# Protein polymer accumulation during grain development and relations to quality: Influences of cultivar and environment

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## ABSTRACT

Bread baking quality of wheat is influenced by protein concentration and composition, and amount and size distribution of polymeric protein (ASPP). Reasons for variation in ASPP in mature wheat are not fully understood and can be searched for during grain development. The aims of our investigations were to evaluate cultivar and environment influences on protein polymer composition in mature wheat, to investigate general built-up patterns of polymeric proteins, and to explain alterations by cultivar and environment. Protein concentration, composition and polymerisation, and bread-making quality have been determined in spring and winter wheat of different cultivars grown in climate chambers, green-houses and on field during grain-filling and at maturation. The results show that;

- Gluten strength is influenced by protein concentration, specific protein composition and ASPP
- Protein concentration and ASPP is influenced by cultivar and environment, while specific protein composition is determined by cultivar
- Rate of nitrogen is influencing protein concentration, while timing of nitrogen application influences gluten strength and ASPP
- Temperature together with nitrogen availability and cultivar determined development times are the main factors influencing ASPP
- Grain moisture are an important parameter for protein polymerisation in the developing wheat grain

Thus, the general protein accumulation pattern in wheat is a pre-determined event, although ASPP is influenced by cultivar, temperature and nitrogen availability during grain development leading to differences in the mature grain.

## INTRODUCTION

Protein parameters, such as grain protein content, specific protein composition and amount and size distribution of polymeric protein (ASPP), are to a large extent determining bread-baking quality of wheat[1-5]. Specific protein composition is determined genetically, while the other protein parameters are determined both by cultivar and environment as well as their interactions[1-9]. Protein characters in the mature grain are determined during the grain-filling period[10].

The aim of the present paper was to compile present knowledge about patterns of grain protein accumulations and also to add new information from our latest experiments. Influences of cultivars and environmental factors such as nitrogen application rate and timing as well as temperature, on protein parameters such as grain protein content, specific protein composition and ASPP is evaluated.

## MATERIALS AND METHODS

Grain protein content, specific protein composition and ASPP is determined in a range of cultivars during the latest 15 years using near infrared reflectance spectroscopy, nitrogen analyser (Carlo Erba), sodium dodecyl sulphate polyacryl amide gel electrophoresis and high performance liquid chromatography[4,5,6,8,9,10]. Wheat cultivars have been grown in field, green-house and biotron and samples taken at various stages of development, from anthesis and until maturity. Different nitrogen application rates and temperatures have been used during the experiments and cultivars with variations in maturation time have been investigated. Data has been statistically evaluated using Microsoft Excel and SAS programs. Main statistical methods have been analyses of variance (ANOVA or GLM), calculations of means with least significance difference or Duncan, Spearman rank correlation analyses and standard deviations.

## RESULTS AND DISCUSSION

Gluten strength has been found to be influenced by several of the protein parameters as e.g. protein concentration, specific protein composition and ASPP[5,6,8,10]. Several of the protein parameters are influenced by both cultivar and environment although specific protein composition is determined only by the cultivar[4,5,6,8,9,10]. A general pattern for accumulation of different types of proteins in the wheat grain has been found (Fig 1). This pattern shows that the polymeric proteins are increasing during the latter half of the grain development period, while the smaller monomeric proteins are decreasing early after anthesis (Fig 1).

Irrigation and fertilizer rates have been shown to influence protein accumulation in wheat[11-12]. Cultivar, temperature and nitrogen application as well as their interactions seems to be of equal importance for different protein factors in mature wheat (Table 1).

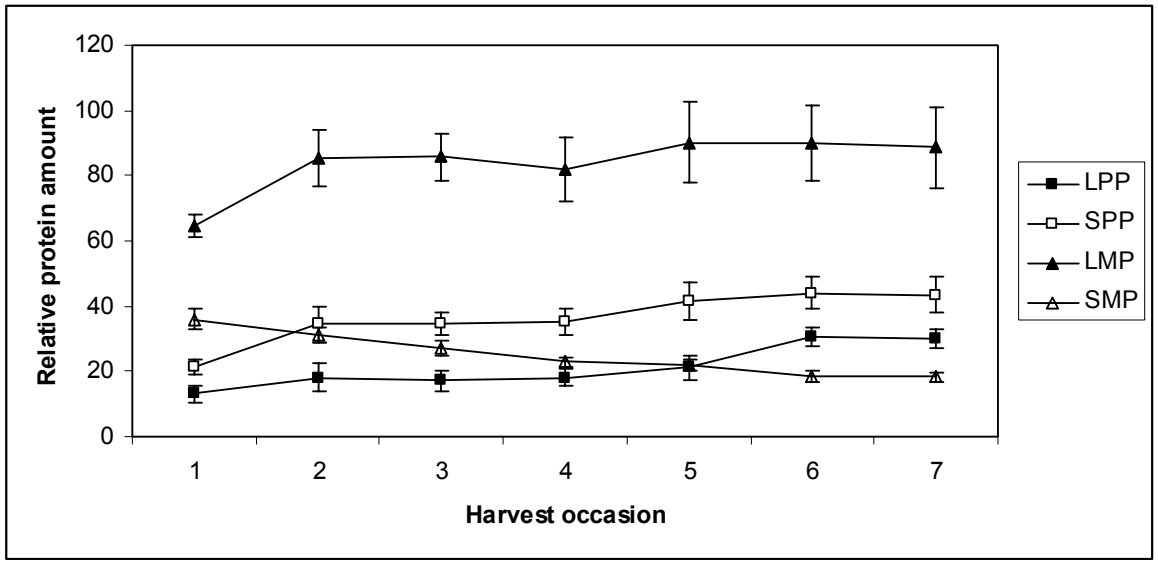


Fig 1. Changes in relative amounts of different types of proteins during grain maturation. LPP=Large polymeric proteins, SPP=Smaller polymeric protein, LMP=Large monomeric protein, SMP=Smaller monomeric protein. Bars indicate standard deviation.

Table 1. Mean squares from analyses of variance of relationships among protein parameters and cultivar, temperature and nitrogen levels as well as their interactions.

| Source | Df | TOTE | TOTU | %UPP |
|---|---|---|---|---|
| Cultivar | 3 | 136.1*** | 2.15 | 0.07*** |
| Temperature | 1 | 1.45 | 4.49* | 0.02*** |
| Nitrogen | 3 | 150.0*** | 13.5*** | 0.07*** |
| CxT | 3 | 25.5*** | 1.76 | 0.004 |
| CxN | 9 | 20.9*** | 3.66*** | 0.009*** |
| TxN | 3 | 15.3** | 4.14 | 0.009* |
| TxN | 3 | 15.3** | 4.14* | 0.009* |
| CxNxT | 9 | 31.7*** | 1.12 | 0.011** |
| Error | | 3.48 | 1.02 | 0.002 |

Df= degree of freedom, C=cultivar, T=temperature, N=nitrogen
*, **, *** = significant at P<0.05, 0.01, 0.005.

Also, nitrogen timing in combination with temperature and maturation time has been shown to influence protein accumulation during grain development and amount and size distribution of polymeric protein in mature grain[13]. Another important parameter for protein polymerisation in developing wheat grain is grain moisture (results accepted for publication in J Sci Food Agric).

Thus, protein accumulation during grain maturation, determining gluten strength in mature wheat, is a complicated process with a lot of interactions between various parameters. However, the most important parameters determining protein composition in mature wheat is cultivar (specific protein composition, time to anthesis and grain maturation time), nitrogen availability before anthesis and during grain maturation and temperature during grain maturation.

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