# Control of grain constituents involved in colour and colour stability in Asian noodles

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## INTRODUCTION

Flour and end-product colour are important criteria of wheat, *Triticum aestivum* L., quality that play a critical role in determining the suitability of wheat for particular products and markets. Flour colour is affected by two main components: i) contamination by bran flakes during milling which results in speckiness, and ii) the inherent colour of the starchy endosperm. In turn, end-product colour depends on the colour of the flour together with reactions and interactions that occur during the mixing of flour with water and other ingredients and subsequent processing and cooking. Different end products of wheat have different colour requirements, for example, white flour is important for bread production in many regions, a bright white to creamy colour is desirable for white salted noodles (WSN), whereas development of a bright yellow colour is required for yellow alkaline noodles (YAN). Some products are sold in a raw form and both initial dough/product colour and the maintenance of colour and brightness are important.

Colour and colour stability, change in colour over time, can be objectively determined using reflectance spectrophotometry and the colour of an object assigned coordinates (L*- white/black axis, a*- red/green axis and b*- yellow/blue) in 3-D colour space (CIE - Commission Internationale I'Eclairage)). Whilst this technology provides an accurate measure of colour it does not necessarily provide the most efficient tool for selecting genotypes that will give improved end-product colour. Since product colour is a summation of contributions, positive and negative, of a number of independent grain constituents, a more logical approach for cultivar improvement is to identify the components of colour and develop specific biochemical and molecular screening technologies.

This report summarises results of investigations of the specific grain and flour constituents that contribute to colour and colour stability in Asian noodles – how they impact on colour and the location of QTL associated with genetic variation.

## RESULTS AND DISCUSSION

Research to date has identified a number of components of colour and colour stability of Asian noodles (Table 1).

**Table 1. Components of Colour and Colour Stability of Asian Noodles**

| | Biochemical constituent |
|---|---|
| **Initial colour** | |
| Lightness/brightness | Protein content |
| Creamy/yellow | |
| White salted noodles (WSN) | Lutein and lutein esters |
| Yellow alkaline noodles (YAN) | Lutein and lutein esters + apigenin-C-diglycosides |
| **Colour stability** | |
| Darkening | PPO and non-PPO |
| Loss of creamy (WSN) | LOX |
| Loss of yellow (YAN) | ----- |

### Initial colour:

**Brightness (L*).** Variation in initial noodle brightness for a set of 8 wheat cultivars from over 20 sites and 2 years was very strongly correlated with protein content ($r = -0.91$ in 2001 and -0.93 in 2002) but in contrast with some previous reports there was no significant correlation with polyphenol oxidase ($r = 0.1$).

**Creamy/yellow colour (b*).** The creamy colour of WSN is determined primarily by the lutein and lutein ester content of the starchy endosperm. Variation in total lutein content (free plus ester forms) is associated with QTL located on chromosomes 3A, 3B, 7A and 7B [1] and in the case of genotypes carrying the 7*Ag* segment, chromosome 7D. During aging of grain, or flour, free lutein may be converted to mono- or di-fatty acid esters depending on the temperature and humidity [2]. The mechanism and genetic control of this conversion is still unclear however there are bread and durum wheats where esterification does not occur. Esterification significantly increases the hydrophobicity of lutein and may effect pigment distribution in dough. In contrast to WSN, YAN develop a strong yellow colour that is additional to that contributed by the lutein content. Asenstorfer *et al*. [3] demonstrated that this additional pigment is generated by the interaction of alkaline salts, more specifically the higher pH, with apigenin-C-diglycosides. At neutral or acid pH, the apigenin-C-diglycosides are colourless but as pH increases towards

9-10 they turn increasingly yellow. These flavonoid compounds are concentrated in the germ tissue, however, a significant portion is partitioned into flour during milling. Whilst there is genetic variation for apigenin-C-diglycoside content, genetic control is still unclear.

### Colour stability:

**Darkening (ΔL*).** A large proportion of observed genetic variation for noodle darkening can be attributed to polyphenol oxidase (PPO) activity. This enzyme is located in the seed coat of wheat grains and darkening is attributable to the small percent of seed coat, bran, which is a contaminant of flour. Low PPO is inherited as a recessive trait. Near-zero PPO genotypes have been identified [4] and recovery of near-zero PPO in breeding populations shown to be dependent on the presence of the donor parent alleles at all 3 grain PPO QTL on 2A, 2B and 2D. PPO activity in noodle sheets can be eliminated either by genetic means or by the use of specific PPO inhibitors, however, a substantial portion of darkening remains. This non-PPO darkening appears to be associated with the starchy endosperm, shows only limited genetic variation and is strongly correlated with protein content. Preliminary investigations suggest that the non-PPO component of darkening is largely non-enzymatic.

**Loss of creamy/yellow colour (Δb*).** In WSN, a rapid loss of lutein during production results from the presence of lipoxygenase (LOX). Genetic variation for LOX activity in durum [5] and bread wheat [6] is associated with a QTL located on chromosome 4B. Near-zero LOX has been identified in durum wheats and a small number of synthetic hexaploid wheats [4]. In contrast to WSN, lutein in YAN is relatively stable due to the low activity of LOX at higher pH whilst apigenin-C-diglycosides appear to also be relatively stable [3]. Both lutein and apigenin-C-diglycosides are slowly oxidised by non-enzymic mechanisms in flour during storage at room temperature and in noodle sheets. In addition to these mechanisms that result in a loss of the pigment compounds, darkening that results from PPO and non-PPO reactions can mask the presence of yellow pigments. Inclusion of small amounts Indian ink to noodle sheets resulted in corresponding reductions not only in brightness (L*) but also yellowness (b*) [7]. This apparent loss of pigment was not accompanied by any reduction in lutein or apigenin-C-diglycoside content.

## CONCLUSIONS

Significant progress has been made in identifying wheat grain constituents that contribute to colour and colour stability of Asian Alkaline noodles. Screening technologies, including molecular markers, have been developed and in the case of two key constituents involved in colour stability, PPO and LOX, genotypes with near-zero activity are available to breeders.


## ACKNOWLEDGEMENTS

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