mixing parameters between genotypes might be due to the variation in genetic background.

Table 4. *Amount of %UPP in the flour and dough of the 51 organically grown wheat genotypes*

Sample number	Genotype name	%UPP Flour	%UPP Dough	Sample number	Genotype name	%UPP Flour	%UPP Dough
7	**Hjelmqvist 6356**	19.36	12.76	120	**Ertus Ax**	26.11	6.30
10	**LV Gotland vit**	21.79	12.09	122	**Extrem**	55.98	14.62
11	**Ax/7**	33.76	11.84	124	**Gamme land v.lådden**	20.42	10.52
13	**T. Polonicum**	44.06	11.11	127	**Gammel landvete**	31.31	12.60
14	**Eroica 1026/4**	46.91	9.68	129	**Golden 10**	43.53	11.48
16	**Ax 14 1027**	45.66	9.54	134	**Halländska**	27.04	7.02
27	**15 Schweiz**	34.87	7.99	135	**Hansa Ax**	23.83	6.23
35	**4496 L v Gotland (ax10)**	41.87	14.50	138	**Hansa brun Ax**	46.88	9.88
36	**Lv Gotland 4496 spelt**	42.95	15.55	140	**Hartmut Spiess 1027**	46.00	18.30
39	**5113 rad / Brun**	25.91	11.00	142	**Helge Ax**	45.81	8.01
54	**Hjelmqvist 6357 blå**	49.06	37.42	150	**Inntaler Ax**	22.90	9.10
65	**Lantvete Uppsala 6692**	21.84	18.42	154	**Jacoby 59 utan borst**	34.26	16.82
67	**A x 11 bruna**	24.97	8.20	162	**Kippenhauser vete**	39.29	13.45
69	**Agron**	52.42	44.51	165	**Krachi 1026/18**	49.83	9.81
71	**Albihn**	20.08	9.56	167	**Krachi borst**	43.94	12.18
74	**Armensk vete**	40.88	17.66	833	**Rival**	28.65	15.90
75	**Aros Ax**	36.10	14.94	836	**Apu**	34.60	15.31
77	**Aszita**	32.85	13.96	838	**Progress**	36.96	12.88
80	**Ax 9:1**	20.14	10.02	842	**Urval Ölands 8**	37.88	21.48
83	**Ax 14**	26.92	9.88	843	**Lv Dalarna16**	31.57	8.32
98	**Ax-5**	33.70	9.40	844	**Fylgia röd**	22.17	7.42
104	**Borst vete gotland Ax**	31.52	8.43	847	**Ex Kolben**	32.01	13.74
106	**Browichs röd**	20.37	14.89	849	**Diamant vit**	26.19	9.68
111	**Durum Ax**	27.34	18.76	850	**Dala Urval**	35.36	11.62
112	**Effrada**	45.78	27.12	851	**Öland I utan borst**	27.41	8.47
117	**Erbe brun Ax**	36.78	9.82				

4.8.2 Microstructure of wheat dough (Paper VII)

The LM and CLSM images of dough samples of selected wheat genotypes showed some differences in protein network (Paper VII). The protein network of Inntaler and Agron had a dispersed structure, with different sizes of starch granules (Paper VII). Some clusters of proteins have been also observed in the dough of Agron (Paper VII). The genotype Inntaler showed few differences in starch and protein structure i.e. some oval shaped starch granules and continuous and compact protein network (not viscoelastic) (Paper VII).Two genotypes, Gammel landvete and Extrem, showed relatively more starch granules and more discontinuous protein network in optimally developed dough compared to Agron (Paper VII).

The CLSM images of gluten structure showed differences between the genotypes (Paper VII). The optimally mixed dough of Agron had a clear distribution of HMW-gs and gliadins in the network (in the form of fibrils) (Paper VII). The CLSM image, similarly to LM image, for the genotype Inntaler showed the entire starch granules being well embedded in the protein matrix. A possible reason for this might be due to the genotypic difference that might result in different starch swelling and/or bounding to protein (Paper VII). The results of LM and CLSM indicated that high %UPP in both flour and optimally mixed dough give stronger dough and this correspond well to previous findings on differences in gluten protein network between different quality of flours (Peighambardoust *et al.*, 2006; Kuktaite *et al.*, 2005).

5 Conclusions and recommendations

- There was great variation between the 51 organically grown wheat genotypes investigated in terms of minerals, heavy metals, tocochromanols and amount and size distribution of protein fractions. This variation can be exploited in breeding programmes to improve the nutritional and bread-making quality of organically grown wheat.

- It may be possible to produce wheat with high mineral concentrations close to the daily requirements by selecting appropriate wheat genotypes together with suitable growing conditions, *i.e.* organic farming. Promising genotypes with high mineral concentrations were: Lantvete Gotland, *Triticum monococcum*, *T. dicoccum*, Lantvete Dalarna, Ölands Urval, T. polonicum, Apu and Schweiz spelt.

- Organically grown primitive wheat had a lower Cd content than the other genotype groups. A low bio-concentration factor (BCF) of Cd in primitive wheat confirmed the lower Cd accumulation in this genotype. This indicates that primitive wheat can be used in future wheat breeding programmes to develop low Cd concentration genotypes.

- Hazard Quotient (HQ) was calculated to estimate the health risks posed by the individual toxic HMs through consumption of wheat grain. The HQ values were less than 1 in all genotypes, suggesting that the health risks from individual HMs are not significant when consuming wheat from this genetic material.

- The differences in concentrations of minerals and HMs observed in wheat samples from different growing locations suggest that environmental factors such as temperature, rainfall *etc*. and soil properties such as soil pH, clay content and organic matter content influence these concentrations.

- Organically grown wheat had similar amounts of tocochromanols to conventionally grown wheat. However, organically produced wheat grain can be a better source of tocochromanols, since it is more commonly consumed as whole and sprouted grain, whereas heat treatment lowers tocopherol content.

- The wide variation in tocochromanol content between wheat genotypes from diverse genetic backgrounds indicates that genotypes with high tocochromanol content can be exploited to produce varieties with high nutritional value. Primitive wheat might be of special interest due to its high tocotrienol content in the grain.

- Organically produced wheat genotypes with high contents of nutritionally important minerals and total tocochromanols and low contents of heavy metals can be used in human food to obtain increased health benefits. However, in future breeding programmes other nutritional elements such as proteins, fibre, glycaemic index and vitamin B content and quality should be included in order to breed organic wheat genotypes of high nutritional value.

- There was substantial variation in ASPP between genotypes. Genotypes with high TOTE and/or %UPP can be used to develop organic wheat with good bread-making quality. Only one genotype Kenya, was found among both the twenty genotypes with the highest TOTE and %UPP. Among the investigated genotypes, Öland urval 10 lång borst spelt, Brun spelt Alnarp 1027, Fram and Ölands 17 showed the highest amount of TOTE and the genotypes with the highest %UPP were Kulturemmer, Reno, Rollo and Olympia.

- None of the genotypes with the highest TOTE or %UPP was found among the genotypes with high amounts of minerals and tocochromanols and low amounts of HMs in the wheat grain. Thus, nutritionally superior genotypes with high amounts of minerals and tocochromanols might not have superior baking quality.

- Genotypes with high %UPP in the flour and a small decrease in %UPP during mixing, such as Agron, Hjelmqvist 6357 blå and Effrada, can be of particular use in breeding to achieve high gluten strength in organically produced wheat.

- The genotypes Durum, Lantvete Gotland 4496 spelt, Erbe brun and Jacoby 59 were found to have valuable mixing characteristics during mixing of whole meal flour and might therefore also be of interest in breeding for improved bread-making quality for organically produced wheat.

6 Future prospects

- The substantial variation observed in the amount of nutritionally relevant compounds such as minerals, antioxidants, heavy metals and protein polymerisation between genotypes indicates that the material can be used in future breeding programmes to develop varieties with high nutritional and bread-making quality.

- The promising wheat genotypes identified here can be used for further research to evaluate bread-making quality, *e.g*. loaf volume and sensory evaluation of wholemeal bread.

- The concentrations of other health-related compounds such as dietary fibre, glycemic index and B-group vitamins in the material can be determined in order to enhance the health benefits of organically produced wheat genotypes.

- Some of the investigated genotypes in the present thesis are already in use by the organic farmers because of their good taste. These genotypes could be of potential interest to be further investigated for the factors responsible for good taste.

- Small scale local bakeries accept flour with low gluten strength opposite to commercial baking industry, which requires high gluten strength. This might be of interest to be further investigated: why are the technological properties not so important for small scale local bakeries and what is important for organic wheat bread consumer?

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Appendix 1

Appendix. 1. Nordic Gene Bank number (NGB) and year of introduction of different genotypes. The genotypes taken from Arnulf Merker indicated by "AM" in NGB number column.

Serial No.	Genotype name	NGB number	Year of introduction
1	**Aros**	14	1947
2	**Banco**	16	1953
3	**Bore II**	6712	1902
4	**Eroica II**	15	1943
5	**Ertus**	9076	1953
6	**Hansa**	6721	1945
7	**Holger**	2435	1981
8	**Jarl**	3	1925
9	**Olympia**	8985	
10	**Pansar III**	6707	1923
11	**Robur**	6724	1949
12	**Sol IV**	6715	1911
13	**Starke II**	22	1959
14	**Svale**	6725	1955
15	**Virtus**	13	1945
16	**Browichs röd**	8945	
17	**Gammel Landvete**	8199	
18	**Halländsk**	9057	
19	**Vama**	7194	
20	**Krachi**	8209	
21	**Odin**	6723	1949
22	**Walde**	24	1972
23	**Krim**	8208	
24	**Vakka**	344	1953
25	**Aura**	347	1976
26	**Varma**	9020	1933
27	**Helge**	26	1980
28	**Red Prolific**	7038	
29	**Spelt ustakket**	9005	
30	**Spelt blå**	9056	
31	**Spelt hvid**	9055	

Serial No.	Genotype name	NGB number
32	**Ostar**	AM
33	**Oberkulmer**	AM
34	**Schwabenkorn**	AM
35	**Kippenhauser**	AM
36	**Tysk Dinkel**	AM
37	**Hjelmqvist6356**	AM
38	**Hjelmqvist6357**	AM
39	**Hjelmqvist6358**	AM
40	**Schweiz dinkel**	AM
41	**T. monococcum**	4497
42	**Svart emmer**	4499
43	**T turgidum cst**	9011
44	**T.turgidum mirakelvete**	4777
45	**T.turgidum mumievete**	4795
46	**T.timophevii**	7198
47	**T. polonicum**	8991
48	**Spelt lådden gråsort**	4781
49	**T,spelta ustakket lådden**	9027
50	**Speltvete Gotland**	4495
51	**Lantvete Gotland**	4496
52	**Lantvete Halland**	6691
53	**Lantvete Uppsala**	6692
54	**Dinkelvete från Schweiz**	AM
55	**Dinkelvete från Roséns**	AM
56	**Steiners Roter Tiroler**	AM
57	**Golder**	AM
58	**Neuegger Dinkel Schweiz**	AM
59	**Zuzgen Dinkel Schweiz**	AM
60	**Österreicher Burgdorf**	AM
61	**Albin Belgien**	AM
62	**Braunschweig13869**	AM
63	**Ostro**	AM

Spring wheat

Serial No.	Genotype name	NGB number	Year of introduction
64	**Apu**	358	1949
65	**Atle**	7455	1936
66	**Atson**	7460	1954
67	**Diamant II**	6681	1938
68	**Ex Kolben II**	8923	1926
69	**Fylgia II**	6685	1953
70	**Kärn II**	7458	1958
71	**Pondus**	7459	1950
72	**Progress**	6682	1942
73	**Rival**	6684	1952
74	**Svenno**	7461	1953
75	**Dala**	9708	
76	**Landvv Dalarna**	6410	
77	**Landv Dalarna**	6673	
78	**Landv Halland**	6674	
79	**Aurore**	9690	
80	**Peko**	9704	

Serial No.	Genotype name	NGB number	Year of introduction
81	**Red Fife**	7056	
82	**Walter**	7473	1979
83	**Sappo**	7467	1971
84	**Kolben**	6676	1909
85	**Reno**	2134	1975
86	**Rollo**	2135	1963
87	**Runar**	2136	1972
88	**Touko**	359	1950
89	**William**	7474	
90	**Ella**	6683	1950
91	**Fram II**	2127	1940
92	**Möystad**	2131	1966
93	**ÅS II**	9710	1945
94	**Kenya 338**	7063	
95	**Östby**	8922	
96	**Algot**		1969

Allkorn Collection

Serial No.	Genotype name	NGB number
97	**Ölands 1**	22700
98	**Ölands 16 borst**	22759
99	**Ölands 17 borst**	22760
100	**Ölands 18**	22704
101	**Ölands 18 spelt**	22762
102	**Ölands 18 vete**	22697
103	**Ölands 1 borst**	22705
104	**Ölands 8**	22698
105	**Ölands 8 spelt**	22790
106	**Albihn**	22764
107	**Armensk vete**	22745
108	**Österreicher Burgsdorfer**	22765
109	**Browiks röd**	23636
110	**Brun spelt**	22522
111	**Dalarna 14**	22667
112	**Dalarna 15**	22669
113	**Dalarna 16 brun borst**	22709
114	**Dalarna 16 vit borst**	22722
115	**Dala**	22665
116	**Diamant brun borst**	22674
117	**Diamant kort**	22675
118	**Diamant vit**	22676
119	**Enkorn lång**	22763
120	**Enkorn Sötofte**	22756
121	**Emmer svart**	22778
122	**Emmer vit borst**	22526
123	**Emmer vit**	22797
124	**Erbe brun**	22737
125	**Erbe**	22497
126	**Tysk spelt**	22792
127	**Golden brun**	22784
128	**Golden brun**	22734
129	**Golden vit**	22514
130	**Gotlands lv 10**	22796
131	**Gotlands lv 15**	22740
132	**Gotlands lv 1**	22503
133	**Gotlands lv 2**	22741
134	**Gotlands lv 4**	22504
135	**Gotlands lv 6**	22525

Serial No.	Genotype name	NGB number
136	**Hansa brun**	22491
137	**Hartmut Spiess**	22507
138	**Holger lång**	22748
139	**Holger röd**	22753
140	**Holger**	22535
141	**Holme lång**	22508
142	**Vit spelt**	22788
143	**Jacoby 59**	22770
144	**Jacoby borst**	22520
145	**Kamut platt**	22518
146	**Kamut platt**	22501
147	**Kippenhauser**	22786
148	**Krachi**	22747
149	**Krim lång**	22794
150	**Kulturemmer**	22776
151	**Lys östpreussisk**	22746
152	**Lyshvede brun**	22532
153	**Lyshvede ax 9**	22536
154	**Enkorn Metalla**	22783
155	**Neuegger dinkel**	22755
156	**Hjelmqvist 6356**	22754
157	**Hjelmqvist 6357**	22739
158	**Hjelmqvist 6358**	22500
159	**Oberkulmer**	22516
160	**Ostar**	22779
161	**Ostro**	22793
162	**Peter Jacoby**	22771
163	**Red Fife**	22718
164	**Red Prolific**	22495
165	**Rosén**	22512
166	**Schwabenkorn**	22517
167	**Borstspelt**	22733
168	**Ax 11**	22519
169	**Ax 14**	22775
170	**Ax 3**	22506
171	**Ax 4:1 borst**	22768
172	**Ax 4:1**	22513
173	**Ax 4:2**	22736

Appendix 2

Appendix 2. Gentype name, group,type, growing location and concentration of minerals and heavy metals in the wheat grain ($mgkg^{-1}$).

Prov	Location	Genotype name	Type	Group	Al	B	Ba	Ca	Cd	Co	Cr	Cu	Hg	Fe	K	Mg	Mn	Mo	Ni	P	Pb	S	Se	Zn
1	Alnarp	**T. Spelta blå**	Winter	Spelt	9.08	2.420	1.36	356	0.074	0.009	0.43	5.22	0.000	45.5	4457	1237	20.7	1.38	1.40	4690	0.003	1326	0.168	30
2	Alnarp	**Ax 4:1**	Winter	Selection	2.68	1.330	2.08	572	0.097	0.009	0.29	5.04	0.003	39.4	4448	1495	37.0	4.38	0.34	5178	0.008	1524	0.190	59
3	Alnarp	**KrachiGotland**	Winter	Old cultivar	4.34	1.354	2.20	323	0.053	0.009	0.34	4.25	0.000	33.7	3750	1256	23.2	2.42	0.44	4377	0.019	1215	0.127	32
4	Alnarp	**Ax 05**	Winter	Selection	2.76	1.080	1.30	332	0.072	0.011	0.12	4.72	0.000	32.6	3254	1472	28.2	3.70	0.36	4812	0.000	1356	0.226	37
5	Alnarp	**Vama**	Winter	Old cultivar	3.42	1.272	1.41	383	0.063	0.005	0.21	4.08	0.000	26.9	3414	1313	25.2	2.40	0.21	4361	0.003	1124	0.144	28
6	Alnarp	**Holger 2 1026/25**	Winter	Old cultivar	1.78	0.634	2.78	323	0.080	0.019	0.20	4.22	0.000	29.7	4534	1280	18.4	1.36	0.65	4481	0.012	1200	0.177	38
7	Alnarp	**6356**	Winter	Landrace	5.80	1.770	1.25	372	0.079	0.006	0.22	6.14	0.000	38.6	4232	1318	21.1	1.69	0.52	4752	0.000	1220	0.178	33
8	Alnarp	**Aros 1026/1**	Winter	Old cultivar	9.08	1.798	2.20	324	0.069	0.007	0.17	4.24	0.000	26.2	4215	1053	20.9	1.12	0.47	3940	0.000	1033	0.153	25
10	Alnarp	**LV Gotland vit**	Winter	Landrace	14.82	2.240	4.86	310	0.084	0.018	0.21	4.90	0.000	27.9	4728	1136	21.2	1.39	0.62	4096	0.001	1168	0.135	29
11	Alnarp	**Ax/7**	Winter	Selection	4.66	1.610	1.91	389	0.083	0.006	0.20	5.68	0.000	36.9	3664	1436	27.5	2.34	0.39	4857	0.000	1394	0.186	38
13	Alnarp	**T. Polonicum**	Winter	Primitive	3.16	0.978	1.47	305	0.107	0.003	0.23	7.08	0.000	42.0	4645	1567	19.0	2.22	0.22	6014	0.000	1597	0.136	69
14	Alnarp	**Eroica 1026/4**	Winter	Old cultivar	2.06	1.664	2.20	316	0.087	0.003	0.10	4.56	0.000	25.7	4338	1153	18.8	1.44	0.47	4362	0.000	1108	0.165	30
16	Alnarp	**Ax 14 1027**	Winter	Selection	2.68	1.074	1.09	325	0.154	0.006	0.26	6.04	0.000	39.2	4224	1407	22.2	1.09	0.42	4837	0.007	1536	0.083	46
21	Alnarp	**Mirakelvete Ax**	Winter	Primitive	4.46	0.866	2.22	346	0.035	0.004	0.27	4.66	0.000	28.0	5660	1250	16.1	1.26	0.30	4716	0.004	1137	0.063	39
22	Alnarp	**Kippenhauser**	Winter	Spelt	2.64	1.836	1.17	260	0.045	0.013	0.23	5.58	0.000	39.8	4196	1260	27.3	2.66	0.62	4983	0.000	1344	0.082	40
23	Alnarp	**6357 Klyvn**	Winter	Selection	2.58	0.972	2.00	313	0.083	0.004	0.21	5.36	0.000	38.2	3996	1366	23.1	2.26	0.24	4797	0.001	1481	0.282	52
26	Alnarp	**15 Schweiz**	Winter	Spelt	4.98	2.220	1.26	303	0.047	0.009	0.43	6.53	0.001	47.4	4007	1381	29.1	2.66	0.75	5065	0.024	1447	0.041	58
27	Alnarp	**15 Schweiz**	Winter	Spelt	2.32	1.188	0.97	325	0.115	0.004	0.24	6.66	0.000	46.3	4575	1439	16.9	3.08	0.24	5612	0.001	1584	0.548	55
31	Alnarp	**32 comp Ax**	Winter	Selection	4.90	2.280	5.36	356	0.102	0.005	0.16	5.79	0.003	31.6	4795	1365	26.8	4.08	0.27	5276	0.038	1368	0.032	44
32	Alnarp	**32 Schweiz**	Winter	Spelt	3.30	1.538	1.22	321	0.116	0.004	0.25	7.90	0.001	51.0	4809	1460	20.0	1.57	0.36	5709	0.013	1585	0.218	51
35	Alnarp	**4496 Lv Gotland (a x 10)**	Winter	Landrace	2.56	0.828	3.26	414	0.173	0.005	0.21	4.92	0.000	28.3	5284	1217	20.7	0.94	0.33	4782	0.000	1236	0.102	32
36	Alnarp	**4496 spelt**	Winter	Landrace	5.34	1.246	4.24	354	0.056	0.012	2.16	3.97	0.000	30.6	4355	1335	27.8	4.34	8.46	4861	0.012	1265	0.187	30
38	Alnarp	**5113 (rod 4)**	Winter	Selection	2.22	1.538	1.68	312	0.101	0.009	0.25	5.94	0.000	33.6	4243	1296	18.7	2.86	0.43	4436	0.020	1354	0.152	37
39	Alnarp	**5113 rad / Brun**	Winter	Selection	4.06	1.110	2.70	331	0.042	0.006	0.21	5.02	0.000	36.4	4601	1427	27.3	2.46	0.30	4815	0.005	1218	0.082	38
39	Alnarp	**5113 rad / Brun**	Winter	Selection	2.46	1.782	2.98	304	0.046	0.007	0.49	4.94	0.003	43.9	4049	1295	25.9	2.70	1.74	4569	0.013	1145	0.054	35
40	Alnarp	**5113 rad 4**	Winter	Selection	2.24	2.080	2.10	307	0.048	0.006	0.10	4.64	0.000	33.0	4049	1411	23.4	2.70	0.35	4439	0.000	1167	0.113	33
41	Alnarp	**5113 rad brun**	Winter	Selection	3.34	1.522	2.20	333	0.114	0.009	0.21	5.96	0.000	36.9	4274	1336	19.0	1.29	0.27	4902	0.028	1496	0.246	49
43	Alnarp	**6356**	Winter	Landrace	3.50	0.956	1.50	384	0.108	0.005	0.23	7.74	0.000	40.6	4473	1489	23.2	0.99	0.35	5353	0.005	1486	0.117	45
43	Alnarp	**6356**	Winter	Landrace	2.12	1.172	1.38	381	0.083	0.011	1.84	6.98	0.000	34.1	4592	1431	22.0	3.94	9.38	5314	0.000	1348	0.125	40
43	Alnarp	**6356**	Winter	Landrace	2.36	0.612	1.73	375	0.091	0.004	0.17	6.64	0.000	34.3	4225	1332	22.0	1.23	0.30	5163	0.000	1418	0.079	40
43	Alnarp	**6356**	Winter	Landrace	7.36	1.432	1.48	349	0.085	0.033	0.17	6.00	0.000	40.8	4008	1247	19.2	1.37	0.82	4490	0.000	1255	0.342	31
44	Alnarp	**6356**	Winter	Landrace	12.76	1.258	1.38	367	0.064	0.012	0.49	5.38	0.000	39.2	3694	1382	27.7	2.64	0.47	4814	0.033	1116	0.177	30

Prov	Location	Genotype name	Type	Group	Al	B	Ba	Ca	Cd	Co	Cr	Cu	Hg	Fe	K	Mg	Mn	Mo	Ni	P	Pb	S	Se	Zn
45	Alnarp	**6356 Spelt**	Winter	Spelt	2.56	1.102	4.60	356	0.046	0.005	0.19	5.28	0.000	35.9	3624	1440	17.6	2.24	0.29	5165	0.014	1486	0.338	53
48	Alnarp	**6357 Klyvn sp**	Winter	Spelt	2.62	0.870	1.57	305	0.102	0.009	0.19	5.30	0.000	36.5	4442	1261	18.8	1.93	0.46	4869	0.000	1425	0.204	44
49	Alnarp	**6357 10**	Winter	Spelt	6.72	1.238	1.41	345	0.100	0.007	0.24	4.44	0.000	32.7	3482	1328	27.2	2.34	0.45	4699	0.000	1298	0.216	57
50	Alnarp	**6357**	Winter	Spelt	2.02	1.486	1.43	332	0.172	0.006	0.12	6.50	0.000	36.5	4210	1343	19.3	4.56	0.55	4840	0.000	1480	0.214	52
50	Alnarp	**6357**	Winter	Spelt	17.68	1.880	1.49	375	0.170	0.034	6.06	6.04	0.000	50.0	4157	1451	21.0	9.46	28.60	4940	0.049	1431	0.177	45
51	Alnarp	**6357 24**	Winter	Spelt	4.48	0.842	1.18	290	0.138	0.008	0.63	4.94	0.000	35.3	4058	1521	28.6	2.54	0.42	5412	0.006	1634	0.141	42
54	Alnarp	**6357 blå**	Winter	Spelt	2.64	1.190	0.91	271	0.119	0.005	0.09	5.46	0.000	33.2	3715	1433	26.1	1.66	0.37	4989	0.000	1574	0.193	45
56	Alnarp	**6357 brun**	Winter	Spelt	4.76	1.408	1.71	281	0.117	0.005	0.23	5.96	0.000	30.7	3613	1412	24.4	1.85	0.57	5004	0.035	1493	0.127	35
59	Alnarp	**6357 vit**	Winter	Spelt	13.66	1.130	1.90	276	0.125	0.008	0.43	5.72	0.000	41.1	3806	1377	23.3	1.73	0.29	5038	0.012	1550	0.198	31
61	Alnarp	**6358 16A3**	Winter	Landrace	4.84	1.346	3.52	257	0.116	0.010	0.29	6.93	0.000	35.6	3532	1512	31.4	1.99	1.00	4968	0.016	1417	0.166	36
63	Alnarp	**6358 Brun röd**	Winter	Landrace	3.74	1.828	6.32	344	0.082	0.005	0.13	5.97	0.000	26.1	3866	1243	20.3	1.35	0.32	4567	0.019	1199	0.242	47
64	Alnarp	**6358 vit**	Winter	Landrace	3.14	1.450	4.28	267	0.064	0.006	0.14	4.98	0.000	28.4	4723	1475	19.8	3.64	0.37	4861	0.012	1292	0.064	35
65	Alnarp	**6692**	Winter	Landrace	2.80	1.854	1.69	307	0.028	0.007	0.26	5.12	0.000	34.0	4084	1186	29.2	1.28	1.08	4336	0.000	1257	0.085	42
66	Alnarp	**9 Schweiz**	Winter	Spelt	4.50	1.544	1.44	342	0.042	0.008	0.51	5.76	0.000	45.0	4301	1323	29.2	1.60	1.08	5160	0.009	1447	0.046	50
67	Alnarp	**A x 11 bruna**	Winter	Selection	9.48	1.558	1.41	384	0.074	0.010	0.25	5.82	0.000	32.1	4423	1160	19.1	1.19	1.05	4256	0.000	1154	0.270	28
68	Alnarp	**A x3**	Winter	Selection	3.08	2.040	1.91	390	0.096	0.011	0.21	4.70	0.000	35.7	3660	1403	31.2	4.38	0.95	4677	0.000	1226	0.276	52
69	Alnarp	**Agron**	Winter	Cultivar	5.58	1.606	1.60	383	0.068	0.007	0.22	4.13	0.002	25.5	4107	1328	28.7	3.20	0.93	4402	0.020	1179	0.073	28
71	Alnarp	**Albihn**	Winter	Spelt	3.58	1.406	1.60	291	0.076	0.004	0.38	4.57	0.001	31.6	4589	1265	21.2	2.00	0.78	4662	0.007	1310	0.127	29
74	Alnarp	**Armensk vete**	Winter	Landrace	1.49	0.802	4.04	502	0.109	0.005	0.20	5.96	0.000	41.1	4859	1416	25.9	1.42	0.30	5436	0.000	1386	0.121	44
75	Alnarp	**Aros**	Winter	Old cultivar	4.60	1.632	2.32	395	0.037	0.006	0.13	3.93	0.000	19.9	4241	1079	25.7	1.49	0.27	4194	0.014	923	0.093	30
77	Alnarp	**Aszita**	Winter	Cultivar	3.62	1.066	2.22	489	0.059	0.010	0.23	4.10	0.000	35.4	4105	1291	36.3	1.97	0.97	4869	0.010	1188	0.222	37
78	Alnarp	**Aura**	Winter	Old cultivar	3.60	0.618	1.87	394	0.049	0.005	0.15	3.88	0.000	25.2	4445	1194	27.8	2.16	0.22	4459	0.000	1004	0.091	27
79	Alnarp	**Aura lång**	Winter	Old cultivar	1.78	1.272	2.10	340	0.042	0.004	0.16	3.92	0.000	22.5	4023	1105	22.2	2.98	0.23	3904	0.009	989	0.109	27
80	Alnarp	**Ax 9:1**	Winter	Selection	4.76	1.900	1.86	276	0.072	0.010	0.17	4.56	0.000	42.4	3795	1293	17.6	2.40	0.47	4604	0.000	1224	0.248	43
81	Alnarp	**Ax 11 1027**	Winter	Selection	3.42	1.644	1.59	366	0.126	0.083	0.20	6.34	0.000	37.6	4373	1291	23.5	0.82	0.49	4636	0.000	1328	0.320	36
82	Alnarp	**Ax 14**	Winter	Selection	3.84	1.244	1.72	416	0.048	0.013	0.11	4.72	0.001	29.0	4064	1240	27.1	2.94	0.93	4632	0.004	1198	0.150	39
83	Alnarp	**Ax 14**	Winter	Selection	1.77	1.780	1.34	391	0.118	0.004	0.12	7.02	0.000	41.3	4648	1304	17.6	2.90	0.32	4901	0.000	1442	0.218	48
85	Alnarp	**Ax 3**	Winter	Selection	1.49	1.436	1.74	362	0.103	0.005	0.17	5.10	0.000	35.1	3992	1305	20.7	1.70	0.42	4745	0.000	1328	0.318	46
86	Alnarp	**Ax 4:1 1027**	Winter	Selection	3.50	1.760	1.61	345	0.096	0.004	0.20	5.40	0.000	36.8	4192	1243	22.8	1.30	1.79	4473	0.000	1323	0.246	35
88	Alnarp	**Ax 4:2**	Winter	Selection	33.05	0.834	3.28	437	0.057	0.040	1.14	3.88	0.000	49.3	3842	1145	17.8	2.32	1.46	4370	0.045	1092	0.250	44
93	Alnarp	**Ax 4:2 brun**	Winter	Selection	3.94	1.614	2.14	292	0.094	0.004	0.18	4.39	0.001	25.9	3813	1141	20.8	3.34	0.24	4121	0.007	1187	0.097	28
94	Alnarp	**Ax 4:2 vit**	Winter	Selection	5.42	1.740	2.48	288	0.096	0.003	0.19	4.56	0.000	34.8	3721	1210	23.0	2.66	0.32	4309	0.020	1240	0.186	63
95	Alnarp	**Ax 7**	Winter	Selection	5.54	1.146	2.64	387	0.075	0.011	0.83	5.04	0.000	32.6	3894	1420	23.1	3.20	4.12	4821	0.003	1361	0.280	44
97	Alnarp	**Ax11**	Winter	Selection	2.36	1.310	2.34	401	0.085	0.007	0.21	5.70	0.000	31.5	3980	1257	21.5	1.60	0.56	4618	0.008	1275	0.190	44

Prov	Location	Genotype name	Type	Group	Al	B	Ba	Ca	Cd	Co	Cr	Cu	Hg	Fe	K	Mg	Mn	Mo	Ni	P	Pb	S	Se	Zn
98	Alnarp	**Ax-5**	Winter	Selection	1.17	0.864	2.28	361	0.113	0.005	0.20	5.62	0.000	39.6	4045	1534	20.3	1.61	0.27	5209	0.015	1545	0.330	42
99	Alnarp	**Ax5**	Winter	Selection	6.30	1.634	2.10	355	0.083	0.014	0.87	4.78	0.000	44.4	3387	1481	26.7	2.74	3.46	4710	0.000	1405	0.326	51
100	Alnarp	**Banco 1026/2**	Winter	Old cultivar	1.96	0.730	2.12	314	0.085	0.013	0.16	4.66	0.000	27.1	4291	1223	18.7	1.46	0.19	4764	0.001	1256	0.089	32
101	Alnarp	**Bore II (1026/3)**	Winter	Old cultivar	4.92	1.684	2.58	428	0.068	0.005	0.16	6.20	0.001	33.8	4197	1458	22.0	1.01	0.23	5237	0.006	1473	0.139	32
103	Alnarp	**Borstv Gotland max**	Winter	Landrace	2.25	1.486	1.79	362	0.095	0.005	0.34	6.94	0.000	36.7	4687	1443	22.6	2.00	1.16	5110	0.011	1405	0.109	40
104	Alnarp	**Borstvete Gotland**	Winter	Landrace	2.28	1.592	1.62	360	0.076	0.014	0.16	5.60	0.002	29.1	4090	1420	30.0	3.56	0.89	4966	0.007	1195	0.145	32
105	Alnarp	**Borstvvete Gotland**	Winter	Landrace	4.27	2.060	1.37	430	0.046	0.048	0.32	5.32	0.000	23.5	4087	1388	27.8	3.82	2.60	4990	0.030	1034	0.090	53
106	Alnarp	**Browichs röd**	Winter	Landrace	26.12	1.882	2.48	292	0.097	0.026	0.66	4.38	0.000	48.9	4859	1166	19.1	1.44	1.51	4469	0.026	1212	0.146	36
109	Alnarp	**Capu**	Winter	Cultivar	3.29	1.620	1.93	400	0.069	0.044	0.24	4.34	0.002	27.4	4328	1363	24.8	2.10	2.02	4427	0.033	1203	0.120	75
111	Alnarp	**Durum**	Winter	Primitive	3.34	2.100	0.31	342	0.041	0.016	0.26	3.18	0.000	16.7	5046	973	13.6	1.83	0.86	3822	0.002	764	0.046	45
112	Alnarp	**Effrada**	Winter	Cultivar	1.31	1.088	1.45	394	0.064	0.009	0.21	3.64	0.000	24.0	4213	1338	27.8	3.22	0.25	4284	0.028	1143	0.086	26
116	Alnarp	**Erbe 1026/24**	Winter	Old cultivar	3.22	2.060	2.04	318	0.153	0.048	0.34	6.74	0.000	34.7	5136	1218	18.2	1.20	2.28	4680	0.021	1354	0.117	54
117	Alnarp	**Erbe brun**	Winter	Old cultivar	4.04	1.720	2.36	349	0.102	0.006	0.20	5.34	0.001	33.9	3785	1332	27.0	2.44	0.43	4560	0.008	1333	0.126	33
120	Alnarp	**Ertus**	Winter	Old cultivar	2.31	1.584	1.57	358	0.046	0.007	0.27	4.90	0.000	20.5	4398	1177	26.2	2.48	0.51	4220	0.000	1009	0.081	28
121	Alnarp	**Ertus 1026/ 5**	Winter	Old cultivar	2.70	1.822	2.64	292	0.089	0.004	0.15	7.24	0.003	22.8	4494	1113	16.7	1.55	0.60	4317	0.005	1143	0.114	29
122	Alnarp	**Extrem**	Winter	Cultivar	7.03	1.646	2.10	506	0.062	0.019	0.41	4.84	0.001	27.0	4301	1229	26.6	3.84	1.47	4579	0.019	1242	0.074	34
123	Alnarp	**Extrem**	Winter	Cultivar	3.49	1.928	2.72	547	0.072	0.016	0.25	5.20	0.001	34.2	4527	1434	26.8	3.64	0.74	5179	0.019	1401	0.132	48
124	Alnarp	**Gamme land v.lådden**	Winter	Landrace	2.89	1.596	2.68	357	0.053	0.008	0.14	4.40	0.001	35.2	4855	1286	24.8	3.02	0.74	4890	0.015	1356	0.109	34
125	Alnarp	**Gammel landv**	Winter	Landrace	1.58	1.546	2.14	330	0.110	0.012	0.18	4.94	0.000	46.4	4063	1313	15.4	2.48	0.46	4735	0.016	1365	0.256	37
126	Alnarp	**Gammel landv röd spelt**	Winter	Landrace	3.83	1.796	2.40	445	0.124	0.005	0.17	5.36	0.001	39.0	4442	1391	17.5	1.06	0.23	5069	0.017	1467	0.189	31
127	Alnarp	**Gammel landvete**	Winter	Landrace	2.50	2.160	3.04	375	0.054	0.020	0.14	3.72	0.001	70.0	3711	1303	14.1	4.58	0.34	4249	0.007	1100	0.032	28
129	Alnarp	**Golden 10**	Winter	Spelt	2.75	1.762	1.49	338	0.098	0.058	0.66	5.84	0.000	34.7	4686	1169	27.4	2.74	2.34	4443	0.052	1269	0.104	49
130	Alnarp	**Golden 10**	Winter	Spelt	9.82	1.642	1.35	319	0.076	0.005	0.23	5.50	0.000	36.5	4534	1354	26.0	3.12	0.26	4893	0.001	1256	0.113	43
131	Alnarp	**Golden Ax-10**	Winter	Spelt	2.40	1.604	2.72	321	0.093	0.007	0.22	5.88	0.000	35.9	4282	1221	21.2	2.44	0.43	4500	0.008	1271	0.148	42
134	Alnarp	**Halländska**	Winter	Landrace	2.62	1.954	3.18	327	0.038	0.006	0.26	4.16	0.000	26.8	4637	1279	19.9	4.06	0.39	4341	0.007	1093	0.047	28
135	Alnarp	**Hansa**	Winter	Old cultivar	4.06	2.040	1.46	350	0.030	0.048	0.18	4.42	0.001	24.1	3951	1100	26.6	1.84	2.42	4098	0.043	1048	0.113	48
137	Alnarp	**Hansa Ax**	Winter	Old cultivar	2.68	1.812	1.40	346	0.058	0.004	0.28	5.04	0.000	30.3	4279	1340	23.0	3.16	0.58	4544	0.007	1209	0.127	42
138	Alnarp	**Hansa brun**	Winter	Old cultivar	7.62	2.060	2.52	347	0.077	0.051	0.40	5.78	0.001	30.9	3907	1177	25.4	3.66	3.38	4309	0.036	1235	0.179	48
139	Alnarp	**Hansa brun (1026/26)**	Winter	Old cultivar	4.56	2.020	2.48	321	0.087	0.044	0.37	6.20	0.000	31.3	4552	1163	17.3	1.28	1.91	4315	0.020	1310	0.195	51
140	Alnarp	**Hartmut Spiess 1027**	Winter	Cultivar	8.23	1.492	1.29	353	0.098	0.002	0.10	5.98	0.000	27.7	4174	1202	16.1	1.34	0.22	4494	0.007	1281	0.117	33
141	Alnarp	**Hartmut Spiess**	Winter	Cultivar	2.18	1.408	1.38	302	0.068	0.004	0.20	4.88	0.002	21.9	3811	1220	17.2	1.90	0.31	4062	0.022	1153	0.198	23
142	Alnarp	**Helge**	Winter	Cultivar	6.25	2.020	3.82	416	0.051	0.017	0.25	3.36	0.000	28.2	4208	1097	25.4	2.50	0.84	4276	0.016	1084	0.145	31
145	Alnarp	**Holger Brun**	Winter	Old cultivar	4.21	2.220	2.22	322	0.091	0.047	0.41	5.20	0.000	34.6	3880	1125	25.8	1.40	2.02	3906	0.019	1245	0.114	41
146	Alnarp	**Holger Brun**	Winter	Old cultivar	1.41	1.376	3.48	382	0.046	0.022	0.14	4.16	0.001	21.9	4412	1240	29.0	2.26	0.94	4482	0.013	989	0.076	35

Prov	Location	Genotype name	Type	Group	Al	B	Ba	Ca	Cd	Co	Cr	Cu	Hg	Fe	K	Mg	Mn	Mo	Ni	P	Pb	S	Se	Zn
146	Alnarp	**Holger Brun**	Winter	Old cultivar	3.15	1.624	4.56	320	0.041	0.005	0.39	4.42	0.000	35.1	5013	1223	19.2	1.91	0.28	4599	0.007	1080	0.220	32
148	Alnarp	**Inntaler**	Winter	Old cultivar	4.01	1.812	3.72	467	0.054	0.049	0.25	4.40	0.001	28.7	3445	1168	24.6	1.98	2.30	3853	0.047	1180	0.199	40
150	Alnarp	**Inntaler**	Winter	Old cultivar	3.96	1.974	3.12	524	0.034	0.037	0.26	4.20	0.000	25.3	4032	1164	27.6	2.22	1.53	4189	0.014	1009	0.078	41
150	Alnarp	**Inntaler**	Winter	Old cultivar	3.36	1.320	5.20	477	0.041	0.012	0.18	4.10	0.001	28.4	3882	1195	25.8	2.36	0.42	4542	0.101	1147	0.186	34
153	Alnarp	**Inntaler 1027**	Winter	Old cultivar	1.43	1.658	2.76	367	0.076	0.005	0.28	5.18	0.000	26.1	3826	1148	14.6	1.51	0.47	4153	0.004	1286	0.112	32
154	Alnarp	**Jacoby 59 utan borst**	Winter	Landrace	2.84	1.418	2.24	331	0.059	0.008	0.19	4.82	0.000	27.5	5025	1251	23.8	3.34	0.65	4763	0.006	1134	0.150	30
157	Alnarp	**Jacoby max**	Winter	Landrace	2.38	1.434	4.02	337	0.042	0.005	0.18	4.36	0.002	26.2	4311	1168	16.1	2.74	0.31	4439	0.008	1092	0.270	38
157	Alnarp	**Jacoby max**	Winter	Landrace	19.22	1.428	2.60	331	0.131	0.005	0.18	5.74	0.001	44.8	3906	1460	19.5	1.47	0.36	4760	0.011	1399	0.173	36
159	Alnarp	**Jarl**	Winter	Old cultivar	3.19	2.200	2.48	366	0.117	0.049	0.22	5.66	0.001	28.8	4842	1253	21.6	1.36	2.62	4775	0.034	1316	0.114	51
162	Alnarp	**Kippenhauser vete**	Winter	Selection	3.52	1.760	1.36	354	0.067	0.021	2.16	5.38	0.000	27.5	3986	1438	26.4	4.84	8.72	5220	0.017	1371	0.218	35
165	Alnarp	**Krachi 1026/18**	Winter	Old cultivar	9.02	1.688	3.80	476	0.087	0.015	0.18	6.36	0.000	32.2	4634	1370	19.5	1.57	1.16	5031	0.011	1392	0.230	47
166	Alnarp	**Krachi borst**	Winter	Old cultivar	1.79	1.982	2.92	354	0.083	0.017	0.20	5.56	0.000	35.8	4579	1308	16.2	2.38	0.88	4814	0.007	1413	0.135	48
166	Alnarp	**Krachi borst**	Winter	Old cultivar	4.96	1.594	3.70	295	0.113	0.006	0.21	6.00	0.000	30.1	4556	1301	19.6	1.40	0.29	4584	0.013	1298	0.290	38
167	Alnarp	**Krachi borst**	Winter	Old cultivar	4.03	2.740	4.26	417	0.056	0.045	0.22	5.26	0.002	29.4	4213	1348	23.0	2.56	2.22	4783	0.043	1236	0.018	54
168	Alnarp	**Krachi borst 3**	Winter	Old cultivar	2.95	2.040	3.30	495	0.082	0.040	0.32	6.70	0.000	36.2	4329	1408	19.5	1.44	1.75	5120	0.021	1408	0.134	54
169	Alnarp	**Krachi borst utan**	Winter	Old cultivar	2.82	1.674	2.98	395	0.081	0.004	0.16	5.66	0.000	37.7	4038	1326	25.6	1.96	0.27	4556	0.010	1282	0.092	36
170	Alnarp	**Krachi brun**	Winter	Old cultivar	4.05	1.334	1.92	415	0.076	0.010	0.34	5.30	0.000	43.3	4106	1377	23.4	3.56	0.36	5080	0.011	1446	0.145	36
171	Alnarp	**Krachi urval**	Winter	Old cultivar	4.73	1.704	2.42	399	0.075	0.043	0.49	6.16	0.000	39.3	4353	1434	27.0	3.14	1.79	5013	0.023	1435	0.109	54
173	Alnarp	**Krachi utan borst**	Winter	Old cultivar	25.34	2.040	3.72	370	0.046	0.004	0.19	3.88	0.000	28.0	4542	1296	21.0	2.70	0.27	4633	0.007	1135	0.041	45
175	Alnarp	**Krim**	Winter	Old cultivar	6.74	1.784	3.30	349	0.086	0.034	0.53	6.48	0.000	35.0	4731	1382	25.6	3.98	2.00	4890	0.027	1232	0.151	54
176	Alnarp	**Krim**	Winter	Old cultivar	2.80	1.982	3.24	350	0.045	0.045	0.36	5.82	0.000	26.3	4920	1234	24.2	1.98	1.91	4505	0.021	1106	0.109	48
177	Alnarp	**Krim långa**	Winter	Old cultivar	3.16	2.080	2.14	341	0.052	0.025	0.19	5.26	0.005	30.3	4158	1242	21.2	3.60	1.27	4511	0.017	1236	0.094	46
180	Alnarp	**Lv Gotland 9:10**	Winter	Landrace	4.60	2.460	3.08	362	0.145	0.042	0.31	6.96	0.000	32.2	4890	1255	25.0	0.96	1.92	4827	0.021	1354	0.043	52
182	Alnarp	**LV Halland**	Winter	Landrace	3.31	2.700	3.36	368	0.039	0.005	0.22	4.94	0.000	26.9	4019	1286	26.4	3.48	0.44	4219	0.001	1166	0.038	35
183	Alnarp	**Lv. Gotland I**	Winter	Landrace	9.00	1.958	3.42	386	0.169	0.022	0.25	6.54	0.000	46.6	4705	1363	21.6	1.29	0.97	5167	0.014	1465	0.067	50
184	Alnarp	**Lysh vede brun**	Winter	Old cultivar	2.95	1.762	2.22	388	0.060	0.008	0.17	4.56	0.000	29.6	3886	1176	27.4	3.38	0.53	4331	0.021	1211	0.117	28
185	Alnarp	**Lyshvede brun borst**	Winter	Old cultivar	5.42	2.100	4.54	485	0.038	0.049	0.34	4.48	0.000	23.8	3841	1134	18.1	2.90	2.44	4163	0.038	1121	0.276	57
186	Alnarp	**Lyshvede**	Winter	Old cultivar	2.17	1.470	1.65	418	0.058	0.007	0.25	3.90	0.000	30.4	3809	1201	33.2	2.80	0.26	4382	0.010	1146	0.109	27
188	Alnarp	**Mirakelvete**	Winter	Primitive	4.54	2.240	2.18	341	0.039	0.052	0.24	5.38	0.000	24.6	5563	1145	13.4	1.30	2.58	4261	0.040	1114	0.093	49
190	Alnarp	**Mumievete**	Winter	Primitive	3.96	1.416	1.77	302	0.015	0.004	0.13	3.80	0.000	25.1	4894	1066	18.1	1.08	0.26	3974	0.006	868	0.065	28
191	Alnarp	**Neuegger dinkel 10**	Winter	Spelt	3.20	1.574	1.63	378	0.069	0.055	0.17	6.22	0.000	30.5	4253	1366	32.4	2.08	0.43	4656	0.024	1159	0.127	53
193	Alnarp	**Neuegger 10**	Winter	Spelt	14.75	1.934	1.94	302	0.081	0.017	0.27	6.46	0.000	35.1	4528	1195	23.8	1.89	0.98	4600	0.003	1271	0.084	46
194	Alnarp	**Neuegger dinkel vete**	Winter	Spelt	5.73	1.966	1.29	374	0.044	0.051	0.19	5.12	0.002	27.0	3849	1090	25.6	2.10	2.28	4018	0.037	1041	0.130	50
195	Alnarp	**Neuegger dinkel vete 10**	Winter	Selection	5.79	2.340	1.82	347	0.093	0.027	0.26	6.18	0.000	41.8	3754	1313	26.8	1.34	1.23	4772	0.013	1448	0.051	40

Prov	Location	Genotype name	Type	Group	Al	B	Ba	Ca	Cd	Co	Cr	Cu	Hg	Fe	K	Mg	Mn	Mo	Ni	P	Pb	S	Se	Zn
198	Alnarp	**Odin**	Winter	Old cultivar	2.14	1.710	4.12	479	0.044	0.014	0.13	4.46	0.001	22.4	4184	1171	26.4	2.60	0.63	4562	0.015	1032	0.111	32
204	Alnarp	**Olympia**	Winter	Landrace	1.60	1.346	3.58	366	0.033	0.007	0.17	3.42	0.000	19.4	3826	1113	20.0	4.36	0.47	4054	0.002	978	0.159	28
206	Alnarp	**Österr Burgsdorfer**	Winter	Spelt	2.71	2.940	1.64	257	0.041	0.020	0.20	4.04	0.000	28.4	4471	1255	21.2	2.38	1.61	4488	0.015	1097	0.033	33
207	Alnarp	**Österr Burgsd 5**	Winter	Spelt	7.19	1.818	1.72	332	0.069	0.012	0.14	4.32	0.002	31.6	4718	1286	22.6	2.14	1.50	4623	0.014	1262	0.159	30
217	Alnarp	**Rauweizen**	Winter	Primitive	7.02	1.600	1.63	337	0.087	0.009	0.42	4.60	0.000	33.2	4789	1248	22.1	1.31	0.53	4593	0.017	1147	0.111	35
218	Alnarp	**Rauweizen**	Winter	Primitive	2.48	1.332	1.92	335	0.055	0.061	0.36	5.34	0.000	29.2	5672	1349	22.6	1.50	5.40	4966	0.010	1141	0.214	36
219	Alnarp	**Rauweizen**	Winter	Primitive	5.30	1.490	1.80	338	0.068	0.063	0.92	4.92	0.000	36.3	5204	1389	24.4	1.39	2.94	5173	0.036	1087	0.109	51
220	Alnarp	**Robur**	Winter	Old cultivar	8.38	1.530	2.46	364	0.059	0.012	1.05	3.56	0.000	21.8	3713	1170	23.5	4.44	4.34	4130	0.008	1012	0.177	34
221	Alnarp	**Robur 1026/10**	Winter	Old cultivar	3.34	1.658	2.74	307	0.103	0.009	0.19	4.57	0.005	29.0	4251	1142	19.0	1.66	0.73	4074	0.058	1161	0.187	32
223	Alnarp	**Rosen3**	Winter	Spelt	3.18	1.362	0.85	285	0.081	0.012	0.29	5.83	0.003	40.5	4349	1501	34.4	3.76	0.50	5407	0.012	1483	0.170	41
224	Alnarp	**Rosens Ax**	Winter	Spelt	4.20	1.850	1.18	270	0.050	0.013	0.45	5.87	0.000	51.0	4369	1389	30.4	1.84	1.05	5056	0.009	1347	0.074	47
226	Alnarp	**Svale**	Winter	Old cultivar	16.62	1.578	3.06	303	0.075	0.016	0.70	4.23	0.000	38.8	4102	990	17.9	1.20	0.61	3735	0.028	1102	0.224	26
227	Alnarp	**Schwabenkorn**	Winter	Spelt	1.48	1.602	1.32	323	0.089	0.003	0.16	6.41	0.000	41.2	4625	1268	18.8	1.35	0.41	5019	0.014	1423	0.082	38
228	Alnarp	**Sol**	Winter	Old cultivar	5.61	1.522	1.53	266	0.042	0.006	0.17	4.22	0.000	26.5	4555	1217	19.9	2.02	0.40	4327	0.009	1068	0.103	35
229	Alnarp	**Sol 1026 /11**	Winter	Old cultivar	3.08	1.830	2.28	285	0.059	0.006	0.19	5.53	0.001	25.0	5207	1172	17.9	1.46	0.65	4318	0.005	1194	0.125	29
230	Alnarp	**Spelt Ustakket 1026/22**	Winter	Spelt	2.42	1.728	2.30	287	0.077	0.005	0.16	4.62	0.000	25.7	4098	999	16.1	1.19	0.42	3773	0.005	1162	0.130	29
231	Alnarp	**Spelt ustakket 14 vete Ax**	Winter	Selection	3.70	2.740	2.18	305	0.052	0.011	0.33	4.61	0.000	31.4	3696	1165	24.4	3.06	0.76	4070	0.004	1053	0.119	38
231	Alnarp	**Spelt ustakket 14 vete Ax**	Winter	Selection	1.42	1.906	3.30	328	0.051	0.014	0.24	4.98	0.002	32.2	4298	1324	23.3	4.22	0.29	4459	0.043	1193	0.077	32
234	Alnarp	**Spelt blå Ax**	Winter	Spelt	3.14	2.780	2.22	310	0.059	0.006	0.20	4.46	0.000	33.5	4253	1226	24.0	1.55	0.43	4524	0.007	1194	0.046	38
239	Alnarp	**Spelt lådden gråsort**	Winter	Spelt	3.96	1.928	1.67	356	0.085	0.075	0.46	4.84	0.000	40.3	4581	1291	19.5	1.64	6.52	5030	0.021	1349	0.115	35
240	Alnarp	**Spelt låddengrå**	Winter	Spelt	4.76	1.638	1.61	347	0.058	0.025	0.27	4.13	0.000	37.8	4136	1373	28.1	3.32	1.65	4975	0.010	1168	0.145	28
244	Alnarp	**Spelt Ustakket**	Winter	Spelt	2.14	1.540	2.14	285	0.091	0.006	0.16	5.00	0.000	31.8	4376	1105	16.5	1.81	0.47	4139	0.001	1165	0.110	29
247	Alnarp	**Spelt ustakket 14 vete**	Winter	Spelt	4.35	2.480	3.08	339	0.171	0.010	0.22	4.84	0.002	34.1	4199	1284	24.0	2.66	0.89	4522	0.016	1192	0.032	37
249	Alnarp	**Starke**	Winter	Old cultivar	3.59	1.620	2.50	308	0.109	0.006	0.23	4.64	0.000	27.8	4257	1074	16.2	1.89	0.40	4157	0.009	1130	0.226	30
250	Alnarp	**Starke II 1026/ 12**	Winter	Old cultivar	2.14	1.664	2.76	293	0.075	0.006	0.17	4.99	0.000	25.0	4874	1173	19.3	1.51	0.50	4323	0.001	1092	0.133	25
251	Alnarp	**Stava**	Winter	Cultivar	2.80	1.708	4.56	402	0.056	0.007	0.21	4.13	0.001	30.8	4289	1250	13.9	2.66	0.44	4315	0.018	1189	0.266	36
252	Alnarp	**Sv 5113 1026/ 19**	Winter	Selection	3.50	1.784	2.24	325	0.092	0.011	0.20	5.27	0.000	27.6	4659	1243	14.6	1.58	0.83	4386	0.008	1209	0.130	33
254	Alnarp	**Svale**	Winter	Old cultivar	3.94	1.712	2.74	371	0.049	0.011	0.17	3.85	0.001	21.6	4730	1064	22.7	1.97	0.62	4210	0.003	1014	0.166	29
261	Alnarp	**T. Turgidum cst**	Winter	Primitive	3.79	1.930	0.92	371	0.064	0.019	0.18	4.28	0.000	31.1	5888	1348	20.6	1.73	1.38	5084	0.015	1146	0.087	47
262	Alnarp	**T. Vulgare ferr**	Winter	Landrace	2.10	1.414	1.38	286	0.057	0.007	0.32	5.13	0.000	30.7	3912	1228	24.2	2.76	0.46	4265	0.006	1151	0.152	28
263	Alnarp	**T. Vulgare ferr kort borst**	Winter	Landrace	2.48	1.312	1.43	362	0.037	0.006	0.44	4.34	0.000	20.0	4179	1120	23.9	2.36	0.48	4038	0.005	982	0.116	24
264	Alnarp	**T. Vulgare ferr lång**	Winter	Landrace	3.40	1.748	1.08	324	0.033	0.013	0.16	3.90	0.000	19.1	3997	1037	20.5	3.16	0.97	3804	0.000	958	0.210	26
266	Alnarp	**T.Timopheevii**	Winter	Primitive	2.99	1.812	2.18	296	0.047	0.015	0.27	3.72	0.000	33.5	4792	1483	17.1	0.77	0.49	5463	0.015	1379	0.118	47
270	Alnarp	**URE**	Winter	Cultivar	3.32	1.296	1.48	318	0.043	0.007	0.22	3.89	0.000	24.3	3785	1287	27.8	3.52	0.34	4331	0.007	1093	0.115	31

Prov	Location	Genotype name	Type	Group	Al	B	Ba	Ca	Cd	Co	Cr	Cu	Hg	Fe	K	Mg	Mn	Mo	Ni	P	Pb	S	Se	Zn
271	Alnarp	**Ure**	Winter	Cultivar	4.32	1.354	1.56	294	0.074	0.024	4.14	4.00	0.000	27.4	3825	1219	26.6	7.60	17.26	4145	0.010	1092	0.169	32
272	Alnarp	**URE Brun**	Winter	Cultivar	5.34	1.604	3.26	384	0.071	0.011	0.26	4.34	0.000	29.6	3642	1335	22.7	2.50	1.03	4525	0.007	1232	0.356	49
275	Alnarp	**Vakka**	Winter	Old cultivar	10.11	1.776	2.68	349	0.088	0.013	0.15	5.20	0.000	29.6	4103	1269	25.0	2.54	1.01	4356	0.021	1193	0.054	28
276	Alnarp	**Vakka**	Winter	Old cultivar	9.86	1.548	2.02	360	0.044	0.007	0.28	4.30	0.000	25.1	4611	1321	27.4	2.20	0.67	4718	0.007	1020	0.104	27
282	Alnarp	**Vama höst**	Winter	Old cultivar	2.98	1.654	2.72	365	0.057	0.010	0.14	3.93	0.000	21.2	4120	1093	23.7	2.56	0.83	4166	0.000	1016	0.169	29
284	Alnarp	**Vama höst lång**	Winter	Old cultivar	5.08	1.644	2.16	386	0.038	0.008	0.15	6.82	0.000	30.9	3292	1382	36.0	2.36	0.48	4596	0.008	1296	0.179	45
286	Alnarp	**Wärmland**	Winter	Landrace	2.96	1.622	1.79	366	0.048	0.009	0.24	4.38	0.000	25.5	3661	1219	22.4	2.08	0.62	4227	0.000	1164	0.187	33
287	Alnarp	**Virtus 1026 / 14**	Winter	Old cultivar	2.44	1.726	3.28	311	0.077	0.008	0.14	5.16	0.000	29.6	4892	1278	18.8	1.37	0.61	4826	0.010	1245	0.071	32
288	Alnarp	**Virtus 2**	Winter	Old cultivar	6.71	1.744	3.80	349	0.068	0.007	0.26	5.08	0.000	35.1	3511	1152	22.4	1.66	0.57	4068	0.012	1264	0.300	27
292	Alnarp	**Vit spelt 1026/27**	Winter	Spelt	2.84	1.328	1.13	311	0.115	0.005	0.21	4.86	0.000	36.4	4382	1177	14.5	0.96	0.65	4603	0.003	1359	0.095	37
294	Alnarp	**Zanda 1026 / 21**	Winter	Old cultivar	5.86	1.714	1.91	284	0.078	0.005	0.13	4.80	0.003	26.6	4741	1119	15.4	1.12	0.46	4269	0.008	1194	0.109	31
295	Alnarp	**Zuzgendinkel**	Winter	Spelt	3.78	1.604	1.71	284	0.100	0.011	0.20	6.86	0.000	38.4	4813	1431	28.7	2.76	0.69	5285	0.008	1544	0.130	35
310	Alnarp	**Eroica 1046/07 6**	Winter	Old cultivar	4.71	1.780	3.80	327	0.072	0.011	0.15	4.38	0.000	27.2	3735	1168	22.2	1.04	1.05	4298	0.012	1080	0.075	30
313	Alnarp	**Erbe 1040/05 72**	Winter	Old cultivar	3.05	1.764	5.46	373	0.069	0.005	0.19	5.06	0.000	26.7	4192	1084	7.9	1.23	0.58	3995	0.008	1200	0.328	29
314	Alnarp	**Vama höst 1040/5 61**	Winter	Old cultivar	3.33	1.746	6.48	488	0.065	0.007	0.14	4.66	0.001	26.8	4767	1146	7.9	1.09	0.47	4430	0.011	1341	0.324	31
319	Alnarp	**Ax 4:2**	Winter	Selection	4.44	1.494	2.12	469	0.077	0.012	0.40	5.64	0.000	36.9	3668	1335	31.4	2.66	0.71	4569	0.017	1455	0.100	39
320	Alnarp	**Tysk spelt 1040/5 33**	Winter	Spelt	2.72	1.860	3.18	391	0.048	0.004	0.19	4.98	0.000	27.6	4413	1148	9.8	1.52	0.27	4533	0.010	1292	0.220	28
322	Alnarp	**Schwabenkorn**	Winter	Spelt	4.52	1.382	0.89	319	0.057	0.033	0.53	6.28	0.001	48.0	4725	1372	25.2	2.54	2.14	5212	0.014	1468	0.135	49
324	Alnarp	**Spelt ustakket lådden**	Winter	Spelt	16.20	1.770	2.26	354	0.084	0.009	0.28	4.66	0.002	39.2	5433	1222	24.8	2.60	0.42	5003	0.012	1392	0.250	37
328	Alnarp	**T.monococcum 1033/04**	Winter	Primitive	4.12	2.220	4.50	541	0.012	0.012	0.50	6.70	0.000	35.6	4625	1339	14.2	1.46	1.81	5546	0.027	1601	0.540	46
329	Gotland	**40.Ostro**	Winter	Spelt	1.88	1.386	0.72	326	0.021	0.006	0.25	5.70	0.000	35.3	4348	1282	8.3	1.12	0.69	4333	0.022	1461	0.016	39
332	Gotland	**48. Olympia**	Winter	Landrace	5.14	2.780	1.97	370	0.021	0.022	1.12	5.76	0.000	33.5	4637	1402	15.0	2.38	1.93	4342	0.009	1228	0.000	38
333	Gotland	**35. 6356**	Winter	Landrace	1.11	2.420	1.02	360	0.020	0.006	0.35	4.08	0.000	22.6	3626	1054	12.9	1.62	0.96	3321	0.000	1104	0.007	28
337	Gotland	**15.6357**	Winter	Spelt	1.93	2.240	1.07	277	0.046	0.006	0.37	4.76	0.000	33.1	3429	1342	10.7	1.49	0.55	3717	0.015	1193	0.028	32
338	Gotland	**34.6356**	Winter	Landrace	0.80	2.300	1.37	414	0.023	0.007	0.48	5.22	0.002	28.2	4685	1442	17.5	1.88	0.76	4470	0.006	1160	0.030	32
339	Gotland	**45.Lantvete Gottland AX-9**	Spring	Landrace	1.10	2.520	1.96	397	0.035	0.006	0.35	5.00	0.003	25.0	4737	1280	13.5	1.10	1.11	4266	0.009	1151	0.035	32
341	Gotland	**6357 blå**	Winter	Spelt	2.44	2.120	1.74	360	0.017	0.005	0.27	4.08	0.001	27.2	4318	1257	13.9	0.91	0.44	3937	0.046	1116	0.020	23
342	Gotland	**Dala imp**	Spring	Landrace	2.16	2.140	1.95	513	0.022	0.006	0.34	3.96	0.000	29.5	3804	1221	8.4	1.09	0.66	3615	0.010	1179	0.036	25
344	Gotland	**Lantvete Gotland Vit**	Spring	Landrace	1.33	3.700	1.80	405	0.021	0.007	0.43	4.02	0.001	22.0	4445	1091	15.4	1.65	0.84	3550	0.010	1134	0.026	28
345	Gotland	**LV Gotland Spelt**	Winter	Spelt	2.76	2.400	0.78	378	0.021	0.013	2.52	4.64	0.001	23.5	3830	1224	16.1	3.50	9.92	3585	0.006	1056	0.027	33
346	Gotland	**Svart emmer**	Winter	Primitive	2.58	2.440	2.56	440	0.045	0.026	0.93	4.10	0.001	23.5	4498	1233	13.4	0.87	2.18	3996	0.007	1068	0.033	27
347	Gotland	**Sol**	Winter	Old cultivar	0.74	0.000	0.59	339	0.018	0.003	0.36	5.44	0.000	22.0	4436	1363	15.6	1.28	0.46	3984	0.000	1021	0.021	40
348	Gotland	**Ertus**	Winter	Old cultivar	1.35	2.020	1.35	437	0.022	0.007	0.40	5.16	0.000	24.1	4212	1372	17.1	1.42	0.78	3935	0.017	1043	0.033	32
349	Gotland	**Jacoby borst**	Winter	Landrace	32.60	2.660	3.30	442	0.017	0.014	0.65	4.94	0.000	25.1	4074	1371	14.9	1.35	4.64	4116	0.060	1101	0.066	45

Prov	Location	Genotype name	Type	Group	Al	B	Ba	Ca	Cd	Co	Cr	Cu	Hg	Fe	K	Mg	Mn	Mo	Ni	P	Pb	S	Se	Zn
350	Gotland	**Virtus**	Winter	Old cultivar	2.58	2.000	1.45	387	0.022	0.004	0.31	5.30	0.000	25.2	4052	1274	19.0	1.38	0.53	3856	0.014	1079	0.033	39
352	Gotland	**Eroica**	Winter	Old cultivar	1.28	2.040	1.33	396	0.023	0.006	0.50	3.98	0.000	22.1	3386	1060	13.5	1.25	0.60	3190	0.017	1013	0.039	25
353	Gotland	**Aros**	Winter	Old cultivar	1.62	3.140	1.48	431	0.021	0.013	0.56	4.56	0.000	22.6	4088	1183	17.1	1.28	1.81	3568	0.000	976	0.049	32
355	Gotland	**Banco**	Winter	Old cultivar	1.39	2.640	1.20	370	0.020	0.010	0.56	4.00	0.001	22.9	3779	1168	13.1	1.31	1.15	3621	0.009	1012	0.006	28
356	Gotland	**Starke**	Winter	Old cultivar	1.16	0.000	0.77	354	0.017	0.004	0.46	5.30	0.000	20.3	3696	1159	15.9	1.46	0.54	3434	0.000	993	0.000	34
357	Gotland	**Robur**	Winter	Old cultivar	1.49	3.020	0.86	384	0.026	0.005	0.48	4.32	0.000	20.7	3592	1132	15.2	1.23	0.65	3200	0.000	978	0.057	37
358	Gotland	**Bore**	Winter	Old cultivar	1.01	2.340	1.40	477	0.020	0.007	0.46	6.56	0.000	28.7	3734	1421	21.2	1.24	0.63	3953	0.000	1110	0.017	38
359	Gotland	**Jarl**	Winter	Old cultivar	1.98	1.944	0.56	373	0.026	0.008	0.58	4.42	0.000	22.6	3910	1145	16.1	1.32	1.03	3702	0.014	1027	0.019	32
360	Gotland	**Holger**	Winter	Old cultivar	1.47	2.240	1.51	380	0.019	0.008	0.52	5.00	0.000	27.7	4019	1329	18.0	1.53	2.86	3756	0.000	1020	0.009	33
361	Gotland	**Vit Spelt Alnarp**	Winter	Spelt	1.18	4.100	0.54	272	0.023	0.005	0.30	4.52	0.000	23.6	4057	1151	12.2	1.25	0.59	3625	0.013	1063	0.057	26
362	Gotland	**Fylgia**	Spring	Old cultivar	21.40	1.990	1.41	337	0.036	0.004	0.43	5.64	0.000	37.2	3491	1073	29.4	0.63	0.59	3282	0.025	1276	0.054	32
363	Gotland	**Algot**	Spring	Old cultivar	0.94	3.040	3.34	437	0.043	0.010	0.50	5.96	0.000	39.7	3895	1054	21.3	0.40	1.24	3192	0.002	1086	0.038	35
364	Gotland	**Atle**	Spring	Old cultivar	4.50	3.360	2.70	343	0.040	0.014	0.83	4.80	0.000	35.7	4383	1201	25.1	1.03	2.42	3580	0.000	1153	0.071	38
365	Gotland	**Atson**	Spring	Old cultivar	1.11	2.280	2.34	320	0.044	0.008	0.47	4.20	0.000	34.2	4176	1106	21.7	0.61	1.47	3414	0.000	1105	0.000	30
366	Gotland	**Peko**	Spring	Old cultivar	1.01	1.086	0.47	288	0.045	0.004	0.37	3.74	0.000	31.4	4318	1114	20.0	0.54	0.42	3459	0.006	1197	0.009	32
367	Gotland	**Rival**	Spring	Old cultivar	15.28	1.604	1.50	392	0.035	0.061	4.98	3.98	0.002	62.2	3725	1187	25.0	1.07	3.44	3414	0.025	1150	0.062	30
368	Gotland	**Pondus**	Spring	Old cultivar	1.63	1.404	2.88	282	0.044	0.010	0.53	8.50	0.001	32.5	4126	973	21.2	0.46	0.90	3055	0.008	1016	0.021	30
369	Gotland	**Kärn**	Spring	Old cultivar	1.40	1.590	1.65	310	0.031	0.024	0.58	4.24	0.000	28.2	3856	956	23.3	0.52	2.12	3037	0.000	1105	0.062	25
370	Gotland	**Dala urval**	Spring	Landrace	1.41	1.888	1.44	353	0.034	0.006	0.44	4.06	0.000	29.8	3874	1091	23.2	0.77	0.47	3301	0.004	1146	0.036	29
371	Gotland	**Progress**	Spring	Old cultivar	1.50	2.380	0.89	304	0.037	0.007	0.57	5.44	0.000	35.5	3520	1080	30.0	0.73	0.89	3193	0.012	1231	0.041	38
372	Gotland	**Svenno**	Spring	Old cultivar	0.90	1.770	1.71	326	0.033	0.006	0.46	3.74	0.000	34.8	4508	1086	20.5	0.65	0.47	3416	0.005	1121	0.026	30
373	Gotland	**Ölands**	Spring	Landrace	0.76	0.000	1.27	400	0.031	0.004	0.42	5.18	0.000	37.4	3543	1281	28.1	0.87	0.68	3781	0.000	1266	0.027	39
374	Gotland	**Aurora**	Spring	Old cultivar	0.97	2.500	1.05	392	0.035	0.009	0.64	4.80	0.000	39.6	3983	1100	29.5	0.49	1.16	3442	0.003	1230	0.000	34
375	Gotland	**Våremmer**	Spring	Primitive	1.53	2.260	0.87	348	0.045	0.006	0.31	5.28	0.001	35.1	4025	1221	20.1	0.60	1.29	3668	0.021	1344	0.050	34
376	Gotland	**Öland spelt**	Spring	Landrace	2.98	3.360	1.30	270	0.035	0.007	0.67	5.66	0.000	40.2	3912	1180	21.3	0.71	1.61	3800	0.009	1275	0.038	37
377	Gotland	**Lv Gotland**	Spring	Spelt	1.43	3.500	1.27	222	0.051	0.007	0.56	6.76	0.000	41.3	3899	1199	19.9	0.65	0.91	3733	0.016	1417	0.063	31
382	Gotland	**Öland1**	Spring	Landrace	0.83	2.300	1.82	434	0.036	0.005	0.32	3.78	0.001	40.2	3950	1409	26.9	0.52	0.71	4080	0.008	1371	0.050	30
383	Gotland	**Öland 14**	Spring	Landrace	1.50	2.740	1.73	402	0.039	0.010	0.54	3.62	0.000	40.2	3892	1295	26.7	0.53	1.51	3930	0.011	1383	0.042	31
385	Gotland	**Öland 2**	Spring	Landrace	0.98	2.360	1.97	443	0.043	0.008	0.41	3.10	0.000	34.3	4103	1369	29.2	0.60	1.76	4214	0.001	1316	0.002	30
393	Gotland	**Oberkulmer**	Winter	Spelt	17.18	1.976	0.41	279	0.029	0.013	0.52	4.84	0.000	35.0	3598	1110	11.6	1.82	1.45	3700	0.000	1516	0.048	36
394	Gotland	**Lantvete Uppsala**	Winter	Landrace	4.52	0.165	1.04	352	0.020	0.006	1.00	5.40	0.000	31.1	3655	1285	17.9	2.06	3.00	3751	0.004	1237	0.017	39
395	Gotland	**Neuegger**	Winter	Spelt	1.08	2.680	0.54	272	0.038	0.005	0.31	5.52	0.000	39.5	4090	1196	15.5	1.41	0.69	3846	0.005	1331	0.047	36
397	Gotland	**Lantvete Halland**	Winter	Landrace	1.45	2.160	1.39	350	0.024	0.005	0.43	5.60	0.000	30.3	3893	1275	18.0	1.50	0.53	3866	0.011	1264	0.051	38
398	Gotland	**Schweiz**	Winter	Spelt	2.46	4.740	0.50	300	0.029	0.012	0.76	5.92	0.000	44.9	3765	1256	11.8	1.42	1.32	4009	0.018	1439	0.060	38

Prov	Location	Genotype name	Type	Group	Al	B	Ba	Ca	Cd	Co	Cr	Cu	Hg	Fe	K	Mg	Mn	Mo	Ni	P	Pb	S	Se	Zn
399	Gotland	**Rosens**	Winter	Spelt	8.64	6.420	0.38	282	0.029	0.011	0.40	6.16	0.000	43.9	4449	1369	13.7	1.53	0.90	4388	0.026	1412	0.041	42
401	Gotland	**Kippenhauser**	Winter	Spelt	1.29	2.250	0.53	293	0.028	0.005	0.41	7.06	0.000	37.6	4274	1356	17.9	1.86	0.62	4278	0.028	1407	0.043	91
402	Gotland	**Speltvete Gotland**	Winter	Spelt	1.38	2.460	1.69	336	0.043	0.006	0.37	6.24	0.000	37.0	4734	1439	20.2	1.38	0.71	4496	0.008	1452	0.032	36
403	Gotland	**Golden**	Winter	Spelt	0.77	1.040	0.44	311	0.034	0.002	0.25	4.72	0.000	51.7	3975	1266	15.8	1.45	0.32	3877	0.003	1355	0.016	36
404	Gotland	**Erbe**	Winter	Old cultivar	1.96	2.960	1.16	319	0.038	0.012	0.61	5.14	0.000	29.9	4268	1135	15.2	1.41	1.43	3668	0.003	1182	0.064	34
405	Gotland	**Starke**	Winter	Old cultivar	1.05	2.200	1.02	285	0.023	0.008	0.51	4.20	0.000	23.2	3418	943	15.0	1.40	0.84	3053	0.002	1007	0.004	27
407	Gotland	**Svale**	Winter	Old cultivar	1.18	0.000	0.76	335	0.024	0.004	0.35	5.20	0.000	24.3	4744	1186	13.9	1.15	0.55	3743	0.000	1202	0.043	33
408	Gotland	**Schwaben**	Winter	Spelt	1.53	2.300	0.49	304	0.023	0.023	0.37	5.54	0.001	34.0	4002	1193	12.0	1.56	2.12	3993	0.017	1430	0.037	36
410	Gotland	**6356**	Winter	Landrace	1.03	2.040	0.69	449	0.029	0.005	0.39	5.16	0.000	27.5	3724	1253	16.4	1.30	1.23	3887	0.002	1269	0.023	32
411	Gotland	**Zuzgendinkel**	Winter	Spelt	3.30	1.656	0.73	291	0.037	0.005	0.60	5.78	0.000	39.8	4517	1288	16.9	1.97	2.38	4223	0.053	1490	0.054	34
412	Gotland	**Sol**	Winter	Old cultivar	1.65	2.480	1.00	290	0.026	0.007	0.39	4.88	0.002	25.3	4438	1145	15.0	1.43	1.50	3564	0.010	1145	0.050	31
414	Gotland	**Holger 2**	Winter	Old cultivar	25.00	2.320	1.59	350	0.030	0.008	0.50	5.20	0.000	32.1	4099	1301	19.7	1.71	1.02	3868	0.000	1193	0.033	39
415	Gotland	**Lantvete Gotland**	Winter	Spelt	17.28	3.020	2.38	387	0.040	0.009	0.78	5.34	0.000	29.9	4402	1299	17.2	2.00	2.96	4009	0.005	1289	0.040	39
416	Gotland	**Jacoby borst**	Winter	Landrace	0.88	2.140	1.29	345	0.022	0.004	0.40	4.10	0.002	22.2	3077	1010	13.0	1.49	0.50	3165	0.021	1260	0.034	28
417	Gotland	**Eroica**	Winter	Old cultivar	0.60	0.044	0.88	332	0.024	0.005	0.38	5.08	0.000	28.6	4167	1351	17.6	1.66	0.40	3965	0.000	1173	0.022	33
418	Gotland	**Hansa Brun**	Winter	Old cultivar	0.85	2.080	0.98	316	0.030	0.010	0.47	5.38	0.000	30.4	3897	1105	15.2	1.31	1.06	3623	0.001	1249	0.008	35
419	Gotland	**T.spelta brun hvid**	Winter	Spelt	1.07	2.360	0.69	373	0.034	0.006	0.37	5.24	0.000	35.6	3786	1406	22.5	1.77	0.90	4078	0.000	1397	0.017	42
423	Gotland	**Öland urv 10 lång borst**	Spring	Spelt	2.08	0.410	0.92	424	0.024	0.006	0.55	6.66	0.000	52.3	3781	1343	27.7	0.30	0.88	4061	0.002	1797	0.010	56
425	Gotland	**Lantvete Gotland 8**	Spring	Spelt	2.28	1.880	1.82	340	0.072	0.012	0.38	6.26	0.001	54.0	4113	1293	23.1	0.27	1.00	3898	0.019	1660	0.076	43
426	Gotland	**Lantvete Gotland 9**	Spring	Spelt	1.67	2.780	1.14	339	0.055	0.006	0.51	6.68	0.000	55.3	4020	1325	27.3	0.28	0.83	3847	0.006	1736	0.058	44
427	Gotland	**Lantvete Halland 1**	Spring	Landrace	1.08	3.340	2.00	440	0.025	0.025	0.50	6.30	0.000	48.8	3921	1214	29.7	0.29	2.74	3400	0.003	1520	0.051	48
431	Gotland	**Ölands 5**	Spring	Landrace	1.41	2.820	1.44	469	0.020	0.006	0.42	4.42	0.000	42.3	3511	1220	21.6	0.24	0.87	3209	0.000	1421	0.000	32
432	Gotland	**Lantvete Gotland borst 2**	Spring	Spelt	1.69	2.120	1.72	378	0.051	0.005	0.32	5.54	0.000	56.8	4044	1258	28.0	0.29	0.81	3850	0.032	1771	0.037	43
435	Gotland	**Ölands 62**	Spring	Landrace	1.37	2.940	1.83	488	0.019	0.006	0.41	4.56	0.000	43.5	3610	1208	25.4	0.21	0.90	3400	0.001	1458	0.000	37
437	Gotland	**Aurore 2**	Spring	Old cultivar	1.49	1.384	0.76	429	0.015	0.003	0.37	4.68	0.000	39.0	3872	1093	22.0	0.27	0.59	3114	0.001	1471	0.038	30
438	Gotland	**Diamant Brun**	Spring	Old cultivar	2.08	3.480	1.63	520	0.019	0.006	0.61	5.84	0.000	46.8	4215	1218	26.0	0.47	1.63	3353	0.001	1487	0.031	36
440	Gotland	**Atle**	Spring	Old cultivar	2.32	2.720	2.34	502	0.024	0.007	0.50	5.36	0.000	48.0	4316	1206	23.4	0.38	0.60	3561	0.007	1542	0.024	34
441	Gotland	**Progress 1**	Spring	Old cultivar	1.09	2.880	1.21	474	0.025	0.004	0.35	5.72	0.001	44.9	3887	1155	23.1	0.29	0.93	3353	0.016	1571	0.020	34
443	Gotland	**Fylgia 93**	Spring	Old cultivar	1.10	3.120	1.41	408	0.018	0.008	0.51	5.26	0.000	40.2	3826	1046	23.6	0.25	0.73	2988	0.001	1401	0.034	36
489	Gotland	**Borstvete Gotland**	Winter	Landrace	0.97	5.800	1.42	350	0.022	0.007	0.41	4.84	0.000	25.7	4060	1242	13.9	1.35	0.91	3831	0.003	1007	0.039	27
501	Gotland	**Kulturemmer**	Winter	Primitive	1.93	2.600	0.58	426	0.035	0.009	0.50	5.66	0.001	38.6	5067	1343	13.4	1.38	1.80	4876	0.022	1480	0.116	49
502	Gotland	**Röd Emmer**	Winter	Primitive	2.44	8.160	0.56	448	0.044	0.009	0.56	7.18	0.000	51.4	5588	1830	18.0	1.89	0.84	6083	0.021	1732	0.148	58
503	Gotland	**Ostro**	Winter	Spelt	1.96	2.900	0.84	305	0.025	0.004	0.44	6.72	0.002	40.5	4741	1253	11.9	1.40	0.79	4474	0.034	1521	0.130	39
505	Gotland	**Schweiz Spelt**	Winter	Spelt	2.50	1.368	0.73	302	0.028	0.008	0.36	5.30	0.000	37.1	3966	1119	11.6	2.06	0.99	3802	0.144	1431	0.122	37

Prov	Location	Genotype name	Type	Group	Al	B	Ba	Ca	Cd	Co	Cr	Cu	Hg	Fe	K	Mg	Mn	Mo	Ni	P	Pb	S	Se	Zn
507	Gotland	**Vit Emmer**	Winter	Primitive	1.83	2.260	1.01	349	0.016	0.007	0.35	4.64	0.000	30.6	4860	1196	12.9	0.98	0.47	4253	0.030	1386	0.087	37
509	Gotland	**Vit Spelt**	Winter	Spelt	1.82	2.320	0.83	317	0.026	0.006	0.50	4.74	0.000	32.2	4140	1033	9.8	1.86	0.36	3638	0.009	1359	0.112	35
510	Gotland	**Svart emmer**	Winter	Primitive	3.72	7.060	1.70	344	0.040	0.016	1.11	11.94	0.014	27.9	4503	1150	13.1	2.22	1.40	3926	0.047	1437	0.300	90
513	Gotland	**Lantvete Gotland 1**	Spring	Spelt	9.20	8.230	1.55	387	0.038	0.007	0.38	5.38	0.000	38.2	4103	1070	12.8	1.05	0.75	3696	0.005	1374	0.123	35
514	Gotland	**Enkorn**	Winter	Primitive	1.78	3.020	1.42	306	0.007	0.003	0.34	6.06	0.000	34.9	5243	1252	15.8	1.37	0.49	4566	0.003	1467	0.108	43
516	Gotland	**Kippenhauser**	Winter	Spelt	2.26	4.580	0.81	334	0.023	0.005	0.38	5.54	0.000	35.7	4617	1233	14.4	1.92	0.65	4304	0.016	1427	0.143	33
521	Gotland	**Speltvete gotland**	Winter	Spelt	2.08	1.658	0.63	309	0.025	0.011	0.26	5.78	0.003	36.8	4209	1210	11.2	1.53	0.83	4160	0.026	1416	0.088	44
523	Gotland	**Folke**	Winter	Cultivar	2.76	2.080	0.46	316	0.026	0.017	0.33	5.32	0.000	34.2	4298	1226	11.4	1.85	1.47	4285	0.014	1549	0.094	39
523	Gotland	**Folke**	Winter	Cultivar	2.02	2.220	1.91	499	0.018	0.004	0.32	5.34	0.000	27.8	5112	1166	15.2	1.90	0.46	4053	0.012	1283	0.116	36
525	Gotland	**Jarl**	Winter	Old cultivar	1.24	1.288	1.06	524	0.028	0.003	0.42	5.02	0.000	34.7	5138	1304	13.9	1.60	0.30	4419	0.001	1361	0.062	38
526	Gotland	**Lantvete Gotland vit**	Winter	Spelt	5.04	3.460	2.40	548	0.020	0.007	0.46	4.82	0.000	25.5	4773	1214	15.0	1.33	0.72	3949	0.001	1245	0.117	39
528	Gotland	**6356**	Winter	Landrace	3.40	2.280	1.21	416	0.019	0.007	0.37	4.78	0.001	27.8	4497	1032	11.5	1.67	1.43	3725	0.001	1352	0.043	34
529	Gotland	**Peter Jacoby**	Winter	Landrace	2.02	3.340	1.81	535	0.020	0.011	0.48	6.26	0.000	30.5	5038	1341	17.6	1.83	1.24	4368	0.000	1309	0.119	48
531	Gotland	**Bore**	Winter	Old cultivar	1.74	2.160	1.20	437	0.017	0.010	0.56	6.38	0.000	27.8	4521	1429	19.9	1.55	2.12	4391	0.001	1166	0.000	34
532	Gotland	**Borst vete Gotland**	Winter	Landrace	1.63	3.100	1.16	396	0.021	0.011	0.54	5.22	0.000	25.7	4229	1331	15.9	1.11	2.02	3946	0.000	1011	0.034	34
534	Gotland	**Olympia**	Winter	Landrace	2.90	3.680	1.27	381	0.036	0.015	0.43	5.74	0.000	28.5	4444	1309	14.1	1.10	1.40	3868	0.000	1137	0.000	37
536	Gotland	**Borstvete Gotland**	Winter	Landrace	2.54	2.000	0.82	427	0.021	0.010	0.65	5.10	0.000	28.4	4453	1409	17.8	1.26	0.53	4195	0.019	1085	0.030	30
539	Gotland	**Browichs**	Winter	Old cultivar	1.59	1.408	0.83	328	0.021	0.006	0.28	3.10	0.000	25.7	4339	1221	15.6	1.53	0.71	3824	0.012	1066	0.010	26
546	Gotland	**Olympia**	Winter	Landrace	1.31	2.140	1.85	423	0.018	0.014	0.58	4.00	0.000	25.1	3472	1180	15.7	1.02	2.14	3404	0.012	1040	0.014	26
547	Gotland	**Enkorn**	Winter	Primitive	1.11	2.420	1.58	372	0.010	0.005	0.32	4.96	0.001	31.6	3717	1279	26.1	0.80	0.51	4252	0.038	1378	0.028	46
549	Gotland	**Svart emmer**	Winter	Primitive	1.31	1.880	0.77	331	0.022	0.006	0.42	5.78	0.001	30.0	4117	1487	15.5	0.59	0.76	4455	0.007	1344	0.016	44
550	Gotland	**NI-enkorn**	Winter	Primitive	1.25	1.970	1.96	478	0.012	0.005	0.29	7.56	0.000	34.2	4331	1383	23.2	0.93	0.51	4709	0.020	1362	0.088	48
561	Gotland	**Albihn**	Winter	Spelt	1.55	1.342	0.68	396	0.018	0.010	0.40	3.58	0.003	26.8	4045	1303	15.9	1.11	1.00	3893	0.024	1042	0.020	28
564	Gotland	**Armensk6**	Winter	Old cultivar	2.32	2.640	2.06	548	0.021	0.011	0.43	4.38	0.000	20.6	3325	1059	12.9	0.94	1.40	3468	0.000	1073	0.004	32
570	Gotland	**Kamut Platt**	Winter	Primitive	2.16	1.274	1.05	300	0.050	0.008	0.31	4.84	0.000	27.9	3872	1348	13.1	0.73	0.58	4073	0.013	1211	0.033	42
573	Gotland	**6357 vit**	Winter	Spelt	1.69	2.260	1.26	330	0.033	0.007	0.31	4.20	0.000	26.9	4646	1472	19.7	1.24	0.78	4352	0.012	1086	0.034	28
576	Gotland	**T.dicoccum emmer**	Winter	Primitive	0.85	2.980	0.62	302	0.021	0.005	0.37	6.10	0.000	24.3	3620	1361	15.2	0.66	0.65	3993	0.000	1368	0.048	42
583	Gotland	**Jacoby Max**	Winter	Landrace	0.82	5.180	1.61	344	0.025	0.009	0.71	5.20	0.000	30.0	5004	1213	16.9	1.85	2.22	3976	0.006	1173	0.029	35
587	Gotland	**Vit spelt**	Winter	Spelt	1.31	1.344	0.72	344	0.026	0.007	0.34	4.64	0.002	31.5	4488	1316	11.4	1.67	0.75	4328	0.007	1253	0.054	39
588	Gotland	**Kippenhauser**	Winter	Spelt	1.69	2.280	0.80	324	0.022	0.008	0.63	4.34	0.000	24.7	4044	1134	13.7	1.54	1.06	3680	0.010	1172	0.048	28
589	Gotland	**Zuzgendinkel**	Winter	Spelt	4.56	1.128	0.93	325	0.028	0.013	0.34	4.94	0.002	43.6	4593	1256	15.0	1.32	1.11	4229	0.026	1432	0.040	33
590	Gotland	**Österreicher Burgsdorf**	Winter	Spelt	2.52	2.380	0.87	302	0.017	0.007	0.35	7.46	0.001	30.3	4579	1144	15.2	1.79	0.90	3829	0.016	1186	0.042	30
593	Gotland	**6357 brun**	Winter	Spelt	1.75	2.920	0.90	292	0.031	0.031	0.32	5.46	0.000	34.4	3764	1164	14.9	1.21	2.12	3635	0.006	1301	0.057	29
598	Gotland	**T.monococcum tina**	Winter	Primitive	3.34	3.360	1.83	413	0.010	0.004	0.39	3.98	0.000	30.1	4911	1421	27.5	1.04	0.56	4826	0.001	1480	0.012	47

Prov	Location	Genotype name	Type	Group	Al	B	Ba	Ca	Cd	Co	Cr	Cu	Hg	Fe	K	Mg	Mn	Mo	Ni	P	Pb	S	Se	Zn
600	Gotland	**Röd Emmer**	Winter	Primitive	3.54	2.320	0.37	321	0.041	0.011	0.59	5.50	0.002	36.2	4330	1439	10.0	1.81	2.04	4621	0.012	1526	0.065	41
601	Gotland	**Speltvete Gotland**	Winter	Spelt	3.08	1.690	0.75	378	0.025	0.009	0.42	5.78	0.002	44.2	4465	1419	7.0	1.13	0.79	4574	0.021	1497	0.012	42
602	Gotland	**Lantvete Gotland I**	Spring	Spelt	1.41	2.800	1.10	330	0.027	0.005	0.45	4.76	0.000	32.7	4292	1199	15.2	1.32	0.51	3842	0.006	1194	0.060	30
604	Gotland	**Llantvete Dalarna**	Spring	Landrace	1.38	3.000	2.40	517	0.060	0.006	0.42	5.94	0.001	38.2	3875	1156	22.5	0.78	1.09	3714	0.012	1419	0.056	38
606	Alnarp	**Ölands 17 borst spelt**	Spring	Spelt	4.16	1.514	1.87	395	0.100	0.021	3.68	5.40	0.001	64.0	3421	1547	19.7	4.10	15.20	4217	0.019	1654	0.178	39
607	Alnarp	**Koga I**	Spring	Old cultivar	1.39	2.100	0.70	348	0.078	0.008	0.41	4.10	0.001	34.4	3560	1047	27.9	1.19	3.74	3399	0.000	1314	0.236	33
608	Alnarp	**Lv. Gotland 6 borst**	Spring	Spelt	1.90	2.280	4.22	311	0.112	0.016	0.50	5.44	0.001	43.9	4426	1587	20.9	1.02	2.54	4515	0.013	1492	0.168	32
609	Alnarp	**Atle 3007**	Spring	Old cultivar	1.12	2.300	1.93	402	0.074	0.005	0.38	4.68	0.000	31.4	3296	1081	23.4	0.73	0.60	3210	0.011	1445	0.160	30
629	Alnarp	**Lv. Halland I**	Spring	Landrace	4.06	3.520	1.54	386	0.075	0.016	0.94	6.10	0.000	51.0	3516	1399	27.1	2.22	1.01	4040	0.005	1553	0.316	34
630	Alnarp	**Fylgia 9**	Spring	Old cultivar	3.52	3.040	1.40	328	0.086	0.028	2.14	5.42	0.000	53.7	3382	1295	30.8	1.81	1.93	3669	0.001	1463	0.230	34
631	Alnarp	**Algot**	Spring	Old cultivar	0.83	2.420	2.82	468	0.097	0.009	0.49	6.02	0.001	36.4	3621	1278	23.8	2.54	1.05	3737	0.010	1290	0.198	32
634	Alnarp	**Dala 2**	Spring	Landrace	2.22	2.880	1.69	442	0.076	0.009	0.65	5.46	0.000	45.0	3693	1322	25.8	1.12	0.93	3959	0.000	1543	0.180	36
636	Alnarp	**Walter brun**	Spring	Old cultivar	12.78	0.000	1.45	340	0.062	0.005	0.53	5.20	0.000	29.2	4039	1194	26.7	2.32	0.57	3417	0.000	1167	0.179	31
637	Alnarp	**Reno**	Spring	Cultivar	1.02	0.083	1.67	425	0.070	0.006	0.48	4.60	0.000	38.0	3837	1199	29.0	2.10	0.57	3850	0.000	1410	0.152	34
638	Alnarp	**Svenno**	Spring	Old cultivar	22.20	2.580	2.54	325	0.099	0.053	4.00	4.68	0.001	74.3	3983	1193	21.6	0.78	2.60	3489	0.019	1325	0.161	29
639	Alnarp	**Pondus 2**	Spring	Old cultivar	0.81	2.380	2.88	329	0.089	0.004	0.37	4.10	0.000	35.5	3911	1101	21.1	0.89	0.64	3318	0.007	1198	0.111	28
640	Alnarp	**Aurore 1**	Spring	Old cultivar	33.40	2.260	0.93	379	0.071	0.082	6.72	5.34	0.000	91.1	3825	1393	30.5	1.52	6.18	4116	0.034	1475	0.171	36
641	Alnarp	**Atle 1**	Spring	Old cultivar	1.96	2.360	3.32	349	0.086	0.005	0.49	4.26	0.001	40.3	3846	1205	25.6	1.13	1.07	3572	0.008	1339	0.119	33
642	Alnarp	**Lv. Dal 15 vit borst**	Spring	Landrace	1.20	2.540	3.26	493	0.105	0.009	0.57	6.82	0.001	42.3	3852	1481	23.4	2.88	3.92	4391	0.001	1350	0.250	35
644	Alnarp	**Lv. Dal 16 vit borst**	Spring	Landrace	11.98	2.820	2.28	635	0.075	0.008	0.54	6.70	0.000	55.1	3919	1441	31.4	2.70	0.56	4545	0.002	1418	0.190	41
646	Alnarp	**Runar**	Spring	Cultivar	1.82	1.414	1.53	369	0.103	0.014	0.60	4.98	0.002	41.0	3925	1350	28.6	3.22	1.49	4135	0.019	1387	0.180	35
647	Alnarp	**Peko 99**	Spring	Old cultivar	1.27	2.100	1.14	339	0.093	0.011	0.49	4.44	0.000	41.5	3889	1301	20.5	0.75	1.11	3836	0.000	1419	0.184	34
650	Alnarp	**Lv. Dal 16 vit**	Spring	Landrace	1.14	2.160	2.50	583	0.072	0.010	0.42	5.54	0.000	49.5	3915	1452	30.9	1.83	1.24	4681	0.000	1463	0.206	38
651	Alnarp	**Rollo**	Spring	Cultivar	0.96	3.540	1.91	388	0.109	0.010	0.58	5.50	0.000	45.4	4298	1441	27.2	2.86	0.97	4368	0.002	1384	0.183	35
652	Alnarp	**Runar brun**	Spring	Old cultivar	1.32	2.740	1.17	425	0.077	0.012	0.46	6.04	0.000	43.4	3293	1382	30.1	2.18	1.18	3930	0.000	1326	0.218	41
653	Alnarp	**APU**	Spring	Old cultivar	1.11	2.500	1.49	336	0.110	0.008	0.53	5.50	0.001	49.0	3902	1429	25.8	0.71	0.95	4414	0.009	1655	0.124	38
655	Alnarp	**Sappo**	Spring	Old cultivar	1.56	3.000	1.97	363	0.071	0.007	0.60	4.62	0.000	31.0	3815	1053	23.5	1.72	0.71	3132	0.000	1109	0.193	27
656	Alnarp	**Lv. Halland 2**	Spring	Landrace	1.92	2.420	2.64	430	0.074	0.012	0.68	4.80	0.000	38.0	3736	1075	23.2	0.73	0.90	3307	0.000	1305	0.105	27
657	Alnarp	**Kärn 1**	Spring	Old cultivar	2.26	2.300	2.20	399	0.066	0.013	0.82	4.72	0.000	36.5	3948	1181	18.6	0.77	1.09	3539	0.000	1310	0.079	26
660	Alnarp	**Fylgia 2**	Spring	Old cultivar	2.74	1.902	1.50	352	0.094	0.018	1.42	5.16	0.000	55.0	3580	1369	31.6	1.02	1.08	3927	0.011	1607	0.129	32
661	Alnarp	**Möystad**	Spring	Old cultivar	1.39	2.580	1.16	369	0.081	0.024	0.62	5.16	0.000	40.4	3504	1162	21.7	0.94	2.84	3545	0.001	1375	0.066	33
665	Alnarp	**Dala 2**	Spring	Landrace	10.70	2.280	1.14	433	0.075	0.029	1.99	5.44	0.000	56.9	3568	1428	31.2	4.42	1.29	4167	0.026	1461	0.117	41
668	Alnarp	**Svenno np**	Spring	Old cultivar	6.72	2.220	1.90	436	0.081	0.018	1.43	5.58	0.002	51.1	3833	1676	26.2	3.26	4.16	4703	0.000	1590	0.084	36
671	Alnarp	**Svenno 1**	Spring	Old cultivar	4.84	1.822	1.74	418	0.061	0.007	0.43	5.00	0.000	38.4	3891	1270	19.9	2.60	0.43	3778	0.005	1365	0.118	29

Prov	Location	Genotype name	Type	Group	Al	B	Ba	Ca	Cd	Co	Cr	Cu	Hg	Fe	K	Mg	Mn	Mo	Ni	P	Pb	S	Se	Zn
672	Alnarp	**Rival 1**	Spring	Old cultivar	12.60	3.760	1.50	518	0.058	0.016	0.61	6.82	0.000	52.6	3874	1617	27.6	2.84	5.86	4496	0.006	1561	0.128	55
674	Alnarp	**Fylgia 1**	Spring	Old cultivar	3.80	2.580	1.46	436	0.081	0.012	0.85	5.98	0.000	53.0	3272	1486	33.7	3.46	2.10	4188	0.001	1685	0.153	39
675	Alnarp	**Dala 1**	Spring	Landrace	1.21	2.500	1.24	465	0.062	0.011	0.40	5.04	0.000	41.9	3568	1353	27.0	3.42	0.89	4097	0.000	1444	0.141	36
677	Alnarp	**T. dicoccum kort**	Spring	Primitive	2.48	2.240	1.18	482	0.073	0.011	1.51	5.66	0.002	52.1	4330	1618	27.1	3.42	1.05	5281	0.024	1751	0.218	41
680	Alnarp	**Atle 4**	Spring	Old cultivar	2.62	2.540	1.82	482	0.061	0.009	0.29	4.70	0.001	41.1	3832	1400	27.3	2.42	1.45	4121	0.000	1480	0.106	33
681	Alnarp	**Lv. Dal vit borst**	Spring	Landrace	1.36	2.220	3.26	487	0.084	0.008	0.48	6.74	0.001	43.8	3272	1498	27.4	3.10	1.53	4142	0.007	1427	0.126	33
682	Alnarp	**Reno**	Spring	Cultivar	3.34	2.580	2.28	514	0.070	0.009	0.50	5.52	0.000	40.0	4024	1407	25.1	2.14	0.83	4247	0.019	1530	0.120	36
683	Alnarp	**Progress 2**	Spring	Old cultivar	3.08	3.960	1.56	420	0.071	0.011	0.54	5.94	0.000	50.8	3627	1511	25.5	2.66	2.20	4059	0.009	1454	0.206	43
686	Alnarp	**Kenya**	Spring	Old cultivar	4.12	2.960	0.89	469	0.093	0.025	0.55	5.86	0.003	60.7	3425	1883	34.0	3.80	2.02	4930	0.011	2202	0.199	50
687	Alnarp	**Red Fite 2**	Spring	Old cultivar	1.35	1.704	1.51	443	0.067	0.007	0.36	7.22	0.000	45.5	3434	1499	30.6	3.98	0.47	4272	0.008	1726	0.149	42
688	Alnarp	**Atson 1**	Spring	Old cultivar	6.76	1.716	1.98	437	0.054	0.024	1.83	6.96	0.000	40.9	4936	1118	24.1	1.49	1.81	3900	0.005	1226	0.061	37
692	Alnarp	**Ölands urval 10 borst spelt**	Spring	Spelt	1.47	3.140	2.12	526	0.075	0.014	0.48	6.60	0.000	44.9	3683	1524	31.8	2.84	1.40	4743	0.000	1709	0.354	55
693	Alnarp	**Urval Ölands 1 brun borst**	Spring	Landrace	1.44	2.420	1.92	492	0.067	0.012	0.53	4.84	0.002	43.2	3421	1421	24.1	1.42	2.30	4224	0.009	1429	0.127	42
694	Alnarp	**Rival 2**	Spring	Old cultivar	1.66	1.956	1.45	418	0.060	0.010	0.34	5.08	0.000	44.6	4205	1379	33.0	2.72	0.62	4384	0.003	1463	0.182	45
695	Alnarp	**Utrecht blue**	Spring	Primitive	1.17	2.420	2.24	423	0.048	0.007	0.40	6.80	0.001	43.2	5184	1284	23.4	0.76	0.83	4719	0.006	1700	0.139	51
696	Alnarp	**Ölands 10 borst spelt kort**	Spring	Spelt	1.47	1.350	2.02	331	0.086	0.011	0.28	5.46	0.003	45.8	3904	1475	23.7	2.28	0.79	4658	0.013	1594	0.238	48
697	Alnarp	**Dala 16 brun 2**	Spring	Landrace	1.95	2.200	2.16	469	0.052	0.012	0.59	5.84	0.000	37.9	4103	1113	30.8	0.90	0.86	4022	0.011	1487	0.167	43
698	Alnarp	**Red Fite**	Spring	Old cultivar	0.97	2.400	2.98	512	0.080	0.008	0.40	5.40	0.000	36.4	3871	1229	24.7	0.89	1.05	3915	0.002	1306	0.107	40
700	Alnarp	**Aurore 2**	Spring	Old cultivar	1.63	2.280	1.05	439	0.051	0.015	0.33	4.90	0.000	37.3	4067	1301	25.6	1.19	1.34	4152	0.009	1595	0.161	39
702	Alnarp	**Lv. Gotland 6**	Spring	Spelt	1.89	1.310	3.34	351	0.059	0.012	0.43	4.78	0.003	38.4	4350	1126	26.5	1.01	0.80	3985	0.013	1413	0.101	37
703	Alnarp	**Lv. Gotland II**	Spring	Spelt	2.64	1.370	2.38	308	0.086	0.012	0.46	6.40	0.000	45.0	4711	1406	30.0	1.67	0.78	4665	0.021	1538	0.206	39
705	Alnarp	**Ölands 17 borst spelt**	Spring	Spelt	4.88	1.870	1.89	471	0.067	0.017	0.90	5.32	0.000	50.9	3845	1353	25.0	1.01	0.80	4289	0.010	1536	0.109	51
706	Alnarp	**Lv. Dal 16 vit**	Spring	Landrace	11.14	2.340	2.58	650	0.053	0.041	3.86	4.96	0.001	56.6	4072	1257	33.3	3.06	11.46	4696	0.015	1506	0.093	54
708	Alnarp	**Diamant kort 2**	Spring	Old cultivar	4.10	2.920	3.44	591	0.059	0.026	2.74	4.56	0.000	30.5	3989	1120	23.6	3.82	12.36	3527	0.004	1194	0.182	43
709	Alnarp	**T. boeoticum**	Spring	Primitive	4.14	2.860	2.42	724	0.044	0.012	0.92	6.58	0.000	57.9	4736	1357	42.1	3.84	1.72	4936	0.010	1937	0.398	63
711	Alnarp	**Rival 1**	Spring	Old cultivar	1.42	2.440	2.22	465	0.075	0.013	0.38	5.60	0.000	38.9	3627	1300	29.4	1.48	1.33	4104	0.020	1511	0.151	43
712	Alnarp	**Lv. Halland I**	Spring	Landrace	2.50	3.860	1.76	504	0.060	0.018	0.73	6.58	0.000	40.5	4480	1245	28.5	1.12	1.65	4272	0.001	1581	0.080	48
715	Alnarp	**Fylgia I**	Spring	Old cultivar	4.16	2.340	2.00	494	0.060	0.027	1.56	5.46	0.002	48.7	4153	1209	33.2	1.44	1.90	4064	0.000	1390	0.117	50
717	Alnarp	**Peko vitborst**	Spring	Old cultivar	0.78	2.240	0.99	374	0.080	0.007	0.41	3.88	0.000	32.6	3597	1010	22.5	0.83	1.00	3366	0.000	1331	0.082	41
718	Alnarp	**Öland 5**	Spring	Landrace	1.77	2.260	2.20	484	0.075	0.017	0.55	5.72	0.000	43.0	3946	1422	27.9	1.51	1.33	4371	0.000	1567	0.098	48
719	Alnarp	**Lv. Dal 16 brun borst I**	Spring	Landrace	4.50	2.360	2.06	484	0.072	0.020	1.00	4.92	0.003	48.3	3833	1316	27.7	1.50	1.89	4032	0.009	1456	0.112	45
720	Alnarp	**Lv. Gotland 8**	Spring	Spelt	1.30	1.046	2.06	274	0.068	0.012	0.36	5.66	0.004	38.6	3969	1186	22.8	1.76	0.69	4011	0.012	1373	0.276	33
721	Alnarp	**Ostby 2**	Spring	Old cultivar	1.69	2.180	2.82	506	0.087	0.013	0.53	6.06	0.000	42.9	3948	1287	29.1	1.03	1.43	4414	0.001	1586	0.082	47
722	Alnarp	**Lv. Gotland 6 borst 1**	Spring	Spelt	1.22	2.480	3.86	404	0.078	0.008	0.36	5.00	0.000	37.6	4864	1368	24.3	1.01	0.85	4586	0.002	1507	0.147	37

Prov	Location	Genotype name	Type	Group	Al	B	Ba	Ca	Cd	Co	Cr	Cu	Hg	Fe	K	Mg	Mn	Mo	Ni	P	Pb	S	Se	Zn
723	Alnarp	**Ölands urval 7**	Spring	Landrace	1.26	2.900	2.04	419	0.081	0.010	0.56	5.90	0.000	46.3	3639	1398	28.5	1.46	0.91	4230	0.005	1611	0.226	50
724	Alnarp	**Ölands 6 I**	Spring	Landrace	0.48	1.866	2.08	430	0.076	0.005	0.22	5.02	0.000	44.0	3981	1472	31.1	0.71	0.27	4519	0.010	1536	0.092	42
725	Alnarp	**APU borst**	Spring	Old cultivar	2.36	2.160	3.40	519	0.093	0.016	2.14	7.42	0.000	49.7	3711	1341	27.2	2.48	10.22	4078	0.028	1524	0.062	46
727	Alnarp	**Lv. Gotland 2**	Spring	Spelt	7.26	2.480	1.95	342	0.068	0.019	0.89	6.02	0.000	63.1	4481	1244	26.7	1.13	0.91	4230	0.005	1400	0.110	39
732	Alnarp	**Ölands urval spelt**	Spring	Spelt	0.72	2.080	1.26	362	0.063	0.008	0.32	5.04	0.000	42.2	3848	1152	27.3	2.44	4.08	4015	0.001	1403	0.100	43
733	Alnarp	**Rollo**	Spring	Cultivar	1.07	0.000	1.08	354	0.073	0.007	0.37	6.04	0.000	38.4	4990	1205	20.0	0.66	0.62	4282	0.000	1396	0.075	42
734	Alnarp	**Kolben**	Spring	Old cultivar	0.64	2.460	2.30	414	0.065	0.006	0.31	5.08	0.000	38.5	3763	1285	26.0	0.77	0.83	4188	0.000	1466	0.066	46
735	Alnarp	**Lv. Gotland borst 1**	Spring	Spelt	1.21	1.584	2.94	393	0.078	0.005	0.25	8.22	0.000	34.5	4464	1318	26.4	1.06	0.39	4261	0.020	1500	0.230	35
736	Alnarp	**Lv. Halland I brun**	Spring	Landrace	4.04	2.540	1.97	499	0.060	0.015	0.50	6.28	0.000	39.5	4548	1329	29.0	0.74	0.97	4420	0.000	1481	0.031	44
741	Alnarp	**Touko**	Spring	Old cultivar	1.77	0.302	1.61	467	0.047	0.005	0.35	4.34	0.000	39.0	3750	1311	28.6	0.97	0.40	4010	0.000	1361	0.107	39
744	Bohus Län	**Stava**	Winter	Cultivar	2.46	2.020	2.18	316	0.030	0.010	0.52	2.64	0.000	33.2	3223	1032	31.2	1.55	1.21	2843	0.007	871	0.020	28
745	Bohus Län	**Jarl**	Winter	Old cultivar	0.54	0.440	0.62	354	0.055	0.006	0.36	3.64	0.000	37.1	3540	1191	46.0	1.36	0.55	3472	0.000	1085	0.044	36
746	Bohus Län	**Brun spelt**	Winter	Spelt	11.60	0.000	0.32	266	0.026	0.010	0.40	5.18	0.000	43.6	3373	1146	27.8	1.75	1.06	3600	0.004	1209	0.026	49
747	Bohus Län	**B 13867 spelt**	Winter	Spelt	1.52	1.912	0.86	229	0.035	0.012	0.17	3.64	0.001	45.4	3597	1199	21.1	1.66	1.36	3452	0.000	1022	0.000	33
748	Bohus Län	**Inntaler tress**	Winter	Old cultivar	0.87	2.040	2.22	459	0.035	0.031	0.46	4.18	0.000	45.1	3383	1189	43.4	1.21	2.86	3354	0.001	1048	0.018	39
749	Bohus Län	**Pansar III**	Winter	Old cultivar	1.58	2.140	1.32	300	0.044	0.009	0.39	3.20	0.001	29.0	3151	998	34.7	1.23	1.61	2789	0.007	911	0.043	27
750	Bohus Län	**Jacoby borst**	Winter	Landrace	0.91	2.020	1.94	383	0.037	0.011	0.43	3.44	0.000	38.8	3184	1102	47.9	1.48	0.98	3037	0.011	976	0.045	35
751	Bohus Län	**Banco**	Winter	Old cultivar	0.65	1.332	1.77	333	0.051	0.008	0.22	3.40	0.000	32.3	3164	1109	39.0	1.40	1.16	3165	0.000	976	0.034	33
752	Bohus Län	**Hansa brun**	Winter	Old cultivar	1.27	1.652	1.24	317	0.034	0.006	0.32	3.46	0.000	37.6	3311	1043	39.5	1.29	0.71	3071	0.000	1015	0.059	31
753	Bohus Län	**Holger**	Winter	Old cultivar	0.59	2.220	3.06	345	0.041	0.010	0.45	3.50	0.001	39.9	3225	1222	42.2	1.73	0.96	3222	0.007	984	0.053	37
754	Bohus Län	**Jacoby urval**	Winter	Landrace	0.63	2.340	2.12	359	0.048	0.008	0.37	4.56	0.000	44.7	4033	1449	42.9	1.69	1.00	3894	0.000	1063	0.000	43
755	Bohus Län	**Hansa**	Winter	Old cultivar	0.42	0.046	0.59	378	0.028	0.006	0.25	4.62	0.000	44.7	3984	1530	46.8	1.70	0.70	3955	0.000	1038	0.050	42
756	Bohus Län	**Aros**	Winter	Old cultivar	0.28	0.000	1.53	364	0.030	0.009	0.37	3.70	0.000	31.0	3204	1145	42.2	1.54	0.78	3110	0.000	957	0.058	34
757	Bohus Län	**Olivin**	Winter	Cultivar	0.90	0.976	1.10	318	0.026	0.008	0.35	2.86	0.000	30.6	3386	1106	28.2	1.10	0.82	2805	0.007	899	0.006	25
758	Bohus Län	**Vit spelt**	Winter	Spelt	1.73	1.690	0.50	315	0.036	0.007	0.28	3.40	0.001	42.7	3208	1062	25.5	1.71	1.34	3286	0.004	1022	0.000	35
759	Bohus Län	**Vit spelt**	Winter	Spelt	1.16	0.000	0.31	315	0.046	0.016	0.41	3.76	0.000	43.5	3156	1087	39.7	0.94	1.64	3189	0.008	905	0.068	43
760	Bohus Län	**Hansa brun**	Winter	Old cultivar	0.63	1.284	1.54	331	0.042	0.008	0.27	3.84	0.000	38.2	3440	1154	48.7	0.85	1.18	3198	0.000	976	0.038	34
761	Bohus Län	**Aros**	Winter	Old cultivar	0.21	2.180	2.58	380	0.043	0.009	0.23	3.62	0.013	36.4	3515	1275	49.4	1.42	1.15	3317	0.007	954	0.032	33
762	Bohus Län	**Holger**	Winter	Old cultivar	0.69	2.160	2.64	264	0.052	0.014	0.38	3.56	0.000	39.6	2559	972	47.1	1.69	1.15	3152	0.007	951	0.033	35
763	Bohus Län	**Pansar III**	Winter	Old cultivar	1.36	2.260	1.98	337	0.056	0.007	0.23	4.28	0.000	36.8	4044	1431	52.6	0.90	1.00	3791	0.000	989	0.024	38
764	Bohus Län	**Jacoby borst**	Winter	Landrace	0.51	2.200	3.26	440	0.059	0.016	0.31	4.26	0.000	43.0	3881	1536	73.9	1.32	1.73	3998	0.000	1033	0.013	45
765	Bohus Län	**Inntaler tress**	Winter	Old cultivar	1.48	1.814	3.14	449	0.050	0.032	0.32	3.78	0.000	36.2	3500	1289	57.5	1.30	2.86	3470	0.014	1070	0.031	43
766	Bohus Län	**stava**	Winter	Cultivar	0.59	2.320	1.63	307	0.032	0.009	0.37	2.30	0.001	30.3	2885	958	29.9	1.17	0.99	2570	0.007	804	0.054	25
767	Bohus Län	**Olivin**	Winter	Cultivar	0.79	0.160	0.99	267	0.035	0.006	0.32	3.18	0.000	29.9	2969	1046	36.2	0.70	0.51	2573	0.000	824	0.024	26

Prov	Location	Genotype name	Type	Group	Al	B	Ba	Ca	Cd	Co	Cr	Cu	Hg	Fe	K	Mg	Mn	Mo	Ni	P	Pb	S	Se	Zn
768	Bohus Län	**Jacoby urval**	Winter	Landrace	0.57	2.080	2.08	352	0.054	0.008	0.33	4.78	0.001	41.3	3511	1219	45.9	1.30	0.82	3404	0.008	993	0.046	37
769	Bohus Län	**Banco**	Winter	Old cultivar	0.52	0.882	1.00	352	0.050	0.005	0.19	3.16	0.000	33.2	3138	1179	38.3	1.13	0.72	3205	0.003	935	0.016	32
770	Bohus Län	**B 13867 spelt**	Winter	Spelt	1.89	0.000	0.45	231	0.038	0.008	0.33	4.72	0.000	46.0	4099	1463	30.2	1.34	1.06	4107	0.000	994	0.041	42
771	Bohus Län	**Brun spelt**	Winter	Spelt	2.04	1.868	0.83	301	0.037	0.007	0.28	5.72	0.000	40.9	3510	1221	34.3	1.23	1.02	3735	0.013	1208	0.055	44
772	Bohus Län	**Hansa**	Winter	Old cultivar	1.23	2.180	1.24	305	0.041	0.007	0.32	3.60	0.001	36.7	3121	1091	51.7	0.96	1.17	2971	0.007	956	0.041	33
773	Gotland	**Lantvete Gotland borst 7/5**	Spring	Spelt	1.94	1.844	2.52	329	0.053	0.006	0.17	7.18	0.001	35.1	4062	1442	12.4	0.77	0.83	4226	0.001	1555	0.024	38
774	Gotland	**Lantvete Gotland borst 2**	Spring	Spelt	1.99	2.020	1.87	291	0.030	0.005	0.25	5.28	0.000	27.3	3324	1010	7.5	0.92	0.56	2963	0.017	1372	0.061	27
775	Gotland	**Lantvete Gotland borst 1**	Spring	Spelt	7.72	2.780	2.32	372	0.055	0.016	0.23	9.06	0.000	27.8	3969	1380	8.0	0.92	1.81	3222	0.024	1203	0.107	40
776	Gotland	**Lantvete Gotland 6 borst**	Spring	Spelt	0.73	1.854	2.32	299	0.034	0.002	0.29	5.50	0.000	29.9	4079	1244	8.5	0.87	0.51	3547	0.008	1428	0.079	30
777	Gotland	**Lantvete Gotland borst 1**	Spring	Spelt	3.86	0.000	0.56	285	0.045	0.004	0.48	6.84	0.000	39.4	3710	1296	14.5	0.65	0.51	3795	0.006	1628	0.049	46
779	Gotland	**Lantvete Gotland 1 vete**	Spring	Spelt	0.91	0.000	0.64	306	0.034	0.009	0.25	5.62	0.000	34.2	3432	1065	16.5	0.32	0.82	3177	0.002	1330	0.055	35
780	Gotland	**Öland 62**	Spring	Landrace	2.68	2.000	0.94	427	0.038	0.005	0.33	5.94	0.000	42.7	3056	1214	17.0	0.27	0.67	3390	0.029	1465	0.017	38
781	Gotland	**Ölands 13 vete**	Spring	Landrace	2.02	2.020	0.95	342	0.039	0.017	0.24	4.94	0.000	40.6	3112	1080	18.0	0.29	2.08	3041	0.020	1247	0.000	31
784	Gotland	**Ölands 18 fält sammet**	Spring	Landrace	2.44	0.000	0.47	376	0.027	0.004	0.51	6.00	0.000	38.3	2768	1170	15.7	0.61	1.67	3317	0.004	1372	0.068	36
785	Gotland	**Spelt vete Gotland**	Winter	Spelt	2.82	1.926	0.28	330	0.009	0.004	0.29	5.80	0.000	26.6	3537	990	8.3	1.07	0.99	3239	0.022	1239	0.034	35
786	Gotland	**6356**	Winter	Landrace	1.25	2.080	0.62	339	0.009	0.012	0.30	4.60	0.000	19.8	3375	1011	12.4	0.83	1.65	2956	0.005	928	0.011	28
787	Gotland	**6356 spelt**	Winter	Spelt	1.97	1.914	1.01	306	0.011	0.005	0.22	5.00	0.000	22.0	3647	1177	12.4	0.93	0.73	3509	0.001	1264	0.004	31
788	Gotland	**Ölands 61**	Spring	Landrace	1.13	2.040	1.05	402	0.046	0.005	0.27	5.78	0.001	43.3	2994	1197	16.8	0.42	0.82	3308	0.002	1466	0.018	33
789	Gotland	**Ölands 5**	Spring	Landrace	1.90	0.000	0.57	434	0.033	0.005	0.35	6.22	0.000	48.0	3310	1294	20.9	0.34	0.60	3597	0.001	1384	0.031	41
790	Gotland	**Lantvete Gotland 4 vete**	Spring	Spelt	1.22	0.000	0.82	296	0.028	0.003	0.27	5.28	0.000	29.7	3279	1123	21.2	0.31	0.45	3317	0.002	1187	0.038	27
791	Gotland	**Ölands 16**	Spring	Landrace	2.56	0.000	0.79	334	0.033	0.006	0.47	5.38	0.000	41.4	3270	1104	19.1	0.32	0.75	3214	0.009	1327	0.068	43
792	Gotland	**Enkorn**	Winter	Primitive	1.70	1.978	1.38	496	0.005	0.002	0.21	8.64	0.000	22.0	4331	1071	11.7	0.85	0.34	3851	0.023	1362	0.058	45
793	Gotland	**Svart emmer**	Winter	Primitive	23.40	1.854	0.57	337	0.011	0.005	0.22	5.76	0.000	17.4	3571	985	6.8	0.77	0.64	3050	0.027	1244	0.032	35
794	Gotland	**Röd Emmer**	Winter	Primitive	16.58	1.866	0.29	350	0.021	0.003	0.21	5.96	0.000	22.8	3729	1193	6.8	1.26	0.34	3760	0.054	1318	0.025	42
795	Gotland	**Enkorn**	Winter	Primitive	3.70	1.998	1.00	420	0.004	0.002	0.23	7.56	0.000	24.2	4015	1001	8.5	0.94	0.31	3686	0.025	1307	0.057	46
796	Uppsala	**Fylgia 93**	Spring	Old cultivar	2.72	1.972	0.80	344	0.063	0.013	1.15	6.40	0.000	59.4	3410	1158	12.4	1.11	1.00	3405	0.035	1508	0.101	46
797	Uppsala	**Lv Dal 10 brun**	Spring	Landrace	0.81	2.240	1.46	500	0.083	0.004	0.38	7.66	0.000	49.6	3524	1275	10.4	0.91	1.01	3659	0.009	1503	0.078	45
798	Uppsala	**Algot**	Spring	Old cultivar	2.04	2.180	1.55	526	0.078	0.010	0.57	7.22	0.000	72.4	3620	1285	10.7	0.72	0.71	3490	0.005	1429	0.090	46
799	Uppsala	**Lv Dal 1**	Spring	Landrace	0.78	2.260	0.88	451	0.057	0.008	0.29	5.64	0.000	47.1	4014	1215	12.8	0.62	0.85	3622	0.007	1405	0.060	42
800	Uppsala	**Atle 1**	Spring	Old cultivar	1.49	0.332	0.63	398	0.057	0.004	0.36	6.04	0.000	60.2	4159	1318	9.7	1.08	0.47	3886	0.003	1447	0.090	49
801	Uppsala	**Atle 2**	Spring	Old cultivar	1.71	1.070	0.77	372	0.057	0.005	0.30	4.64	0.000	52.7	3551	1014	9.7	1.04	0.43	3181	0.026	1494	0.049	38
802	Uppsala	**Lv. Halland alnarp**	Spring	Landrace	1.06	1.490	0.99	427	0.060	0.005	0.33	5.28	0.000	44.5	4003	1173	11.5	0.62	0.81	3407	0.000	1414	0.117	39
803	Uppsala	**Lv. Halland ekhaga**	Spring	Landrace	1.79	1.754	0.93	394	0.055	0.013	0.28	4.66	0.005	41.4	3628	1046	11.6	0.60	1.17	3133	0.024	1381	0.114	36
804	Uppsala	**APU**	Spring	Old cultivar	3.96	0.000	0.31	421	0.052	0.023	0.59	8.32	0.000	86.5	3660	1189	9.3	0.96	1.90	3598	0.004	1619	0.153	60

Prov	Location	Genotype name	Type	Group	Al	B	Ba	Ca	Cd	Co	Cr	Cu	Hg	Fe	K	Mg	Mn	Mo	Ni	P	Pb	S	Se	Zn
805	Uppsala	**Pondus**	Spring	Old cultivar	1.07	2.500	1.18	404	0.063	0.008	0.34	5.80	0.000	52.0	4728	1404	12.0	0.48	0.67	4163	0.000	1397	0.067	51
806	Uppsala	**Atle 3**	Spring	Old cultivar	1.10	2.160	1.42	440	0.057	0.015	0.49	5.30	0.000	54.6	4172	1235	11.7	0.71	1.43	3594	0.010	1427	0.113	42
807	Uppsala	**Atson 99**	Spring	Old cultivar	0.82	0.584	0.77	411	0.051	0.003	0.33	5.14	0.000	49.6	4271	1286	9.3	0.68	0.39	3707	0.002	1388	0.046	43
808	Uppsala	**Progress 2**	Spring	Old cultivar	1.05	2.480	0.65	459	0.070	0.005	0.41	5.94	0.000	50.3	4087	1319	13.4	0.61	0.84	3726	0.001	1434	0.028	53
809	Uppsala	**Red Fite**	Spring	Old cultivar	2.56	2.200	0.88	456	0.055	0.007	0.43	5.98	0.007	50.9	3323	1145	12.8	0.63	0.68	3351	0.011	1479	0.127	49
810	Uppsala	**Ring**	Spring	Cultivar	1.13	1.596	0.93	401	0.057	0.008	0.31	4.86	0.000	49.2	4149	1329	12.2	0.54	0.68	3663	0.007	1371	0.079	44
811	Uppsala	**Diamant brun 2**	Spring	Old cultivar	0.99	1.360	0.68	451	0.056	0.006	0.26	6.42	0.000	56.3	3708	1318	11.7	1.08	0.93	3630	0.000	1601	0.088	50
812	Uppsala	**Aurore 1**	Spring	Old cultivar	1.07	2.140	0.52	420	0.050	0.007	0.31	6.52	0.000	54.2	3932	1258	13.2	1.01	0.83	3665	0.002	1545	0.056	49
813	Uppsala	**Fram**	Spring	Old cultivar	1.03	1.894	0.95	433	0.075	0.005	0.28	6.62	0.000	57.8	3819	1347	13.5	1.32	1.19	3768	0.000	1690	0.139	52
814	Uppsala	**Vinjett**	Spring	Cultivar	1.44	1.138	1.53	353	0.081	0.003	0.48	3.82	0.000	37.6	5445	1270	12.3	1.17	1.88	3512	0.002	1400	0.022	31
815	Uppsala	**Ölands 13**	Spring	Landrace	0.93	2.360	0.77	404	0.065	0.005	0.44	6.28	0.003	63.6	4447	1453	13.7	0.57	1.22	4232	0.013	1473	0.116	50
816	Uppsala	**Ås**	Spring	Old cultivar	1.86	0.242	0.31	427	0.053	0.026	0.49	6.34	0.000	56.3	3188	1231	11.3	0.89	3.10	3429	0.008	1608	0.123	58
817	Uppsala	**William**	Spring	Cultivar	1.96	2.300	0.73	405	0.075	0.007	0.49	5.64	0.000	46.2	4326	1251	13.3	0.89	1.71	3534	0.000	1376	0.034	45
818	Uppsala	**Svenno upp**	Spring	Old cultivar	2.46	2.140	0.97	429	0.078	0.007	0.72	6.40	0.000	56.3	4330	1357	14.6	1.04	2.48	3875	0.010	1506	0.096	52
819	Uppsala	**Lv. Dal 15 vit borst**	Spring	Landrace	0.98	1.386	0.84	433	0.082	0.005	0.29	6.26	0.000	60.0	3949	1560	11.9	1.15	0.86	4284	0.000	1634	0.052	52
820	Uppsala	**Ella**	Spring	Cultivar	7.08	2.380	0.65	443	0.060	0.006	0.29	6.34	0.000	48.8	3895	1282	14.2	0.80	0.68	3969	0.001	1447	0.046	49
821	Uppsala	**Svenno**	Spring	Old cultivar	1.85	2.560	0.96	445	0.059	0.008	0.33	5.46	0.000	46.0	3885	1147	15.1	0.56	0.80	3168	0.000	1453	0.086	45
822	Uppsala	**Fylgia 2**	Spring	Old cultivar	1.56	0.000	0.40	436	0.052	0.007	0.57	7.34	0.000	62.4	3750	1351	15.6	1.23	0.78	3805	0.004	1609	0.134	64
823	Uppsala	**Ex Kolben**	Spring	Old cultivar	0.87	1.570	0.72	380	0.059	0.006	0.38	5.98	0.000	46.0	3895	1281	10.2	0.85	1.24	3908	0.000	1484	0.066	44
824	Uppsala	**Lv. Dal 16 vit borst**	Spring	Landrace	1.71	2.380	1.23	604	0.078	0.006	0.38	7.08	0.000	64.7	3598	1451	13.0	0.97	1.01	4351	0.000	1663	0.072	64
825	Uppsala	**Kärn 1**	Spring	Old cultivar	3.60	0.000	0.73	452	0.048	0.005	0.35	6.14	0.000	48.8	3913	1173	10.8	0.80	0.74	3460	0.011	1456	0.079	45
826	Uppsala	**Lv.dal vit borst**	Spring	Landrace	2.50	2.280	1.17	425	0.077	0.007	0.44	5.64	0.000	50.6	3980	1263	15.4	0.91	1.70	3468	0.001	1427	0.066	47
827	Uppsala	**Svenno 2**	Spring	Old cultivar	1.37	2.340	0.93	411	0.068	0.007	0.31	5.66	0.000	48.8	4269	1247	14.1	0.51	0.72	3533	0.000	1453	0.067	46
828	Uppsala	**Pondus 2**	Spring	Old cultivar	1.50	1.970	0.97	378	0.057	0.004	0.30	5.28	0.000	43.7	3944	1135	11.1	0.46	0.54	3470	0.000	1349	0.110	40
829	Uppsala	**Kärn 2**	Spring	Old cultivar	7.52	0.083	0.52	406	0.044	0.005	0.40	5.90	0.000	42.6	3966	1199	8.2	0.71	0.78	3488	0.000	1341	0.075	39
830	Uppsala	**Sappo**	Spring	Old cultivar	0.84	2.220	1.16	393	0.073	0.007	0.31	5.70	0.002	43.7	3939	1168	20.9	0.65	0.79	3220	0.010	1346	0.089	44
831	Uppsala	**Ölands I borst**	Spring	Landrace	1.92	2.160	0.79	463	0.069	0.008	0.37	6.70	0.000	58.8	3421	1352	12.2	0.74	0.79	3901	0.000	1708	0.061	55
833	Alnarp	**Rival**	Spring	Old cultivar	5.30	3.400	1.47	523	0.056	0.029	2.12	4.52	0.000	48.6	3750	1275	28.8	2.18	2.16	4018	0.014	1288	0.181	40
834	Alnarp	**Atson**	Spring	Old cultivar	10.76	3.780	3.36	464	0.080	0.053	3.40	5.42	0.000	53.1	4228	1230	20.1	1.53	3.02	3858	0.000	1225	0.216	58
835	Alnarp	**Diamant brun**	Spring	Old cultivar	40.00	0.089	1.71	533	0.052	0.113	8.18	6.26	0.000	113.8	4324	1445	28.6	1.92	4.86	4562	0.011	1404	0.180	57
836	Alnarp	**APU**	Spring	Old cultivar	34.00	1.934	2.40	620	0.091	0.076	5.34	7.52	0.001	105.2	3875	1534	34.4	2.02	2.98	4505	0.025	1433	0.195	65
837	Alnarp	**Aurore**	Spring	Old cultivar	18.04	2.660	1.05	451	0.058	0.117	9.96	5.44	0.001	111.0	4236	1339	34.1	2.14	5.48	4270	0.017	1364	0.204	52
838	Alnarp	**Progress**	Spring	Old cultivar	17.02	2.560	1.09	371	0.075	0.068	5.26	6.18	0.000	79.3	4491	1379	31.7	1.44	3.52	4156	0.005	1346	0.132	58
839	Alnarp	**Lv. Dal 15**	Spring	Landrace	4.92	0.000	3.14	530	0.083	0.028	1.96	8.38	0.000	48.5	4099	1426	20.3	1.69	1.22	4587	0.000	1380	0.256	67

Prov	Location	Genotype name	Type	Group	Al	B	Ba	Ca	Cd	Co	Cr	Cu	Hg	Fe	K	Mg	Mn	Mo	Ni	P	Pb	S	Se	Zn
842	Alnarp	**Ur Ölands 8**	Spring	Landrace	2.80	3.920	1.37	378	0.071	0.017	1.11	5.76	0.000	50.7	4109	1406	31.6	3.50	1.14	4540	0.003	1327	0.128	55
843	Alnarp	**Lv Dal 16**	Spring	Landrace	4.44	1.364	1.86	457	0.069	0.030	1.70	5.36	0.000	51.9	4544	1298	34.7	1.73	2.20	4461	0.015	1320	0.128	49
844	Alnarp	**Fylgia röd**	Spring	Old cultivar	27.40	2.780	2.62	459	0.084	0.143	11.86	6.20	0.000	116.2	3894	1305	36.6	2.54	7.36	4107	0.026	1391	0.210	69
845	Alnarp	**Peko borst**	Spring	Old cultivar	8.18	2.280	1.15	425	0.097	0.054	4.54	5.84	0.001	71.4	4367	1303	30.0	1.56	2.48	4202	0.031	1450	0.208	63
847	Alnarp	**Ex Kolben**	Spring	Old cultivar	6.50	2.300	1.80	435	0.070	0.034	2.44	4.72	0.000	52.9	4139	1344	27.7	1.34	1.56	4214	0.013	1374	0.136	44
848	Alnarp	**Algot**	Spring	Old cultivar	7.52	4.100	2.76	537	0.093	0.035	3.90	7.06	0.000	50.2	3885	1298	51.2	3.24	10.90	3949	0.017	1282	0.135	43
849	Alnarp	**Diamant vit**	Spring	Old cultivar	31.20	0.000	1.42	554	0.050	0.089	6.38	6.56	0.000	101.4	4230	1542	33.9	1.95	3.78	4897	0.010	1469	0.210	70
850	Alnarp	**Dala Urval**	Spring	Landrace	1.59	3.660	2.22	407	0.071	0.013	0.89	4.52	0.000	37.5	3857	1201	20.5	1.46	1.40	3947	0.008	1275	0.208	51
851	Alnarp	**Öland I utan borst**	Spring	Landrace	39.60	2.080	2.90	511	0.085	0.086	6.10	6.52	0.000	92.9	3659	1409	29.4	2.44	4.20	4320	0.027	1531	0.189	49
852	Uppsala	**Russisk hvede**	Winter	Landrace	0.90	2.260	1.55	393	0.045	0.031	0.25	4.74	0.000	28.9	3538	955	37.3	0.21	1.45	2878	0.000	1165	0.068	28
853	Uppsala	**Banco lång**	Winter	Old cultivar	0.61	2.760	0.99	349	0.039	0.022	0.33	4.12	0.000	26.7	3292	928	32.9	0.29	1.37	2776	0.020	1141	0.060	26
854	Uppsala	**Svale**	Winter	Old cultivar	1.21	2.500	1.40	341	0.061	0.029	0.31	4.40	0.000	30.1	4080	987	34.5	0.32	1.85	2919	0.002	1161	0.098	28
855	Uppsala	**Walde**	Winter	Old cultivar	0.95	1.900	1.12	333	0.049	0.029	0.26	3.92	0.000	31.0	3577	954	37.2	0.29	2.60	2904	0.000	1178	0.111	29
857	Uppsala	**Aura lång**	Winter	Old cultivar	0.65	2.400	1.38	344	0.070	0.047	0.26	4.54	0.000	32.4	3691	1053	38.4	0.27	2.88	2838	0.000	1190	0.100	28
858	Uppsala	**Erbe**	Winter	Old cultivar	37.60	2.280	1.45	324	0.055	0.066	2.38	4.64	0.000	74.1	3763	950	33.4	0.28	2.72	3012	0.007	1303	0.055	28
859	Uppsala	**Robur**	Winter	Old cultivar	1.53	2.580	1.31	358	0.078	0.028	0.29	4.30	0.000	32.3	3455	912	38.4	0.27	1.36	2687	0.000	1238	0.053	28
860	Uppsala	**Banco**	Winter	Old cultivar	1.16	2.140	1.17	333	0.045	0.027	0.39	4.22	0.001	32.3	3810	1042	36.0	0.30	1.43	3046	0.008	1133	0.116	26
861	Uppsala	**Red Prolific**	Winter	Old cultivar	0.96	2.400	0.98	311	0.061	0.040	0.24	3.62	0.000	32.6	3771	1052	34.8	0.26	2.32	3119	0.000	1122	0.013	28
328-	Gotland	**Ostar**	Winter	Spelt	2.80	1.426	0.99	386	0.038	0.011	0.28	5.24	0.003	39.8	4783	1306	7.6	1.10	1.16	4494	0.030	1402	0.040	36

Appendix 3

Appendix 3. Genotype name, group, type and content of tocochromanol compounds ($mgkg^{-1}$) in the wheat grain.

Sample No	Genotype name	Type	Genotype group	α-T	α-T3	β-T	β-T3	Total Tocotrienols	Total Tocopherols	Total tocochromanols
1	**T. monoccocum**	Winter	Primitive wheat	3.64	8.41	1.00	22.18	30.59	4.64	35.24
2	**Öland 8**	Spring	Landrace	4.19	6.60	1.72	22.04	28.64	5.91	34.55
3	**Lv. Gotland 6**	Spring	Spelt wheat	5.08	4.01	2.85	21.93	25.94	7.94	33.87
4	**Spelt vete Gotland**	Winter	Spelt wheat	2.20	4.02	1.17	20.86	24.88	3.37	28.25
5	**Robur**	Winter	Old cultivar	6.60	2.36	3.06	20.47	22.83	9.66	32.49
6	**Mumie vete**	Winter	Primitive wheat	5.92	3.98	1.89	20.40	24.37	7.81	32.19
7	**Odin**	Winter	Old cultivar	9.81	3.67	4.10	19.70	23.37	13.90	37.27
8	**Olympia**	Winter	Landrace	8.86	4.15	3.96	19.57	23.72	12.82	36.54
9	**Jacoby 59 utan borst**	Winter	Landrace	10.18	3.62	3.45	19.30	22.92	13.63	36.55
10	**Ölands 17 borst spelt**	Spring	Spelt wheat	8.88	3.56	3.28	19.03	22.59	12.16	34.76
11	**Lyshvede brun borst**	Winter	Old cultivar	8.16	3.81	2.67	18.72	22.53	10.83	33.36
12	**Svale**	Winter	Old cultivar	6.81	2.70	3.45	18.35	21.05	10.26	31.31
13	**Aros**	Winter	Old cultivar	8.08	3.78	2.66	18.10	21.87	10.74	32.62
14	**Rauweizen**	Winter	Primitive wheat	8.24	3.47	2.54	17.15	20.62	10.78	31.40
15	**Holme**	Winter	Modern cultivar	8.25	3.47	3.49	16.90	20.36	11.74	32.10
16	**Österr Burgsdorfer**	Winter	Spelt wheat	6.33	3.30	3.92	16.66	19.96	10.24	30.20
17	**Inntaler**	Winter	Old cultivar	6.83	3.25	2.41	16.47	19.71	9.24	28.95
18	**Aura**	Winter	Old cultivar	10.32	4.05	3.67	16.09	20.14	13.99	34.13
19	**Röd Emmer**	Winter	Primitive wheat	1.55	3.48	0.96	15.87	19.35	2.52	21.87
20	**Folke**	Winter	Modern cultivar	9.50	4.14	3.55	15.77	19.91	13.05	32.96
21	**Hansa**	Winter	Old cultivar	7.50	3.54	2.97	15.68	19.22	10.47	29.69
22	**Schwabenkorn**	Winter	Spelt wheat	5.40	4.29	2.67	15.37	19.67	8.07	27.74
23	**Oberkulmer**	Winter	Spelt wheat	5.45	4.20	2.73	14.91	19.12	8.19	27.30
24	**Brun spelt**	Winter	Spelt wheat	5.97	3.98	2.94	14.86	18.84	8.91	27.76
25	**Lv. Gotland 2**	Spring	Spelt wheat	6.87	4.05	3.42	14.80	18.85	10.30	29.15
26	**Vit Emmer**	Winter	Primitive wheat	4.92	3.06	2.28	14.29	17.35	7.21	24.56
27	**Schweiz**	Winter	Spelt wheat	4.75	3.79	2.39	13.82	17.61	7.14	24.75

Sample No	Genotype	Type	Class	α-T	α-T3	β-T	β-T3	Total Tocotrienols	Total Tocopherols	Total tocochromanols
28	**Lv. Dal 16 brun borst I**	Spring	Landrace	13.05	2.82	5.19	13.52	16.33	18.23	34.57
29	**Rival 1**	Spring	Old cultivar	12.24	2.95	4.14	13.26	16.21	16.38	32.59
30	**Lv Dal**	Spring	Landrace	11.82	2.55	4.90	13.08	15.63	16.72	32.35
31	**6356 Spelt**	Winter	Spelt wheat	10.94	4.21	4.19	12.17	16.37	15.13	31.50
32	**Öland 5**	Spring	Landrace	9.64	2.34	3.60	11.93	14.27	13.23	27.50
33	**Lv. Halland I**	Spring	Landrace	11.85	3.04	4.62	10.63	13.67	16.47	30.14
34	**Lv. Dal 16 vit**	Spring	Landrace	12.50	3.05	5.20	10.56	13.60	17.69	31.30
35	**Spelt Ustakket**	Winter	Spelt wheat	6.96	3.40	2.32	10.41	13.81	9.27	23.08
36	**Kolben**	Spring	Old cultivar	9.48	2.17	3.38	10.38	12.55	12.86	25.41
37	**Svart emmer**	Winter	Primitive wheat	6.83	3.90	2.57	9.23	13.14	9.40	22.54
38	**Fylgia I**	Spring	Old cultivar	9.63	2.13	3.25	8.76	10.89	12.89	23.78
39	**Aurore 2**	Spring	Old cultivar	10.61	3.21	3.60	7.67	10.89	14.21	25.09
40	**Östby 2**	Spring	Old cultivar	12.08	2.91	5.28	7.37	10.28	17.36	27.64

Appendix 4

Appendix 4. Growing location, genotype name, type, group and relative amount of different protein fractions in the grain.

Prov number	Location	Genotype name	Type	Group	TOTE (10^8)	TOTU (10^7)	%UPP	%large UPP	%large UMP	Monopol (10^8)
1	Alnarp	**T. Spelta blå**	Winter	Spelt	1.68	4.33	29	29	14	1.91
2	Alnarp	**Ax 4:1**	Winter	Selection	1.65	3.39	24	24	12	1.80
3	Alnarp	**Krachi Gotland**	Winter	Old cultivar	1.38	4.84	42	47	16	1.73
4	Alnarp	**Ax 05**	Winter	Selection	1.60	3.33	21	25	13	1.78
5	Alnarp	**Vama**	Winter	Old cultivar	1.38	3.93	34	37	14	1.63
6	Alnarp	**Holger 2 1026/25**	Winter	Old cultivar	1.25	4.36	39	37	17	1.52
7	Alnarp	**6356**	Winter	Landrace	1.91	3.25	19	20	10	2.02
8	Alnarp	**Aros 1026/1**	Winter	Old cultivar	1.21	3.08	29	32	12	1.37
9	Alnarp	**Zanda 1026/21**	Winter	Old cultivar	1.52	3.02	23	25	10	1.65
10	Alnarp	**LV Gotland vit**	Winter	Landrace	1.46	2.76	22	22	10	1.56
11	Alnarp	**Ax/7**	Winter	Selection	1.42	4.09	34	40	15	1.63
12	Alnarp	**Vama**	Winter	Old cultivar	1.16	3.81	41	50	15	1.40
13	Alnarp	**T. Polonicum**	Winter	Primitive	1.28	5.53	44	54	24	1.70
14	Alnarp	**Eroica 1026/4**	Winter	Old cultivar	1.00	4.23	47	54	19	1.29
15	Alnarp	**Hansa Ax**	Winter	Old cultivar	1.03	2.71	33	40	13	1.16
16	Alnarp	**Ax 14 1027**	Winter	Selection	1.62	5.77	46	53	16	2.01
17	Alnarp	**Hartmut Spiess**	Winter	Cultivar	1.09	4.08	46	55	16	1.36
18	Alnarp	**SOL lV 1026/11**	Winter	Old cultivar	1.18	3.87	40	44	14	1.40
19	Alnarp	**Virtus 1026/14**	Winter	Old cultivar	1.13	3.61	41	46	13	1.33
20	Alnarp	**Schwabenkorn**	Winter	Spelt	1.64	4.32	33	37	14	1.87
21	Alnarp	**Mirakelvete Ax**	Winter	Primitive	1.11	3.67	30	33	21	1.31
22	Alnarp	**Kippenhauser**	Winter	Spelt	1.44	4.55	39	44	16	1.71
23	Alnarp	**6357 Klyvn**	Winter	Selection	1.28	5.27	41	45	22	1.62
24	Alnarp	**Banco**	Winter	Old cultivar	1.17	3.99	39	42	17	1.40
25	Alnarp	**1345(43)**	Winter	Spelt	1.17	3.55	38	39	15	1.36
26	Alnarp	**15 Schweiz**	Winter	Spelt	1.41	3.79	33	36	14	1.58
27	Alnarp	**15 Schweiz**	Winter	Spelt	1.50	4.47	35	37	16	1.74
28	Alnarp	**22 Klyvn**	Winter	Spelt	1.22	3.98	40	43	16	1.44
29	Alnarp	**22 klyvning**	Winter	Spelt	1.65	4.67	34	38	14	1.88
30	Alnarp	**3 Schweiz**	Winter	Spelt	1.41	4.14	34	36	15	1.63
31	Alnarp	**32 comp Ax**	Winter	Selection	1.22	3.15	30	31	13	1.35
32	Alnarp	**32 Schweiz**	Winter	Spelt	1.55	4.09	34	35	13	1.76
33	Alnarp	**33 Schweiz**	Winter	Spelt	1.37	3.69	35	36	13	1.55
34	Alnarp	**4496 comp**	Winter	Spelt	1.21	4.26	42	44	17	1.46
35	Alnarp	**4496 L v Gotland (a x 10)**	Winter	Landrace	1.13	3.72	42	40	14	1.33
36	Alnarp	**4496 spelt**	Winter	Landrace	1.02	3.65	43	43	16	1.22
37	Alnarp	**4496 10 01**	Winter	Landrace	1.41	4.37	35	40	17	1.66
38	Alnarp	**5113 (rad 4)**	Winter	Selection	1.38	3.17	27	31	12	1.50
39	Alnarp	**5113 rad / Brun**	Winter	Selection	1.26	2.52	26	30	8	1.31
40	Alnarp	**5113 rad 4**	Winter	Selection	1.14	2.61	26	29	12	1.20
41	Alnarp	**5113 rod brun**	Winter	Selection	1.40	4.01	33	38	15	1.61
42	Alnarp	**5114**	Winter	Selection	0.91	3.68	43	49	18	1.13
43	Alnarp	**6356**	Winter	Landrace	1.36	3.76	33	41	15	1.57
44	Alnarp	**6356**	Winter	Landrace	1.14	2.78	33	42	12	1.28
45	Alnarp	**6356 Spelt Ax**	Winter	Spelt	1.60	3.88	33	40	11	1.79
46	Alnarp	**6356 spelt**	Winter	Spelt	1.39	3.38	29	35	13	1.53
47	Alnarp	**6357**	Winter	Spelt	1.54	5.53	43	51	17	1.91
48	Alnarp	**6357 Klyvn sp**	Winter	Spelt	1.35	3.80	35	39	12	1.53
49	Alnarp	**6357 10**	Winter	Spelt	1.25	3.59	37	43	13	1.44
50	Alnarp	**6357**	Winter	Spelt	1.39	5.14	41	45	18	1.69
51	Alnarp	**6357 24**	Winter	Spelt	1.48	5.53	38	43	19	1.80

Prov number	Location	Genotype name	Type	Group	TOTE (10^8)	TOTU (10^7)	%UPP	%large UPP	%large UMP	Monopol (10^8)
52	Alnarp	**6357 Ax 9:1**	Winter	Spelt	1.45	4.13	33	38	16	1.68
53	Alnarp	**6357 Ax 4:1 vet**	Winter	Spelt	1.05	4.29	45	49	17	1.32
54	Alnarp	**6357 blå**	Winter	Spelt	1.37	6.28	49	55	21	1.82
55	Alnarp	**6357 blå**	Winter	Spelt	1.15	4.90	47	52	19	1.47
56	Alnarp	**6357 brun**	Winter	Spelt	1.52	5.32	39	43	19	1.86
57	Alnarp	**6357 klyvn**	Winter	Spelt	1.39	4.40	33	31	16	1.58
59	Alnarp	**6357 vit**	Winter	Spelt	1.61	4.39	27	26	18	1.86
60	Alnarp	**6358**	Winter	Spelt	1.23	4.06	37	37	18	1.46
61	Alnarp	**6358 16A3**	Winter	Landrace	1.32	5.01	40	38	20	1.62
62	Alnarp	**6358 brun röd Ax**	Winter	Landrace	1.16	4.29	40	36	19	1.41
63	Alnarp	**6358 Brun röd Ax**	Winter	Landrace	1.22	3.93	33	28	18	1.42
64	Alnarp	**6358 vit**	Winter	Landrace	1.16	4.01	35	31	19	1.36
65	Alnarp	**6692**	Winter	Landrace	1.26	2.84	22	20	14	1.36
67	Alnarp	**A x 11 bruna**	Winter	Selection	1.20	3.23	25	22	17	1.33
68	Alnarp	**A x3**	Winter	Selection	1.19	4.46	33	29	23	1.43
69	Alnarp	**Agron**	Winter	Cultivar	0.92	5.34	52	50	27	1.31
70	Alnarp	**Agron**	Winter	Cultivar	1.22	3.09	29	28	13	1.37
71	Alnarp	**Albihn**	Winter	Spelt	1.54	2.64	20	21	10	1.65
72	Alnarp	**Armensk vete**	Winter	Landrace	1.14	2.95	31	36	14	1.32
73	Alnarp	**Armensk borst**	Winter	Landrace	1.48	3.95	32	35	14	1.69
74	Alnarp	**Armensk vete**	Winter	Landrace	1.27	4.43	41	46	17	1.58
75	Alnarp	**Aros Ax**	Winter	Old cultivar	0.87	2.84	36	35	18	1.06
76	Alnarp	**Aszita**	Winter	Cultivar	1.43	3.23	24	26	13	1.61
77	Alnarp	**Aszita**	Winter	Cultivar	1.19	3.89	33	35	18	1.44
78	Alnarp	**Aura Ax**	Winter	Old cultivar	1.01	2.23	24	26	13	1.14
79	Alnarp	**Aura lång Ax**	Winter	Old cultivar	1.13	2.53	26	28	13	1.27
80	Alnarp	**Ax 9:1**	Winter	Selection	1.60	3.00	20	24	13	1.79
82	Alnarp	**Ax 14**	Winter	Selection	1.30	2.32	20	25	11	1.44
83	Alnarp	**Ax 14**	Winter	Selection	1.87	4.29	27	29	13	2.08
85	Alnarp	**Ax 3**	Winter	Selection	1.67	3.10	19	19	12	1.80
86	Alnarp	**Ax 4:1 1027**	Winter	Selection	1.64	3.52	24	25	13	1.80
89	Alnarp	**Ax 4:2**	Winter	Selection	1.41	2.51	19	22	11	1.52
91	Alnarp	**Ax 4:1 spelt**	Winter	Selection	1.71	3.30	22	25	12	1.91
92	Alnarp	**Ax 4:1spelt**	Winter	Selection	1.88	3.48	22	24	12	2.06
93	Alnarp	**Ax 4:2 brun**	Winter	Selection	1.20	3.99	38	37	16	1.46
94	Alnarp	**Ax 4:2 vit**	Winter	Selection	1.35	3.73	29	28	16	1.57
95	Alnarp	**Ax 7**	Winter	Selection	1.29	3.80	29	27	18	1.53
97	Alnarp	**Ax11**	Winter	Selection	1.33	3.48	24	25	17	1.55
98	Alnarp	**Ax-5**	Winter	Selection	1.52	4.89	34	35	18	1.84
99	Alnarp	**Ax5**	Winter	Selection	1.56	4.19	24	26	18	1.84
100	Alnarp	**Banco 1026/2**	Winter	Old cultivar	1.21	3.76	30	28	18	1.41
101	Alnarp	**Bore II (1026/3)**	Winter	Old cultivar	1.34	4.18	32	33	17	1.58
102	Alnarp	**Borstv Gotland MAX**	Winter	Landrace	1.29	3.28	25	25	16	1.45
103	Alnarp	**Borstv Gotland max**	Winter	Landrace	1.44	3.72	25	25	16	1.63
104	Alnarp	**Borst vete Gotland Ax**	Winter	Landrace	1.32	3.68	32	32	15	1.52
105	Alnarp	**Borst vete Gotland Ax**	Winter	Landrace	1.15	3.33	29	31	18	1.36
106	Alnarp	**Browichs röd**	Winter	Landrace	1.18	2.99	20	19	17	1.33
107	Alnarp	**Brun spelt Alnarp 1027**	Winter	Spelt	2.11	4.35	24	25	12	2.31
108	Alnarp	**Capu**	Winter	Cultivar	1.09	4.62	45	52	21	1.44
109	Alnarp	**Capu**	Winter	Cultivar	1.10	4.06	36	37	22	1.40
110	Alnarp	**Capu 1027**	Winter	Cultivar	1.28	5.17	43	46	20	1.65
111	Alnarp	**Durum Ax**	Winter	Primitive	0.83	2.48	27	32	19	1.00

Prov number	Location	Genotype name	Type	Group	TOTE (10^8)	TOTU (10^7)	%UPP	%large UPP	%large UMP	Monopol (10^8)
112	Alnarp	**Effrada**	Winter	Cultivar	1.04	4.49	46	48	20	1.37
113	Alnarp	**Effrada**	Winter	Cultivar	0.92	5.04	47	49	28	1.31
114	Alnarp	**Enkorn svart Ax**	Winter	Primitive	1.88	4.66	30	28	13	2.13
115	Alnarp	**Enkorn Metala Ax**	Winter	Primitive	2.04	1.95	8	9	7	2.07
116	Alnarp	**Erbe 1026/24**	Winter	Old cultivar	1.36	4.03	32	31	16	1.58
117	Alnarp	**Erbe brun Ax**	Winter	Old cultivar	1.40	4.79	37	37	18	1.71
118	Alnarp	**Erbe brun**	Winter	Old cultivar	1.09	4.51	38	31	24	1.41
119	Alnarp	**Eroica Ax**	Winter	Old cultivar	0.88	4.14	40	31	27	1.18
120	Alnarp	**Ertus Ax**	Winter	Old cultivar	1.14	4.10	26	23	25	1.43
121	Alnarp	**Ertus 1026/ 5**	Winter	Old cultivar	1.05	5.31	44	38	27	1.45
122	Alnarp	**Extrem**	Winter	Cultivar	1.01	7.35	56	53	37	1.66
123	Alnarp	**Extrem**	Winter	Cultivar	1.11	6.63	48	44	33	1.68
124	Alnarp	**Gammel land v.lådden Ax**	Winter	Landrace	1.29	2.62	20	20	12	1.38
125	Alnarp	**Gammel landv**	Winter	Landrace	1.40	3.48	28	30	13	1.54
126	Alnarp	**Gammel landv röd spelt**	Winter	Landrace	1.41	3.39	28	28	12	1.53
127	Alnarp	**Gammel land vete**	Winter	Landrace	1.08	3.03	31	34	15	1.25
128	Alnarp	**Golden Ax**	Winter	Spelt	1.55	3.90	29	30	16	1.82
129	Alnarp	**Golden 10**	Winter	Spelt	1.36	4.95	44	51	19	1.74
130	Alnarp	**Golden 10**	Winter	Spelt	1.24	4.27	33	31	20	1.51
131	Alnarp	**Golden Ax-10**	Winter	Spelt	1.23	5.09	43	45	20	1.57
132	Alnarp	**Golden urval**	Winter	Spelt	1.63	4.31	27	24	16	1.84
133	Alnarp	**Halländsk Lantv 1026/16**	Winter	Landrace	1.32	3.38	29	29	13	1.46
134	Alnarp	**Halländska**	Winter	Landrace	1.05	2.66	27	27	14	1.17
135	Alnarp	**Hansa Ax**	Winter	Old cultivar	1.06	2.50	24	23	14	1.16
136	Alnarp	**Hansa**	Winter	Old cultivar	1.18	3.52	34	36	15	1.35
137	Alnarp	**Hansa Ax**	Winter	Old cultivar	1.13	2.79	30	33	13	1.28
138	Alnarp	**Hansa brun Ax**	Winter	Old cultivar	1.20	4.50	47	52	16	1.52
139	Alnarp	**Hansa brun (1026/26)**	Winter	Old cultivar	1.33	4.88	43	48	16	1.64
140	Alnarp	**Hartmut Spiess 1027**	Winter	Cultivar	1.30	5.06	46	52	15	1.64
142	Alnarp	**Helge Ax**	Winter	Cultivar	1.00	4.19	46	49	20	1.30
143	Alnarp	**Hartmut Spiess**	Winter	Cultivar	1.12	3.91	39	43	16	1.36
145	Alnarp	**Holger Brun Ax**	Winter	Old cultivar	1.27	4.07	36	38	15	1.49
146	Alnarp	**Holger Brun Ax**	Winter	Old cultivar	0.99	3.40	40	43	15	1.20
147	Alnarp	**Holger Brun lång Ax**	Winter	Old cultivar	1.08	4.48	47	46	20	1.41
148	Alnarp	**Inntaler**	Winter	Old cultivar	1.27	3.83	35	38	15	1.49
149	Alnarp	**Inntaler Ax**	Winter	Old cultivar	1.23	3.51	34	37	13	1.41
150	Alnarp	**Inntaler Ax**	Winter	Old cultivar	1.15	2.49	23	22	12	1.23
152	Alnarp	**Inntaler tress Ax**	Winter	Old cultivar	1.20	3.20	28	28	15	1.34
153	Alnarp	**Inntaller 1027**	Winter	Old cultivar	1.43	3.26	26	26	12	1.54
154	Alnarp	**Jacoby 59 utan borst Ax**	Winter	Landrace	1.14	3.30	34	36	15	1.34
155	Alnarp	**Jacoby borst Ax**	Winter	Landrace	1.29	3.07	29	30	13	1.46
156	Alnarp	**Jacoby borst**	Winter	Landrace	1.41	3.50	28	28	13	1.55
157	Alnarp	**Jacoby max**	Winter	Landrace	1.34	4.18	31	30	18	1.56
158	Alnarp	**Jacoby utan borst 1027**	Winter	Landrace	1.27	4.53	43	48	16	1.57
159	Alnarp	**Jarl**	Winter	Old cultivar	1.34	3.62	29	28	15	1.50
160	Alnarp	**Kamut Platt Ax**	Winter	Primitive	1.37	3.54	26	28	17	1.56
161	Alnarp	**Kippenhauser Ax**	Winter	Selection	1.49	4.68	35	37	19	1.84
162	Alnarp	**Kippenhauser vete**	Winter	Selection	1.25	4.29	39	46	19	1.57
163	Alnarp	**Krachi höst 97**	Winter	Old cultivar	1.38	7.90	51	50	32	2.08
164	Alnarp	**Krachi (Gotland)**	Winter	Old cultivar	1.41	7.36	50	46	24	1.97
165	Alnarp	**Krachi 1026/18**	Winter	Old cultivar	1.29	6.93	50	44	26	1.84
166	Alnarp	**Krachi borst**	Winter	Old cultivar	1.42	7.08	47	40	25	1.95

Prov number	Location	Genotype name	Type	Group	TOTE (10^8)	TOTU (10^7)	%UPP	%large UPP	%large UMP	Monopol (10^8)
167	Alnarp	**Krachi borst**	Winter	Old cultivar	1.13	5.36	44	36	26	1.53
168	Alnarp	**Krachi borst 3**	Winter	Old cultivar	1.39	7.75	51	42	27	2.00
328	Alnarp	**T.monococcum 1033/04**	Winter	Primitive	1.50	4.44	36	35	16	1.83
329	Gotland	**40.Ostro**	Winter	Spelt	1.28	6.36	40	40	29	1.81
332	Gotland	**48. Olympia**	Winter	Landrace	1.02	4.50	52	60	18	1.38
333	Gotland	**35. 6356**	Winter	Landrace	1.20	2.81	27	29	13	1.36
337	Gotland	**15.6357**	Winter	Spelt	1.15	5.62	47	50	24	1.61
338	Gotland	**34.6356**	Winter	Landrace	1.18	4.96	41	46	23	1.59
339	Gotland	**45.Lantvete Gotland AX-9**	Spring	Landrace	1.06	4.94	44	46	24	1.45
341	Gotland	**6357 blå**	Winter	Spelt	0.93	3.64	41	39	19	1.21
342	Gotland	**Dala imp**	Spring	Landrace	1.21	5.58	29	35	30	1.68
344	Gotland	**Lantvete Gotland Vit**	Spring	Landrace	1.24	3.11	30	31	14	1.45
344	Gotland	**Lantvete Gotland Vit**	Spring	Landrace	1.16	3.29	34	30	15	1.38
345	Gotland	**LV Gotland Spelt**	Winter	Spelt	1.18	4.36	36	33	21	1.49
346	Gotland	**Svart emmer**	Winter	Primitive	0.95	4.75	59	59	23	1.34
347	Gotland	**Sol**	Winter	Old cultivar	0.88	2.74	36	42	14	1.06
348	Gotland	**Ertus**	Winter	Old cultivar	0.85	3.55	42	49	19	1.09
349	Gotland	**Jacoby borst**	Winter	Landrace	0.89	3.06	35	35	18	1.08
350	Gotland	**Virtus**	Winter	Old cultivar	0.87	3.63	44	52	18	1.14
351	Gotland	**Schmidts**	Winter	Old cultivar	0.67	1.55	21	30	13	0.75
352	Gotland	**Eroica**	Winter	Old cultivar	0.78	3.20	41	46	20	1.01
353	Gotland	**Aros**	Winter	Old cultivar	0.79	3.40	45	53	20	1.04
354	Gotland	**Hansa**	Winter	Old cultivar	0.97	2.20	25	29	11	1.09
355	Gotland	**Banco**	Winter	Old cultivar	0.88	3.02	36	40	17	1.09
356	Gotland	**Starke**	Winter	Old cultivar	0.88	3.39	36	35	21	1.12
357	Gotland	**Robur**	Winter	Old cultivar	0.79	3.09	38	41	19	1.00
359	Gotland	**Jarl**	Winter	Old cultivar	1.00	2.44	22	23	15	1.15
360	Gotland	**Holger**	Winter	Old cultivar	0.94	3.61	37	26	19	1.15
361	Gotland	**Vit Spelt Alnarp**	Winter	Spelt	1.07	2.48	22	17	13	1.20
362	Gotland	**Fylgia**	Spring	Old cultivar	1.04	4.69	39	41	24	1.40
363	Gotland	**Algot**	Spring	Old cultivar	0.99	2.48	26	19	14	1.12
364	Gotland	**Atle**	Spring	Old cultivar	1.09	5.27	48	54	23	1.50
365	Gotland	**Atson**	Spring	Old cultivar	1.04	5.22	51	55	24	1.44
366	Gotland	**Peko**	Spring	Old cultivar	1.11	4.20	38	38	19	1.39
367	Gotland	**Rival**	Spring	Old cultivar	1.06	4.89	47	67	24	1.47
368	Gotland	**Pondus**	Spring	Old cultivar	0.84	5.45	58	66	30	1.30
369	Gotland	**Kärn**	Spring	Old cultivar	1.06	4.87	52	65	20	1.48
370	Gotland	**Dalaurval**	Spring	Landrace	0.94	5.56	52	60	29	1.41
371	Gotland	**Progress**	Spring	Old cultivar	1.15	5.69	46	48	25	1.58
372	Gotland	**Svenno**	Spring	Old cultivar	0.99	5.15	51	58	23	1.39
373	Gotland	**Ölands**	Spring	Landrace	1.18	5.13	42	45	22	1.56
374	Gotland	**Aurora**	Spring	Old cultivar	1.16	3.82	34	37	18	1.41
375	Gotland	**Våremmer**	Spring	Primitive	1.32	4.44	34	36	18	1.61
375	Gotland	**Våremmer**	Spring	Primitive	1.28	4.55	36	38	19	1.58
376	Gotland	**Olandspelts**	Spring	Landrace	1.14	6.16	50	56	27	1.65
377	Gotland	**Lv Gotland**	Spring	Spelt	1.32	5.35	43	51	20	1.74
382	Gotland	**Öland1**	Spring	Landrace	1.37	6.14	43	50	26	1.90
383	Gotland	**Öland 14**	Spring	Landrace	1.40	5.94	46	53	21	1.89
385	Gotland	**Oland 2**	Spring	Landrace	1.36	5.60	42	48	22	1.78
393	Gotland	**Oberkulmer**	Winter	Spelt	1.70	6.48	28	28	26	2.22
394	Gotland	**Lantvete Uppsala**	Winter	Landrace	1.40	4.51	30	35	19	1.71
395	Gotland	**Neuegger**	Winter	Spelt	1.52	5.08	36	35	17	1.88

Prov number	Location	Genotype name	Type	Group	TOTE (10^8)	TOTU (10^7)	%UPP	%large UPP	%large UMP	Monopol (10^8)
397	Gotland	**Lantvete Halland**	Winter	Landrace	1.39	3.64	27	30	15	1.61
398	Gotland	**Schweiz**	Winter	Spelt	1.80	4.61	22	20	17	2.12
399	Gotland	**Rosens**	Winter	Spelt	1.50	6.14	41	48	23	2.02
400	Gotland	**Tysk spelt**	Winter	Spelt	1.46	4.67	35	33	17	1.80
401	Gotland	**Kippenhauser**	Winter	Spelt	1.52	6.43	37	29	25	1.99
402	Gotland	**Spelt vete Gotland**	Winter	Spelt	1.53	5.35	39	39	18	1.94
403	Gotland	**Golden**	Winter	Spelt	1.16	6.40	45	43	29	1.66
404	Gotland	**Erbe**	Winter	Old cultivar	1.12	4.45	37	28	21	1.39
405	Gotland	**Starke**	Winter	Old cultivar	1.02	5.43	50	61	26	1.47
406	Gotland	**Ruta 28**	Winter	Landrace	1.35	7.07	43	47	27	1.93
407	Gotland	**Svale**	Winter	Old cultivar	1.20	4.63	41	53	19	1.56
408	Gotland	**Schwaben**	Winter	Spelt	1.78	4.02	20	21	16	2.06
409	Gotland	**Petkus**	Winter	Old cultivar	0.95	2.98	25	32	21	1.16
410	Gotland	**6356**	Winter	Landrace	1.43	3.66	28	30	15	1.65
411	Gotland	**Zuzgen dinkel**	Winter	Spelt	1.37	5.28	40	44	21	1.79
412	Gotland	**Sol**	Winter	Old cultivar	1.31	3.28	30	34	12	1.52
414	Gotland	**Holger 2**	Winter	Old cultivar	1.16	5.53	49	52	24	1.61
415	Gotland	**Lant vete Gotland**	Winter	Spelt	1.23	6.04	46	47	26	1.73
417	Gotland	**Eroica**	Winter	Old cultivar	1.20	3.88	37	46	16	1.47
418	Gotland	**Hansa Brun**	Winter	Old cultivar	1.16	5.47	47	43	23	1.57
419	Gotland	**T.spelta brun hvid**	Winter	Spelt	1.47	5.69	35	34	22	1.88
420	Gotland	**Schmidt Råg**	Winter	Spelt	1.06	1.94	20	25	11	1.18
423	Gotland	**Öland urval 10 lång borst**	Spring	Spelt	2.25	6.78	32	31	18	2.68
425	Gotland	**Lantvet Gotland 8**	Spring	Spelt	1.67	9.60	50	54	29	2.49
426	Gotland	**Lantvet Gotland 9**	Spring	Spelt	1.97	6.63	39	43	18	2.50
427	Gotland	**Lant vet Halland 1**	Spring	Landrace	1.77	6.18	47	62	17	2.29
431	Gotland	**Ölands 5**	Spring	Landrace	1.81	6.55	46	60	18	2.36
432	Gotland	**Lantvete Gotlands borst 2**	Spring	Spelt	1.96	7.70	41	39	20	2.51
435	Gotland	**Ölands 62**	Spring	Landrace	1.67	8.46	50	56	27	2.40
438	Gotland	**Diamant Brun**	Spring	Old cultivar	1.60	7.94	49	51	24	2.23
440	Gotland	**Atle**	Spring	Old cultivar	1.58	8.27	54	69	24	2.31
441	Gotland	**Progress 1**	Spring	Old cultivar	1.75	7.75	54	64	20	2.41
443	Gotland	**Fylgia 93**	Spring	Old cultivar	1.55	6.99	43	40	24	2.08
481	Gotland	**Lant vete Gotland borst 2/3**	Spring	Spelt	1.27	5.29	45	57	20	1.70
489	Gotland	**Borst vete Gotland**	Winter	Landrace	1.01	3.22	28	19	20	1.22
501	Gotland	**Kulturemmer**	Winter	Primitive	1.17	11.39	66	72	42	2.21
502	Gotland	**Röd Emmer**	Winter	Primitive	1.56	8.78	45	43	31	2.24
503	Gotland	**Ostro**	Winter	Spelt	1.76	4.19	25	18	15	1.99
505	Gotland	**Schweiz Spelt**	Winter	Spelt	1.43	5.18	36	36	19	1.77
507	Gotland	**Vit Emmer**	Winter	Primitive	1.40	4.34	35	43	18	1.74
509	Gotland	**Vit Spelt**	Winter	Spelt	1.26	6.19	44	43	26	1.74
510	Gotland	**Svart emmer**	Winter	Primitive	1.37	6.04	46	48	24	1.88
513	Gotland	**Lant vete Gotland 1**	Spring	Spelt	1.29	6.86	50	49	25	1.83
514	Gotland	**Enkorn**	Winter	Primitive	1.97	3.38	18	13	10	1.92
516	Gotland	**Kippenhauser**	Winter	Spelt	1.47	4.28	35	38	13	1.74
521	Gotland	**Spelt vete Gotland**	Winter	Spelt	1.53	4.33	24	12	19	1.75
523	Gotland	**Folke**	Winter	Cultivar	1.53	5.14	38	46	17	1.92
523	Gotland	**Folke**	Winter	Cultivar	1.45	5.09	38	45	18	1.83
525	Gotland	**Jarl**	Winter	Old cultivar	1.44	4.64	37	39	15	1.77
526	Gotland	**Lantvete Gotland vit**	Winter	Spelt	1.41	3.62	31	27	12	1.58
528	Gotland	**6356**	Winter	Landrace	1.61	4.20	28	25	15	1.81
529	Gotland	**Peter Jacoby**	Winter	Landrace	1.13	6.01	55	63	23	1.62

Prov number	Location	Genotype name	Type	Group	TOTE (10^8)	TOTU (10^7)	%UPP	%large UPP	%large UMP	Monopol (10^8)
531	Gotland	**Bore**	Winter	Old cultivar	1.16	4.64	43	49	20	1.53
532	Gotland	**Borst vete Gotland**	Winter	Landrace	1.07	2.87	31	32	14	1.25
534	Gotland	**Olympia**	Winter	Landrace	0.96	4.90	49	56	26	1.36
536	Gotland	**Borst vete Gotland**	Winter	Landrace	1.12	3.08	22	19	18	1.33
539	Gotland	**Browichs**	Winter	Old cultivar	1.20	3.38	27	27	18	1.44
546	Gotland	**Olympia**	Winter	Landrace	1.03	6.74	59	71	32	1.64
547	Gotland	**Enkorn**	Winter	Primitive	1.67	2.17	11	10	9	1.69
549	Gotland	**Svart emmer**	Winter	Primitive	1.26	5.36	38	40	25	1.69
550	Gotland	**NI-enkorn**	Winter	Primitive	1.48	4.34	14	8	24	1.73
561	Gotland	**Albihn**	Winter	Spelt	0.98	2.91	28	19	18	1.15
564	Gotland	**.Armensk6**	Winter	Old cultivar	1.05	3.38	28	27	20	1.30
570	Gotland	**Kamut Platt**	Winter	Primitive	1.09	5.14	40	43	28	1.51
573	Gotland	**6357 vit**	Winter	Spelt	1.16	4.03	21	25	25	1.49
576	Gotland	**T.dicoccum emmer**	Winter	Primitive	1.21	5.94	41	43	28	1.70
583	Gotland	**Jacoby max**	Winter	Landrace	1.01	4.91	44	43	26	1.40
587	Gotland	**Vit spelt**	Winter	Spelt	1.09	4.92	42	41	24	1.47
588	Gotland	**Kippenhauser**	Winter	Spelt	1.28	4.33	31	30	21	1.60
589	Gotland	**Zuzgen dinkel**	Winter	Spelt	1.25	6.17	39	33	30	1.75
590	Gotland	**Österreicher burgsddorf**	Winter	Spelt	1.08	3.86	34	25	21	1.34
593	Gotland	**6357 brun**	Winter	Spelt	1.38	6.07	41	42	25	1.87
598	Gotland	**T.monococcum Tina**	Winter	Primitive	1.87	4.23	23	18	13	1.93
600	Gotland	**Röd Emmer**	Winter	Primitive	1.08	9.15	58	63	40	1.88
601	Gotland	**Spelt vete Gotland**	Winter	Spelt	1.62	5.38	37	46	18	2.06
602	Gotland	**Lantvete Gotland I**	Spring	Spelt	1.19	5.05	40	29	23	1.52
604	Gotland	**Lantvete Dal**	Spring	Landrace	1.54	4.27	24	22	18	1.78
606	Alnarp	**Ölands 17 borst spelt**	Spring	Spelt	2.05	4.14	24	24	12	2.31
607	Alnarp	**Koga I**	Spring	Old cultivar	1.37	6.10	51	60	19	1.87
608	Alnarp	**Lv. Gotland 6 borst**	Spring	Spelt	1.57	8.52	39	27	33	2.28
609	Alnarp	**Atle 3007**	Spring	Old cultivar	1.45	6.77	42	37	26	2.01
629	Alnarp	**Lv. Halland I**	Spring	Landrace	1.66	4.71	36	47	15	2.04
630	Alnarp	**Fylgia 9**	Spring	Old cultivar	1.84	4.93	28	27	16	2.15
631	Alnarp	**Algot**	Spring	Old cultivar	1.27	4.86	51	67	16	1.67
634	Alnarp	**Dala 2**	Spring	Landrace	1.37	6.12	45	44	24	1.86
636	Alnarp	**Walter brun**	Spring	Old cultivar	1.07	5.55	56	62	25	1.54
637	Alnarp	**Reno**	Spring	Cultivar	1.53	7.70	52	64	25	2.20
638	Alnarp	**Svenno**	Spring	Old cultivar	1.42	5.46	44	52	19	1.87
639	Alnarp	**Pondus 2**	Spring	Old cultivar	1.29	6.67	44	40	30	1.86
640	Alnarp	**Aurore 1**	Spring	Old cultivar	1.68	4.92	36	44	15	2.05
641	Alnarp	**Atle 1**	Spring	Old cultivar	1.36	6.65	45	46	25	1.88
642	Alnarp	**Lv. Dal 15 vit borst**	Spring	Landrace	1.27	7.48	53	60	28	1.90
644	Alnarp	**Lv. Dal 16 vit borst**	Spring	Landrace	1.53	5.80	45	51	17	1.98
646	Alnarp	**Runar**	Spring	Cultivar	1.35	7.19	59	76	25	1.99
647	Alnarp	**Peko 99**	Spring	Old cultivar	1.40	5.41	34	35	23	1.78
650	Alnarp	**Lv. Dal 16 vit**	Spring	Landrace	1.46	6.89	47	55	23	2.02
651	Alnarp	**Rollo**	Spring	Cultivar	1.27	6.26	59	66	23	1.80
652	Alnarp	**Runar brun**	Spring	Old cultivar	1.55	5.08	34	33	18	1.88
653	Alnarp	**APU**	Spring	Old cultivar	1.59	8.08	48	48	25	2.24
655	Alnarp	**Sappo**	Spring	Old cultivar	1.03	5.80	49	46	29	1.50
656	Alnarp	**Lv. Halland 2**	Spring	Landrace	1.47	5.19	30	27	23	1.88
657	Alnarp	**Kärn 1**	Spring	Old cultivar	1.35	5.91	47	54	21	1.83
658	Alnarp	**Lv dal 16 vit ut. Borst**	Spring	Landrace	1.39	5.58	47	54	19	1.85
660	Alnarp	**Fylgia 2**	Spring	Old cultivar	1.67	4.95	27	24	19	1.95

Prov number	Location	Genotype name	Type	Group	TOTE (10^8)	TOTU (10^7)	%UPP	%large UPP	%large UMP	Monopol (10^8)
661	Alnarp	**Möystad**	Spring	Old cultivar	1.37	7.54	51	50	28	2.01
665	Alnarp	**Dala 2**	Spring	Landrace	1.62	5.85	45	59	22	2.14
670	Alnarp	**Petkus 1**	Spring	Old cultivar	1.24	3.06	30	33	15	1.45
671	Alnarp	**Svenno 1**	Spring	Old cultivar	1.52	5.18	35	31	21	1.93
672	Alnarp	**Rival 1**	Spring	Old cultivar	1.45	7.04	49	59	28	2.08
674	Alnarp	**Fylgia 1**	Spring	Old cultivar	1.79	7.01	44	56	22	2.40
675	Alnarp	**Dala 1**	Spring	Landrace	1.44	6.76	49	58	27	2.03
676	Alnarp	**Litauen vårråg**	Spring	Old cultivar	1.17	4.80	38	48	26	1.57
677	Alnarp	**T. dicoccum kort**	Spring	Primitive	1.84	6.75	58	63	21	2.43
680	Alnarp	**Atle 4**	Spring	Old cultivar	1.73	5.52	43	57	18	2.21
681	Alnarp	**Lv. Dal vit borst**	Spring	Landrace	1.49	6.51	57	74	20	2.08
682	Alnarp	**Reno**	Spring	Cultivar	1.33	6.50	60	65	25	1.90
683	Alnarp	**Progress 2**	Spring	Old cultivar	1.45	7.15	36	31	32	2.05
686	Alnarp	**Kenya**	Spring	Old cultivar	1.88	9.53	58	73	27	2.76
687	Alnarp	**Red Fite 2**	Spring	Old cultivar	1.67	7.53	50	53	26	2.33
688	Alnarp	**Atson 1**	Spring	Old cultivar	1.41	6.93	54	60	26	2.01
688	Alnarp	**Atson 1**	Spring	Old cultivar	1.29	6.05	49	53	24	1.80
692	Alnarp	**Ölands urval 10 borst spelt**	Spring	Spelt	1.97	3.48	18	19	12	2.19
693	Alnarp	**Urval Ölands 1 brun borst**	Spring	Landrace	1.58	5.23	38	42	17	1.98
694	Alnarp	**Rival 2**	Spring	Old cultivar	1.49	5.80	25	25	28	1.96
695	Alnarp	**Utrecht blue**	Spring	Primitive	1.26	7.55	52	53	32	1.90
696	Alnarp	**Ölands 10 borst spelt kort**	Spring	Spelt	1.65	7.00	42	43	22	2.19
697	Alnarp	**Dala 16 brun 2**	Spring	Landrace	1.39	6.87	38	37	30	1.93
698	Alnarp	**Red Fite**	Spring	Old cultivar	1.50	4.87	34	45	20	1.91
702	Alnarp	**Lv. Gotland 6**	Spring	Spelt	1.36	5.02	36	35	21	1.71
703	Alnarp	**Lv. Gotland II**	Spring	Spelt	1.58	8.49	37	32	32	2.29
703	Alnarp	**Lv. Gotland II**	Spring	Spelt	1.55	7.30	39	35	27	2.14
705	Alnarp	**Ölands 17 borst spelt**	Spring	Spelt	1.53	9.27	40	39	36	2.34
706	Alnarp	**Lv. Dal 16 vit**	Spring	Landrace	1.51	6.15	40	46	22	2.00
708	Alnarp	**Diamant kort 2**	Spring	Old cultivar	1.32	3.36	39	42	16	1.59
709	Alnarp	**T. boeoticum**	Spring	Primitive	2.00	3.83	19	20	14	2.24
711	Alnarp	**Rival 1**	Spring	Old cultivar	1.86	5.25	28	33	19	2.29
712	Alnarp	**Lv. Halland I**	Spring	Landrace	1.46	5.78	44	50	22	1.94
715	Alnarp	**Fylgia I**	Spring	Old cultivar	1.89	3.95	23	26	14	2.16
717	Alnarp	**Peko vitborst**	Spring	Old cultivar	1.48	3.63	26	29	15	1.73
718	Alnarp	**Öland 5**	Spring	Landrace	1.76	5.91	35	46	21	2.25
719	Alnarp	**Lv. Dal 16 brun borst I**	Spring	Landrace	1.27	6.07	47	50	25	1.77
720	Alnarp	**Lv. Gotland 8**	Spring	Spelt	1.37	6.65	42	33	26	1.83
721	Alnarp	**Ostby 2**	Spring	Old cultivar	1.62	5.85	26	22	25	2.07
722	Alnarp	**Lv. Gotland 6 borst 1**	Spring	Spelt	1.36	5.73	45	48	22	1.82
723	Alnarp	**Ölands urval 7**	Spring	Landrace	1.88	5.95	32	37	20	2.36
724	Alnarp	**Ölands 6 I**	Spring	Landrace	1.63	5.24	37	43	19	2.06
725	Alnarp	**APU borst**	Spring	Old cultivar	1.78	5.58	47	58	18	2.28
727	Alnarp	**Lv. Gotland 2**	Spring	Spelt	1.50	7.10	43	43	26	2.08
732	Alnarp	**Ölands urval spelt**	Spring	Spelt	1.35	5.19	41	43	20	1.74
733	Alnarp	**Rollo**	Spring	Cultivar	1.29	6.45	46	51	27	1.83
734	Alnarp	**Kolben**	Spring	Old cultivar	1.41	6.94	48	48	25	1.99
735	Alnarp	**Lv. Gotland borst 1**	Spring	Spelt	1.40	6.33	40	40	26	1.90
736	Alnarp	**Lv. Halland I brun**	Spring	Landrace	1.67	5.48	33	42	20	2.12
741	Alnarp	**Touko**	Spring	Old cultivar	1.06	6.15	49	56	30	1.58
745	BohusLän	**Jarl**	Winter	Old cultivar	0.87	4.57	48	54	25	1.22
746	BohusLän	**Brun spelt**	Winter	Spelt	1.22	5.12	39	36	22	1.58

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747	BohusLän	**B 13867 spelt**	Winter	Spelt	1.14	3.07	26	30	16	1.35
749	BohusLän	**Pansar III**	Winter	Old cultivar	0.89	2.99	24	25	22	1.11
750	BohusLän	**Jacoby borst**	Winter	Landrace	0.78	4.01	47	49	24	1.08
752	BohusLän	**Hansa brun**	Winter	Old cultivar	1.00	2.99	21	25	22	1.23
753	BohusLän	**Holger**	Winter	Old cultivar	0.87	4.57	47	53	26	1.22
755	BohusLän	**Hansa**	Winter	Old cultivar	0.85	3.54	41	41	21	1.10
756	BohusLän	**Aros**	Winter	Old cultivar	0.85	4.35	38	38	30	1.20
757	BohusLän	**Olivin**	Winter	Cultivar	0.82	3.77	49	59	21	1.12
758	BohusLän	**Vit spelt**	Winter	Spelt	0.87	4.71	50	55	26	1.25
759	BohusLän	**Vit spelt**	Winter	Spelt	0.85	3.58	33	29	26	1.12
760	BohusLän	**Hansa brun**	Winter	Old cultivar	0.77	4.39	54	69	27	1.14
761	BohusLän	**Aros**	Winter	Old cultivar	0.73	3.79	54	64	23	1.04
762	BohusLän	**Holger**	Winter	Old cultivar	0.84	4.39	45	47	27	1.16
765	BohusLän	**Inntaler tress**	Winter	Old cultivar	0.83	4.07	48	59	23	1.16
766	BohusLän	**Stava**	Winter	Cultivar	0.70	4.40	55	69	30	1.07
767	BohusLän	**Olivin**	Winter	Cultivar	0.72	3.87	51	55	24	1.02
768	BohusLän	**Jacoby urval**	Winter	Landrace	0.90	3.20	24	25	25	1.14
769	BohusLän	**Banco**	Winter	Old cultivar	0.84	3.38	32	38	26	1.11
770	BohusLän	**B 13867 spelt**	Winter	Spelt	1.12	2.52	19	16	15	1.24
771	BohusLän	**Brun spelt**	Winter	Spelt	1.23	4.95	40	44	20	1.59
772	BohusLän	**Hansa**	Winter	Old cultivar	0.71	4.11	51	55	26	1.03
773	Gotland	**Lantvete Gotland borst 7/5**	Spring	Spelt	1.80	4.87	31	35	15	2.15
774	Gotland	**Lantvete Gotland borst 2**	Spring	Spelt	1.30	5.92	44	39	23	1.75
775	Gotland	**Lantvete Gotland borst 1**	Spring	Spelt	1.36	6.28	48	54	22	1.89
777	Gotland	**Lantvete Gotland borst 1 spelt**	Spring	Spelt	1.72	7.92	45	43	24	2.37
778	Gotland	**Gotlands korn**	Spring	Spelt	0.99	5.70	42	48	32	1.38
779	Gotland	**Lantvete Gotland 1 vete**	Spring	Spelt	1.33	4.81	42	37	18	1.67
780	Gotland	**Öland 62**	Spring	Landrace	1.71	4.70	27	31	18	2.08
782	Gotland	**Gotlands korn**	Spring	Spelt	0.90	4.35	41	41	26	1.16
783	Gotland	**Lantvete gotland 8**	Spring	Spelt	1.48	6.49	44	49	21	1.98
784	Gotland	**Ölands 18 falt sammet**	Spring	Landrace	1.29	5.80	43	47	23	1.74
785	Gotland	**Spelt vete Gotland**	Winter	Spelt	1.33	2.62	18	17	12	1.42
786	Gotland	**6356**	Winter	Landrace	1.05	2.39	26	25	13	1.19
787	Gotland	**6356 spelt**	Winter	Spelt	1.44	3.36	27	23	12	1.60
788	Gotland	**Ölands 61**	Spring	Landrace	1.51	6.35	42	54	23	2.04
789	Gotland	**Ölands 5**	Spring	Landrace	1.58	4.35	33	49	16	1.92
790	Gotland	**Lantvete Gotland 4 vete**	Spring	Spelt	1.22	5.22	47	55	17	1.61
791	Gotland	**Ölands 16**	Spring	Landrace	1.30	4.77	35	32	21	1.63
792	Gotland	**Enkorn**	Winter	Primitive	1.43	2.47	18	12	9	1.41
793	Gotland	**Svart emmer**	Winter	Primitive	1.20	5.06	38	39	24	1.58
794	Gotland	**Röd Emmer**	Winter	Primitive	1.16	5.57	42	45	27	1.60
795	Gotland	**Enkorn**	Winter	Primitive	1.52	3.67	20	15	16	1.62
796	Uppsala	**Fylgia 93**	Spring	Old cultivar	1.99	5.55	33	31	16	2.41
797	Uppsala	**Lv Dal 10 brun**	Spring	Landrace	1.86	5.75	32	46	21	2.37
800	Uppsala	**Atle 1**	Spring	Old cultivar	1.47	7.25	53	60	26	2.11
801	Uppsala	**Atle 2**	Spring	Old cultivar	2.00	5.00	24	32	18	2.42
803	Uppsala	**Lv. Halland ekhaga**	Spring	Landrace	1.92	4.99	25	36	19	2.34
804	Uppsala	**APU**	Spring	Old cultivar	1.66	8.34	52	58	25	2.39
805	Uppsala	**Pondus**	Spring	Old cultivar	1.51	8.26	56	64	28	2.26
806	Uppsala	**Atle 3**	Spring	Old cultivar	1.81	5.83	28	22	22	2.29
807	Uppsala	**Atson 99**	Spring	Old cultivar	1.94	5.16	31	38	16	2.35
808	Uppsala	**Progress 2**	Spring	Old cultivar	1.43	7.97	56	67	29	2.15

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810	Uppsala	**Ring**	Spring	Cultivar	1.56	8.29	53	55	27	2.30
811	Uppsala	**Diamant brun 2**	Spring	Old cultivar	1.80	7.12	44	54	23	2.42
813	Uppsala	**Fram**	Spring	Old cultivar	2.09	4.92	24	30	17	2.50
814	Uppsala	**Vinjett**	Spring	Cultivar	1.62	5.22	38	50	20	2.06
816	Uppsala	**Ås**	Spring	Old cultivar	1.78	6.80	34	35	24	2.33
819	Uppsala	**Lv. Dal 15 vit borst**	Spring	Landrace	1.95	6.89	43	58	22	2.57
822	Uppsala	**Fylgia 2**	Spring	Old cultivar	1.67	6.60	34	30	25	2.20
823	Uppsala	**Ex kolben**	Spring	Old cultivar	1.67	7.35	49	52	24	2.32
825	Uppsala	**Kärn 1**	Spring	Old cultivar	1.07	4.99	44	48	24	1.45
828	Uppsala	**Pondus 2**	Spring	Old cultivar	1.66	5.32	42	46	20	2.12
830	Uppsala	**Sappo**	Spring	Old cultivar	1.65	5.43	46	49	19	2.11
831	Uppsala	**Ölands I borst**	Spring	Landrace	1.83	7.50	41	49	23	2.46
832	Alnarp	**Atle 10**	Spring	Old cultivar	1.01	5.13	49	66	25	1.44
833	Alnarp	**Rival**	Spring	Old cultivar	1.08	4.48	38	40	24	1.44
834	Alnarp	**Atson**	Spring	Old cultivar	1.46	4.02	34	41	14	1.75
835	Alnarp	**Diamant brun**	Spring	Old cultivar	1.32	4.81	33	37	22	1.66
836	Alnarp	**APU**	Spring	Old cultivar	1.43	5.15	38	44	20	1.84
837	Alnarp	**Aurore**	Spring	Old cultivar	1.32	4.56	30	27	21	1.63
840	Alnarp	**Kärn**	Spring	Old cultivar	0.93	4.79	52	58	23	1.31
842	Alnarp	**Ur Ölands 8**	Spring	Landrace	1.38	4.50	42	49	17	1.73
845	Alnarp	**Peko borst**	Spring	Old cultivar	1.24	4.14	31	25	20	1.49
846	Alnarp	**Lv. Hall 1**	Spring	Landrace	1.25	5.35	42	45	23	1.66
847	Alnarp	**Ex Kolben**	Spring	Old cultivar	1.19	4.70	42	50	21	1.57
848	Alnarp	**Algot**	Spring	Old cultivar	1.20	5.01	37	35	25	1.59
850	Alnarp	**Dala Urval**	Spring	Landrace	0.89	6.06	50	53	35	1.38
853	Uppsala	**Banco lång**	Winter	Old cultivar	0.96	4.67	46	56	24	1.34
855	Uppsala	**Walde**	Winter	Old cultivar	0.94	4.84	49	65	25	1.34
857	Uppsala	**Aura lång**	Winter	Old cultivar	0.96	4.46	43	45	23	1.31
860	Uppsala	**Banco**	Winter	Old cultivar	0.95	4.03	46	58	19	1.28