QUALITY WHEAT
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Quantifying Wheat Quality Attributes for Asian Noodles

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Executive Summary

Advances in breeding technology have resulted not only in high yielding, disease resistant wheat varieties but have successfully produced varieties with desirable quality traits suited to specific end products. Coupled with latest milling techniques in wheat blending, grinding, stock selection, flour blending and air classification many different flour types are produced by commercial flour mills designed for selected end use.

The growth of an affluent, time-poor, discerning market has provided the opportunity to produce shelf stable, convenient, high quality staple meals, which in the past was always prepared or purchased fresh just prior to consumption. This project evaluated the suitability of wheat and flour for the production of long-life udon (LLU) noodles and optimised the process to produce noodles of exceptional quality.

The outcomes of this comprehensive project were achieved by conducting several trials on a series of samples (pure varieties and blends), from two seasons and 6 sites. The methodology to produce and evaluate quality of LLU noodles over a 6 month period, which is the commercially expected shelf life of the product, was initially established. The three main attributes that were used to evaluate quality were colour, firmness and ease of separation of LLU noodles. Changes to colour and firmness were analysed objectively, however, ease of separation was a more subjective, visual measure. Microbial safety of the product was also determined at regular intervals and measured as colony forming units (cfu).

Studies on effect of extraction rates on quality of LLU noodles demonstrated that LLU noodles produced from flours with a 40% extraction rate were whiter (brighter), marginally softer and separated easily when prepared compared to the LLU noodles made with higher extraction flours. However, LLU noodles made from flours with extraction rates up to 60% were still acceptable.

Of the 11 varieties tested over 2 seasons, Batavia, Trident and Goldmark had acceptable colour and firmness over storage. The whiteness of LLU increased on storage and yellowness decreased for all varieties, at different rates. The whiteness and yellowness of cooked fresh noodles was intermediate to that of the freshly prepared dough sheet and dough sheet after 24 hours of production. Firmness of freshly cooked noodles was significantly higher than LLU for all times.

The studies on effect of protein content in flour clearly established the significance of optimal protein content to produce good LLU noodles. Wheat with protein content in the range of 10 -11% were most suited to make LLU noodles. Analysing the data also confirmed previous propositions that flour with amylograph value >900 BU produced LLU noodles with good eating quality. Statistical correlations between other wheat/flour quality characteristics and LLU noodle quality did not provide much information on the most desired wheat or flour characteristic that might impair or improve the quality of LLU noodles.

As the amount of water in the formulation increased firmness of LLU and ease of separation decreased, while whiteness increased marginally only for the first few months. Optimal processing properties and superior end product quality was attained at 35% water in formulation.

Experiments to trial the effectiveness and strength of the food acid used demonstrated that rinsing noodles in 5M acetic acid did not have a detrimental effect on colour or firmness of LLU noodles on storage and maintained the desired microbial quality.

The effect of native and modified starches at 10% inclusion rates on Japanese (60% ASWN, 40% APW) and Korean (30% ASWN, 30% ASWT, 40% APW) blends of wheat were evaluated for fresh and LLU noodle quality. The addition of starch at 10% level did not have a positive effect with respect to colour, texture or separation of LLU noodles.

1.0 Introduction

In S.E Asia, N Asia and Indonesia noodles made from wheat flour are a staple part of the diet. Noodles are strands of dough sheet produced primarily by mixing flour, salt(s) and water that are cut to the desired thickness, depending on regional preferences. The noodles can be consumed fresh or can be dried under strict drying protocols. While wheat flour is the primary ingredient, rice or buckwheat flour are occasionally used. Noodles can be classified based on ingredients, method of manufacture or regional preferences (Nagao 1993).

White salted noodles, contains sodium chloride as the primary salt in the formulation and is often referred to as Udon or Japanese style, which is sold as dry strands of packed noodles or par boiled requiring slight cooking before consumption.

Yellow alkaline noodle (YAN), contains alkaline salts of sodium and potassium as the primary salts in the formulation and is often referred to as Ramen or Chinese style noodles. They can be sold as a fresh product or can be dried and packaged.

Hokkien noodles are similar in formulation to YAN, but are par-boiled, oiled and sold as fresh. As a result these noodles have a limited shelf life and microbial safety is a concern.

Fresh and boiled noodles have a relatively short shelf life in the tropics where they are produced and usually consumed. The shelf life is further reduced due to sub optimal production facility, quality of water, storage, distribution and handling systems (Miskelly 1993).

Instant noodles which are the most popular noodle product are steamed and fried. Although they are high in fat, it is shelf stable and convenient (Azudin 1998).
A product variation on steamed and fried instant noodles are steamed and dried products which has some health benefits.

The formulation may contain additives such as, gluten, starches &/or stabilisers as a processing aid or to improve appearance, cooking quality and texture of the final product. It is common practise to include dried condiments, soups, seasoning sachets and flavours in noodle packets making it a complete and convenient meal.
With technological improvements several other variations, such as frozen, chilled and long life noodles, have been introduced and accepted by the market as products of convenience. However, the raw material requirements, methodology and production procedures for the newer products is still the subject of considerable research in the food industry (Wu et al 1998). There is an obvious gap in information and this project aims to address some of these issues.

Producing high quality noodles is dependent on a consistent supply of flour with the correct specifications. The importance of selecting the most appropriate grade of wheat and setting optimum milling conditions cannot be over emphasised.

About 80% of Australia's total production (~22mt 99/00) is exported to 120 customers for use in a wide range of products. Approximately, 55% of the annual export is destined for the noodle markets (AWB Annual Report, 1998/99). This project focuses on developing a method to produce quality fresh and LLU noodles and evaluating the suitability of Australian wheat for the same.

2.0 Project Aims

1. Quantification of wheat and flour parameters for the production of fresh and long life noodles for specific markets.
2. Establishment of flour, processing and handling treatments which will optimise the shelf life and food safety of fresh noodles.

3.0 Materials and Methods

Australian Standard White Noodle (ASWN), ASWT and Australian Premium White (APW) were collected from WA during the 96/97 harvest for use in supporting experiments that were conducted to develop methodology to produce LLU noodles.

Approximately 50 kgs of 14 pure wheat varieties from the 95/96 and 96/97 seasons were sourced from VIC and SA viz., Horsham and Yeelanna, respectively.

Batavia with differing protein contents were received from Walpeup (13.9%), Horsham (8.1%) in VIC and Avondale (11.2%) in WA in 96/97.

All the grain received was cleaned and milled in the Buhler mill or pilot mill at BRI in Sydney, to specific extraction rates as described in each experiment.

Wheat and flour quality was determined using standard procedures prescribed in the RACI, Cereal Chemistry Division, Official testing methods (1995). Table 1 lists the tests conducted on the wheat, flour and end product.

Table 1 Quality characteristics tests conducted on wheat, flour and end product

Wheat	**Flour**	**End Product**
Test weight	Flour moisture	Colour
Grain Moisture	Flour protein (14% mb)	Firmness **or** TPA
Grain Protein	Minolta flour colour (L*, a*, b*)	Ease of separation of noodles
Falling No.	Minolta paste colour (L*,a*, b*)	Microbial quality*
-	Diastatic activity	-
-	Flour ash (14% mb)	-
-	Farinograph	-
-	Extensograph	-
-	Amylograph	-

* conducted only on selected samples

3.1 Noodle preparation

Fresh noodles were prepared by the Japanese Flour Mills Association (JFMA) method. One hundred parts of flour was mixed with 2 parts of sodium chloride and 34 parts of water and mixed at low speed for 1 minute initially followed by mixing for 2 minutes at medium speed using a paddle attachment in a Hobart mixer. The crumbly dough mixture was compacted with a purpose built compactor prior to sheeting. The dough block was passed between smooth sheeting rolls at a roll gap of 3 mm. The head and tail end of the dough sheet were folded along the direction of the sheeting, such that final length of the dough sheet was one-third its original length. The folded dough sheet was sheeted again. The dough sheet was then folded into half and sheeted and the process was repeated, before resting the dough sheet for 30 minutes in a sealed plastic bag. The rested dough sheet was then subjected to 3 further passes with a 30% reduction in successive roller gap such that the final sheet thickness was 2.5 mm. The dough sheet was cut to produce noodles with a width of 2.1 mm.

3.1.1 Fresh noodle preparation

Freshly cut noodles were cooked for 20 minutes in about 10 times its volume in boiling water in a large utensil. At the end of the cooking time, boiled noodles were transferred to a colander and rinsed in running cold tap water. The noodles were drained by firmly tapping the colander about 5 times on the bench to get rid of excess water. The cooked and rinsed noodles were weighed to calculate yield as a percent of original weight. Textural and colour measurements were conducted on the cooked samples.

3.1.2 Method development for LLU noodles

The main stages in the production of LLU noodles are fresh noodle production, parboiling, washing, acid treatment, oiling, packaging, secondary heat treatment, aging followed by evaluation.
Several process optimisation experiments and effects of several variables such as, milling extraction, varieties, protein content etc were conducted to develop the final method to produce quality LLU noodles in the laboratory.

In order to mimic long term storage trials, LLU noodle blocks were subjected to accelerated storage conditions. Storing for 3 months at 30 ^{0}C in an ageing chamber (Yamato, Model No. YRR-17A) was equivalent to 6 months storage at ambient conditions. An appropriate time/temperature regime (Quail 1997, Personal communication) was selected to study the effect of ageing on the colour and firmness of LLU noodles. The accelerated storage conditions at which the samples were stored and the equivalent long term storage times are listed in Table 3.

For all supporting experiments the protocol used was for LLU production is as detailed in Table 2.

Table 2 Protocol for LLU production

Process	Details
Fresh noodle production	As detailed in 3.1
Parboiling in excess water	5 minutes
Immersing in running cold water	30 seconds
Acetic acid treatment	7.5 M for 1 minute
Oiling in vegetable oil	@ 2% weight of cooked noddle
Packaging	150 g in polyethylene packs, 0.3 g/CC, oxygen permeability
Secondary heat treatment	20 minutes @ 90 ^{0}C

Table 3 Accelerated storage conditions and equivalent long term storage conditions

Storage conditions	Equivalent to
30 ^{0}C/ 3 months	6 months
30 ^{0}C/ 1 month	2 months
30 ^{0}C/ 15 days	1 month
30 ^{0}C/ 7 days	2 weeks
30 ^{0}C/ 1 day	0 week

3.1.3 Evaluation of noodle quality

Colour was objectively evaluated with a Minolta Chroma Meter (CR 310, Osaka) fitted with the large viewing head (50 mm). Dough sheet at zero time, 24 hours after production and cooked noodle colour were evaluated for fresh noodles, while the top surface of the LLU noodle block was objectively evaluated. Dough sheet was placed in a sealed plastic bag in an aging chamber at 22 ^{0}C for 24 hours before recording the 24 hour colour and the fresh noodles were cooked for 20 minutes and colour of the surface of noodles was recorded by placing the viewing head of the chromameter on top of the sample.
Measurements were taken twice and statistical comparisons were made on the L* (whiteness) and +b* (yellowness) of samples over time and different processing conditions.

Cooking yield for fresh noodles was measured as the percent gain in weight of fresh noodles after cooking for 20 minutes.

LLU noodle blocks and noodle samples from strategic processing stages were forwarded to FSA, Werribee for standard plate count., The microbial quality is represented as colony forming units/g (cfu/g) of sample.

LLU noodles were evaluated for the ease of separation by a subjective procedure using trained panellists. Six hundred mls of boiling water was poured over a noodle block, which was previously removed from the packaging and placed in a deep bowl. Separation of the strands commenced as the boiling water was added over the LLU noodle block. The ease with which the noodles dis-aggregate when stirred gently for couple of minutes with a chopstick in to individual strands was noted and scored. Included in the scoring was also the definition of the individual strands (Personal Communication, Korean Noodle Manufacturers 1997).

LLU noodles were scored as detailed;

- 1-3 for poor separation, ie., the noodle strands fragmented on stirring,
- 4-6 for average separation, ie., extent of fragmentation was not high and
- 7-10 for excellent separation to individual strands.

The noodle strands that were separated in boiling water were immersed in tap water for 30 minutes before measuring firmness. Firmness was measured in Newtons (N) with a Lloyd texture meter (Model No.LRX, Manchester), using a 50 N load cell. Sheer tests were conducted thrice on 3 new strands of cooked noodles each time, that were placed on a custom made sample holder and cut as detailed in Agrifood Technology's Technical Procedure No.177.

Texture Profile Analysis (TPA) was conducted on 3 strands of cooked fresh and LLU noodles that were made to study the effect of native and chemically modified starch on noodle quality and measured the following attributes; springiness, cohesiveness, gumminess and chewiness using a Lloyd texture meter (Bourne 1978). TPA measurements were conducted on noodles strands that were separated in boiling water and equilibrated in cold water for 30 minutes.

Hardness is defined as the peak force (N) during the first of the 2 compression cycles, during which the noodles were subjected to 50% compression.

Cohesiveness is defined as the ratio of the positive force area during the second compression to that of the first compression, ie., Area Peak 2/Area Peak 1.

Springiness is defined as the height (mm) that the noodle recovers during the time that elapses between the end of the first bite and the start of the second bite.

Gumminess is defined (N) as the product of Hardness x Cohesiveness.

Chewiness is defined (N.mm) as the product of gumminess x springiness, which can be translated to (Hardness x Cohesiveness) X Springiness

3.2 Supporting experiments

Several supporting experiments were conducted to standardise production of LLU noodles on a laboratory scale. These include;

- effect of milling extraction on LLU noodle quality,
- effect of wheat variety on LLU noodle quality,
- effect of protein on LLU noodle quality
- effect of strength and acid type on LLU noodle quality,
- effect of storage conditions on LLU noodle quality
- effect of native and modified starches on LLU noodle quality

3.2.1 Effect of milling extraction on LLU noodle quality

ASWN grade sourced from WA (~protein = 10.5%) during the 1996/97 harvest were cleaned and milled in a laboratory scale Buhler mill at 40, 50, 60 and 70% extraction rates. Grain and flour quality characteristics are tabulated in Appendix I.
LLU noodles were made according to the method described in Table 2. Colour, firmness and ease of separation were measured after 24 hours, 1 week, 1 fortnight, 1 month, and 3 months of accelerated storage.

3.2.2 Effect of wheat variety on LLU noodle quality

Fourteen typical Wheat varieties that are generally classified as ASWN /APW were identified and grown at Yeelanna in VIC during the 95/96 and 96/97 seasons. The varieties were Batavia, Cadoux, Eradu, Hartog, Janz, Katunga, Machete, Meering, Suneca, Tammin, Trident, Vectis, Yanac and Goldmark. However, no sample of Eradu, Tammin and Vectis was collected in 96/97. Wheat was cleaned and milled to 60% extraction and the quality of fresh and LLU quality was evaluated as detailed in 3.1. and 3.1.3, respectively. Wheat and flour quality characteristics are detailed in Appendix II.

3.2.3 Effect of protein level on LLU noodle quality

High, medium and low protein Batavia from the 96/97 harvest was collected from Walpeup (VIC), Avondale (WA) and Horsham (VIC) sites with the following protein contents 13.9, 11.2 and 8.1%, respectively. Varietal differences that might effect LLU noodle quality was eliminated by selecting one variety with a range in protein contents. Cleaned samples were milled to produce 60% extraction flour in a laboratory scale Buhler mill. Flour quality characteristics are tabulated in Appendix III.
LLU noodles were produced and evaluated according to the method described in Table 2.

3.2.4 Effect of excessive water addition on LLU noodle quality

ASWN from WA of the 96/97 harvest was cleaned and milled at 60% in the laboratory mill. Grain and flour quality characteristics are tabulated in Appendix I.
LLU noodles were produced and evaluated according to the method described in Table 2. However, 3 different water levels, 35, 40 and 45%, two of which were higher than

those normally utilised in the formulation, were used to make the dough Wu et al (1998) indicated that increased water addition could improve texture of final product. Water addition in the manufacture of udon noodles ranges from 28 to 40%, depending on process utilised, flour moisture, seasonal fluctuations and moisture content of end product (Nagao 1989).

3.2.5 Effect of acid type and strength of acid on LLU noodle quality

ASWN from 96/97 was collected from WA. Samples were cleaned and milled to 60% extraction rate. Grain and flour quality characteristics are tabulated in Appendix I.
LLU noodles were produced and evaluated according to the method described in Table 2. Parboiled noodles were immersed separately in 5, 10 and 15 M acetic acid and 5 and 10 M lactic acid for 1 minute and compared with control samples for colour and firmness.

3.2.6 Effect of storage conditions on LLU noodle quality

Cadoux and Eradu from WA and Rosella and Yanac from VIC were collected during the 96/97 harvest and cleaned. The grain was milled to 60% extraction in the pilot mill at BRI, Sydney. Flour quality characteristics are detailed in Appendix IV.
The flours were blended in the following ratios, Cadoux/Eradu (60:40), Cadoux /Eradu (40:60) and Rosella /Yanac (80:20) from which LLU noodle samples were produced as detailed in Table 2. However, the LLU noodle blocks made from the 3 blends of flour were stored for 4-5 months in light and dark (by wrapping in aluminium foil) at room (ambient) temperature and not subjected to accelerated temperature storage. The effect on colour and firmness of LLU noodles subjected to different storage conditions was evaluated at 0, 1, 2, 3 weeks and 1, 2, 3, 4 and 5 months.

3.2.7 Effect of pure and native starches in commercial Japanese and Korean blends

ASWN, ASWT and APW from the 96/97 harvest was sourced from WA and milled to 60% extraction in a laboratory Buhler mill. Grain and flour quality characteristics for the Japanese and Korean blends are detailed in Appendix I and V, respectively. The Japanese blends consisted of:

- ASWN:APW , 60:40 ratio,
- ASWN;APW , 40:60 ratio plus 10% native tapioca starch and
- ASWN;APW , 40:60 ratio plus 10% chemically modified starch (N1 Purity)

The Korean blends evaluated were

- ASWN:ASWT:APW, 30:30:40 ratio
- ASWN:ASWT:APW, 10:30:60 plus 10% native Amioca starch and
- ASWN:ASWT:APW, 10:30:60 plus 10% chemically modified starch (N1 Purity)

The starches were sourced from National Starches, Australia and were a homogenous, white powder with no traces of any other colour detected.. L* values ranged from 94.5 to 95.3. The advantages and effects of substituting ASWN with commercial starches on the quality of fresh and LLU noodles were evaluated at T=0 and 6 months.

ASWT is a special segregation for the Korean market and the combined effect of the 3 grades in the presence of added starches were evaluated for fresh and LLU noodles.
Colour and TPA including firmness were measured as an indicator of quality for fresh noodles while ease of separation of noodles was also tested to determine LLU noodle quality.

4.0 Results and Discussion

Results of supporting experiments that facilitated the development of LLU noodle production are reported here.

4.1 Effect of milling extraction on LLU noodle quality

4.1.1 Effect of storage on colour of LLU made from different extraction flours

Table 4 shows the effect of storage on colour when LLU noodles are made from flours of different extraction rates. At 0 week, (24 hours after production) the L* value of LLU noodles made from 40, 50 and 60% extraction flours were similar (average = 80.4), while the L* value of LLU noodle made from 70% extraction flour was lower (79.5). The b* value of LLU made from the 40% extraction flour was the highest (23.3), while the b* value of LLU noodle made from flours at higher extraction rates were similar (average = 21.6).
Regardless of extraction rates, the L* value increased with time for all LLU noodles. The increase in whiteness (L* value) was more pronounced in LLU noodles made from lower extraction flour and decreased gradually with an increase in extraction rate. However, the increase in whiteness in LLU noodle made from 70% extraction flour was intermediate to the 40 and 60% extraction flours.
All LLU noodle blocks showed a significant decrease in yellowness with time, however, the reduction in yellowness was most significant in LLU noodles made from 40% extraction flour. The decrease in b* value in LLU noodles made from 70% extraction flour followed a similar trend to the L* value, and was intermediate to the 40 and 60% extraction flours. This substantial reduction in b* value and a small increase in L* value confers a ‘bleached’, dull appearance to the product, probably due to the acid environment they are packed in.

4.1.2 Effect of extraction rate of flour on firmness of LLU noodles over time

Table 5 demonstrates the effect of extraction rate on firmness on LLU noodles during storage. The mean firmness (N) of LLU noodle made from 40% extraction flour was lower (1.16 N) compared to the firmness of LLU noodles made from the higher extraction flours. The firmness of LLU noodle made from 40% extraction flour at 1 month and 6 months were significantly softer than at any other time during the study. The average firmness of LLU noodles from 40% extraction flour at 0 week was equivalent to the firmness of LLU noodles made from 60 and 70% extraction flour at 2 and 6 months of storage.

LLU noodles at 40% extraction flour after 6 months of production was the whitest (L* value), had the lowest yellowness (Table 4) and firmness (Table 5) compared to any of the other noodles during any time of the study, suggesting that 40% extraction flour is probably not the optimal flour to produce LLU noodle of the highest quality.

The firmness of LLU noodles made from 50% extraction flour was significantly firmer immediately after production (0 week, 2 weeks) than on storage, while the firmness of LLU noodles produced from 60% extraction flour did not alter on storage.
LLU noodles made from the 70% extraction flour was significantly softer at 1 month than LLU noodles when tested at 0 week and 2 weeks after production.

Table 4 Effect of storage on colour of LLU noodles made with flours of varying extraction rates

Test Time	**ASWN 40%**		**ASWN 50%**		**ASWN 60%**		**ASWN 70%**	
	L*	**b***	**L***	**b***	**L***	**b***	**L***	**b***
0 week	80.3 ± 0.62	23.3 ± 0.37	80.6 ± 0.53	21.8 ± 0.32	80.4 ± 0.30	21.6 ± 0.17	79.6 ± 0.42	21.6 ± 0.26
2 weeks	81.4 ± 0.32	20.1 ± 0.25	81.1 ± 0.49	19.5 ± 0.25	80.5 ± 0.44	19.3 ± 0.17	80.3 ± 0.84	18.9 ± 0.15
1 month	81.0 ± 0.40	18.8 ± 0.12	81.2 ± 0.26	18.1 ± 0.10	80.9 ± 0.19	18.3 ± 0.33	80.3 ± 0.61	18.5 ± 0.25
2 months	81.5 ± 0.30	15.6 ± 0.11	81.2 ± 0.34	16.7 ± 0.17	80.9 ± 0.76	16.0 ± 0.55	80.5 ± 0.35	16.7 ± 0.21
6 months	82.0 ± 0.20	13.3 ± 0.14	81.4 ± 0.37	14.7 ± 0.20	81.1 ± 0.34	14.7 ± 0.21	80.9 ± 0.08	15.1 ± 0.15

Mean ± SD

Table 5 Effect of extraction rate on firmness on LLU noodles during storage

Test Time	**Firmness (N) ASWN 40%**	**Firmness (N) ASWN 50%**	**Firmness (N) ASWN 60%**	**Firmness (N) ASWN 70%**	**Mean**
0 week	1.24**a** ± 0.03	1.36**a** ± 0.01	1.22 ± 0.03	1.32**a** ± 0.03	1.29 ± 0.07
2 weeks	1.20**a** ± 0.02	1.36**a** ± 0.02	1.30 ± 0.04	1.34**a** ± 0.01	1.30 ± 0.07
1 month	1.09**bc** ± 0.02	1.19**b** ± 0.02	1.19 ± 0.04	1.22**bc** ± 0.02	1.10 ± 0.06
2 month	1.16**ac** ± 0.03	1.22**b** ± 0.04	1.16 ± 0.04	1.24**ac**± 0.05	1.20± 0.04
6 month	1.10**bc** ± 0.03	1.23**b** ± 0.02	1.24 ± 0.04	1.23**ac** ± 0.04	1.20± 0.07
Mean	1.16 ± 0.06	1.27 ± 0.08	1.22 ± 0.05	1.27 ± 0.06	

Means in the same column not followed by the same letter are significantly different at p<0.05.
Mean ± SE

Table 6 demonstrates the change in firmness of LLU noodles for different extraction rates over time. The mean firmness of LLU noodles at 0 and 2 weeks were similar and higher than the firmness of LLU noodles stored for longer periods, regardless of the extraction rate.
LLU noodle made form 40 and 60% extraction flour were significantly softer ($p < 0.05$) at 0 week compared to LLU noodle made from 50 and 70% extraction flours. The firmness of LLU noodles made from 50, 60 and 70% extraction flours were similar after 2 weeks of storage.
There was no significant difference in firmness between LLU noodles from any of the extractions when measured 2 months after production.

Table 6 Change in firmness of LLU noodles for different extraction rates with time

Flour Extraction	**Flour Extraction**	**0 weeks**	**2 weeks**	**1 month**	**2 months**	**6 months**	**Mean**
ASWN 40	**ASWN 40**	1.24**a** ± 0.03	1.20**a** ± 0.02	1.09**a** ± 0.01	1.16 ± 0.02	1.10**a** ± 0.03	1.16 ± 0.06
ASWN 50	**ASWN 50**	1.36**b** ± 0.01	1.36**bc** ± 0.02	1.19**bc** ± 0.02	1.22 ± 0.04	1.23**bc** ± 0.02	1.27 ± 0.08
ASWN 60	**ASWN 60**	1.22**a** ± 0.03	1.30**ac** ± 0.04	1.19**ac** ± 0.04	1.16 ± 0.04	1.24**ac** ± 0.04	1.22 ± 0.05
ASWN 70	**ASWN 70**	1.32**b** ± 0.03	1.34**bc** ± 0.01	1.22**bc** ± 0.02	1.24 ± 0.05	1.23**ac** ± 0.04	1.27 ± 0.06
Mean	**Mean**	1.29 ± 0.07	1.3 ± 0.07	1.17 ± 0.06	1.2 ± 0.04	1.2 ± 0.07	

Means in the same column not followed by the same letter are significantly different at $p<0.05$.
Mean ± SE

4.1.3 Effect of extraction rates on ease of separation of noodles

Table 7 shows the ease of separation of LLU noodles made from different extraction rates, when assessed 6 months after production.

Table 7 Ease of separation of LLU noodles made from different extraction rates

Flour Extraction	**Ease of Separation**
ASWN 40	8
ASWN 50	6
ASWN 60	7
ASWN 70	4

It is clear from Table 7, that the ease of separation was the best for LLU noodles made from ASWN extracted at 40%. LLU noodles made form 60% ASWN had better ease of separation than those made from 70% or 50% extraction flour. LLU noodles made form ASWN 70% had poor ease of separation. The ease of separation of LLU noodles made from different extraction flours were similar soon after production (results not tabulated), but the noodle strands tended to adhere to each other on storage, as a result greater force was required to separate them in boiling water causing them to fragment.

4.2 Effect of wheat variety on LLU noodle quality

4.2.1 Effect of wheat variety on LLU noodle colour

The effect on colour due to varietal differences of samples sourced from Yeelanna in the 95/96 harvest is shown in Table 8.

Table 8 Effect on colour of LLU noodles on storage due to varietal differences (95/96 harvest)

Variety	0 week		2 weeks		1 month		2 months		6months	
	L*	b*	L*	b*	L*	b*	L*	b*	L*	b*
Batavia	79.9	22.4	80.2	21.3	80.3	21.6	79.7	19.6	81.4	15.8
Cadoux	79.2	21.7	78.5	20.2	78.9	19.4	79.1	17.8	79.9	14.5
Eradu	80.0	16.0	79.5	15.0	80.0	15.1	79.5	13.8	81.0	13.1
Hartog	78.6	20.0	79.2	18.3	79.5	18.0	80.6	15.6	80.5	14.7
Janz	79.5	20.2	80.0	19.2	80.2	19.0	80.1	17.5	80.6	15.6
Katunga	79.0	21.1	79.3	20.4	79.5	19.0	79.5	17.3	78.7	14.9
Machete	78.9	20.1	79.1	17.5	79.5	17.3	79.5	15.0	79.5	15.6
Meering	79.8	21.5	79.8	20.3	80.3	18.9	80.2	18.6	81.2	15.0
Suneca	80.1	20.5	79.6	19.0	80.2	18.8	80.1	15.5	80.7	14.1
Tammin	79.9	16.9	80.0	15.3	79.7	14.8	79.6	13.9	79.9	14.3
Trident	79.5	23.0	79.7	22.2	79.9	21.5	79.2	20.6	79.6	16.0
Vectis	78.6	25.3	79.5	23.5	79.9	21.2	79.4	19.0	79.4	16.0
Yanac	79.9	18.4	79.9	17.5	80.2	17.5	79.7	16.0	80.0	15.1
Goldmark	79.8	21.9	79.6	20.6	79.7	19.9	79.6	17.6	80.8	16.1

Values are averages of 2 readings

The L* value of LLU noodles spanned a very narrow range from 78.6 in Hartog at 0 week to 81.4 in Batavia, 6 months after storage. The brightness increased with storage in 79% of all varieties, while the L* value was greater than 80.0 units in less than half the varieties tested.

After a slight increase in L* value for LLU noodles made from Katunga during the initial part of the storage study, the L* value at the end of 6 months was lower than that at 0 week. Similarly, Tammin samples showed an increase in brightness 2 weeks after storage, then decreased gradually to have a final L* value similar to 0 week samples.

Yellowness values ranged from 25.3 in LLU noodles made from Vectis at 0 week to 13.1 in Eradu after 6 months of storage. A significant range in b* value was observed in LLU noodles at 0 week starting from 25.3 and decreasing to 16.0, so the drop in b* values on storage was not unanticipated. Owing to the preference of several SE Asian customers for a naturally occurring inherent yellow colour in flour, breeding programs actively target at increasing flavanoid components of wheat (Meares 1996).
All samples recorded a decrease in b* value on storage, while the biggest drop was seen in Vectis (37%).

Rate of change in L* and b* values on storage for the different varieties tested in 95/96 is depicted in Figures 1 a and b, respectively.

Results for brightness and yellowness of LLU noodles made from the 96/97 varieties and its effect on storage are tabulated in Table 9.

Table 9 Effect on colour of LLU noodles on storage due to varietal differences (96/97 harvest)

Variety	**0 week**		**2 weeks**		**1 month**		**2 months**		**6months**	
	L*	**b***	**L***	**b***	**L***	**b***	**L***	**b***	**L***	**b***
Batavia	79.8	20.3	79.5	20.1	80.1	19.0	80.1	14.8	80.5	14.3
Cadoux	79.7	20.0	78.9	19.0	79.7	18.3	79.2	13.7	79.9	13.6
Eradu	-	-	-	-	-	-	-	-	-	-
Hartog	81.2	18.2	80.7	18.0	81.4	17.6	81.0	13.1	81.2	13.9
Janz	79.8	18.1	80.8	17.8	80.6	17.2	80.0	14.6	80.5	12.3
Katunga	79.4	21.4	79.1	21.1	79.3	19.6	78.9	15.6	79.3	12.6
Machete	78.4	19.2	79.1	19.0	79.2	18.7	79.1	16.4	79.2	14.2
Meering	79.0	18.9	78.9	18.6	79.6	18.3	79.2	15.5	79.0	13.9
Suneca	79.7	19.2	81.0	19.1	80.9	18.9	80.6	14.6	80.1	12.9
Tammin	-	-	-	-	-	-	-	-	-	-
Trident	80.1	20.7	80.4	20.4	80.8	20.2	80.0	17.3	80.0	13.9
Vectis	-	-	-	-	-	-	-	-	-	-
Yanac	79.1	16.8	80.1	16.7	79.7	16.4	79.4	14.9	80.2	12.7
Goldmark	79.5	19.5	79.3	19.2	80.4	18.4	80.2	14.9	80.0	13.6

Values are averages of 2 readings

Samples of Eradu, Tammin and Vectis could not be collected in 96/97 and hence seasonal effect on colour of LLU noodles could not be made.
L* values did not exhibit big differences at 0 week for samples that were tested in 95/96 and 96/97 from Yeelanna. However, b* values were lower in all cases in 96/97 than 95/96 at 0 week, with the exception of Katunga that showed a very small increase. Lower b* value for LLU noodles made from all the varieties tested in 96/97 was probably a seasonal effect.

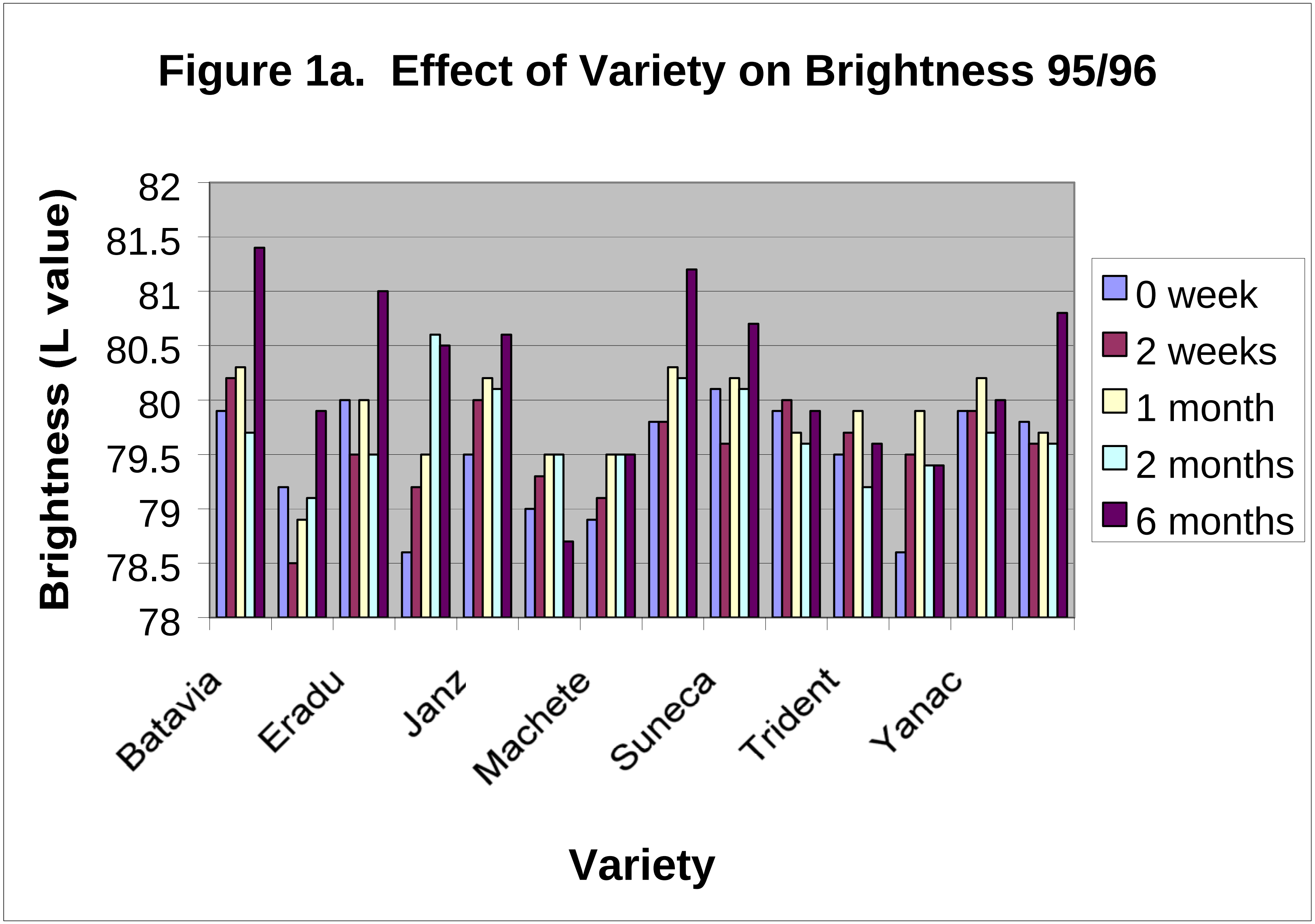


Figure 1a. Effect of Variety on Brightness 95/96
Brightness (L value)
82
81.5
81
80.5
80
79.5
79
78.5
78
Batavia
Eradu
Janz
Machete
Suneca
Trident
Yanac
Variety
0 week
2 weeks
1 month
2 months
6 months

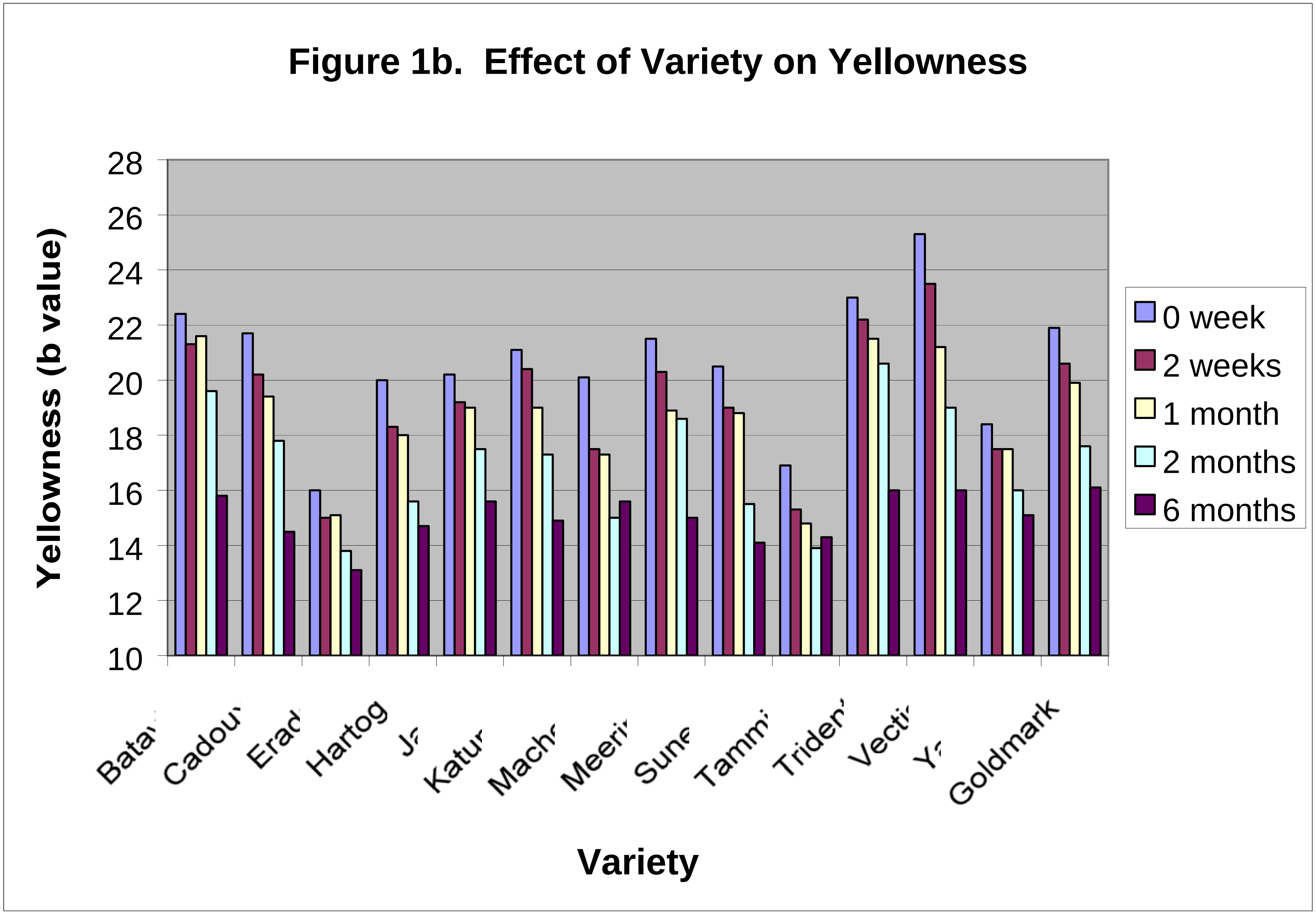


Figure 1b. Effect of Variety on Yellowness
Yellowness (b value)
28
26
24
22
20
18
16
14
12
10
Batav
Cadou
Erad
Hartog
Ja
Katur
Mach
Meeri
Sune
Tamm
Trider
Vecti
Y
Goldmark
Variety
0 week
2 weeks
1 month
2 months
6 months

Brightness of LLU noodles made from 96/97 varieties increased on storage while yellowness decreased, like the samples from 95/96. However, the final b* value for all varieties was lower than the yellowness of LLU noodles made in 95/96. This was probably due to a low b* value at the onset of the storage study. Janz recorded the lowest b* value (12.3) at the end of the storage trial.
Figures 2 a and b shows the change in L* and b* values on storage of varieties tested in 96/97, respectively.

4.2.2 Effect of wheat variety on LLU noodle firmness during storage

The effect of wheat variety sourced from Yeelana during the 95/96 season on firmness of LLU noodle during storage is presented in Table 10.

Table 10 Effect of wheat variety from Yeelana (95/96) on firmness of LLU noodle on storage

Variety	Firmness (N)				
	0 week	2 weeks	1 month	2 months	6months
Batavia	1.30	1.35	1.34	**1.27**	1.31
Cadoux	**1.18**	**1.16**	**1.13**	**1.15**	**1.19**
Eradu	**1.14**	**1.11**	**1.12**	**1.15**	**1.14**
Hartog	1.35	1.37	1.36	1.33	1.41
Janz	1.53	1.63	1.60	1.52	1.56
Katunga	1.37	1.35	1.40	1.46	1.32
Machete	1.32	1.49	1.36	1.38	1.36
Meering	1.38	1.46	1.48	1.33	1.42
Suneca	1.40	1.43	1.34	1.39	1.41
Tammin	**1.07**	**1.10**	**1.12**	**1.15**	**1.19**
Trident	1.31	**1.29**	1.39	1.39	1.40
Vectis	**1.24**	**1.27**	1.30	1.39	**1.29**
Yanac	1.31	1.35	1.34	**1.25**	1.34
Goldmark	1.33	1.39	1.35	1.40	1.31

The firmness for the different varieties on storage spans a narrow range between 1.10 – 1.63 N. To study the effect of varietal differences on firmness during storage, those with a firmness value of less than or equal to 1.3 N have been highlighted in Table 10. A close look at the data suggests that firmness values of LLU noodles averaged around 1.30 N, hence 1.30 N was selected as the cut off point for optimal firmness in LLU noodles. The firmness value for Cadoux, Eradu and Tammin were lower than 1.3 N through out the study, while LLU noodles made from Tammin had the lowest firmness of the 3 varieties. LLU noodles made from Vectis had low firmness at 0, 2 weeks and 6 months but, showed an increase in firmness during 1 and 2 months. No clear trend was observed on the effect of firmness with time for the other varieties tested. Figure 3 demonstrates varietal influences in 95/96 from Yeelanna, on firmness of LLU noodles.

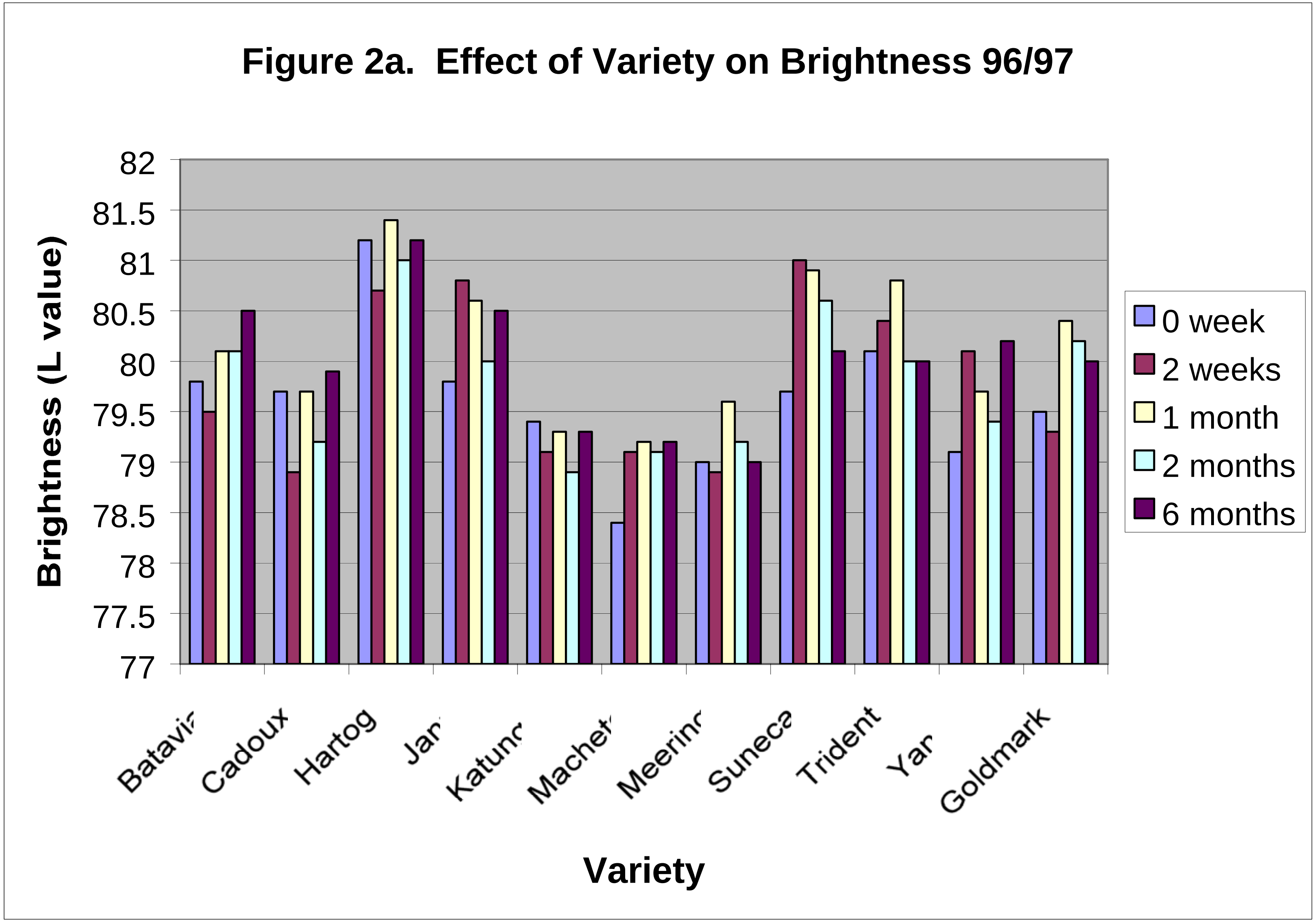


Figure 2a. Effect of Variety on Brightness 96/97
82
81.5
81
80.5
80
79.5
79
78.5
78
77.5
77
Brightness (L value)
Goldmark
Variety
0 week
2 weeks
1 month
2 months
6 months

Figure 2b. Effect of Variety on Yellowness 96/97

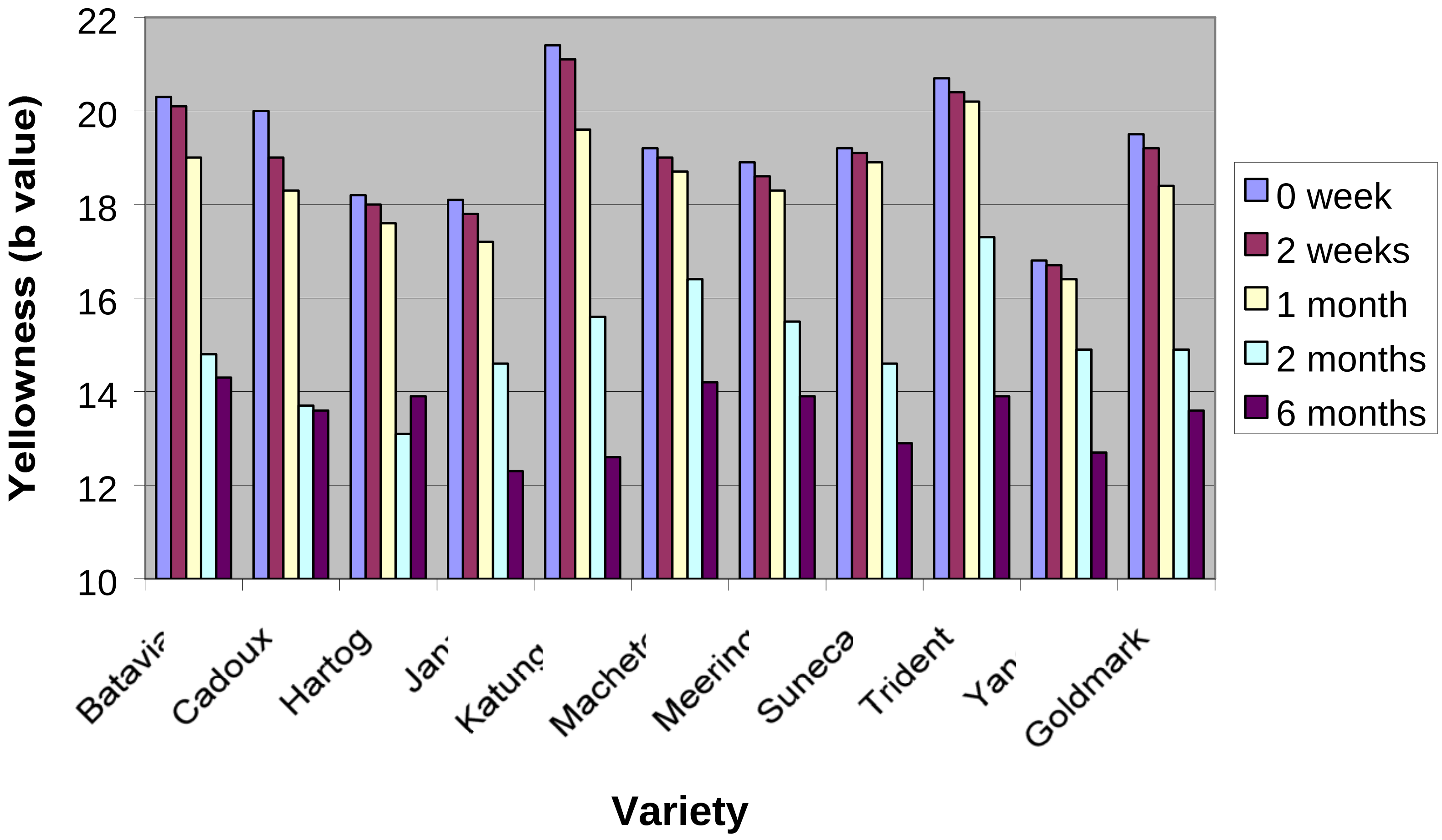
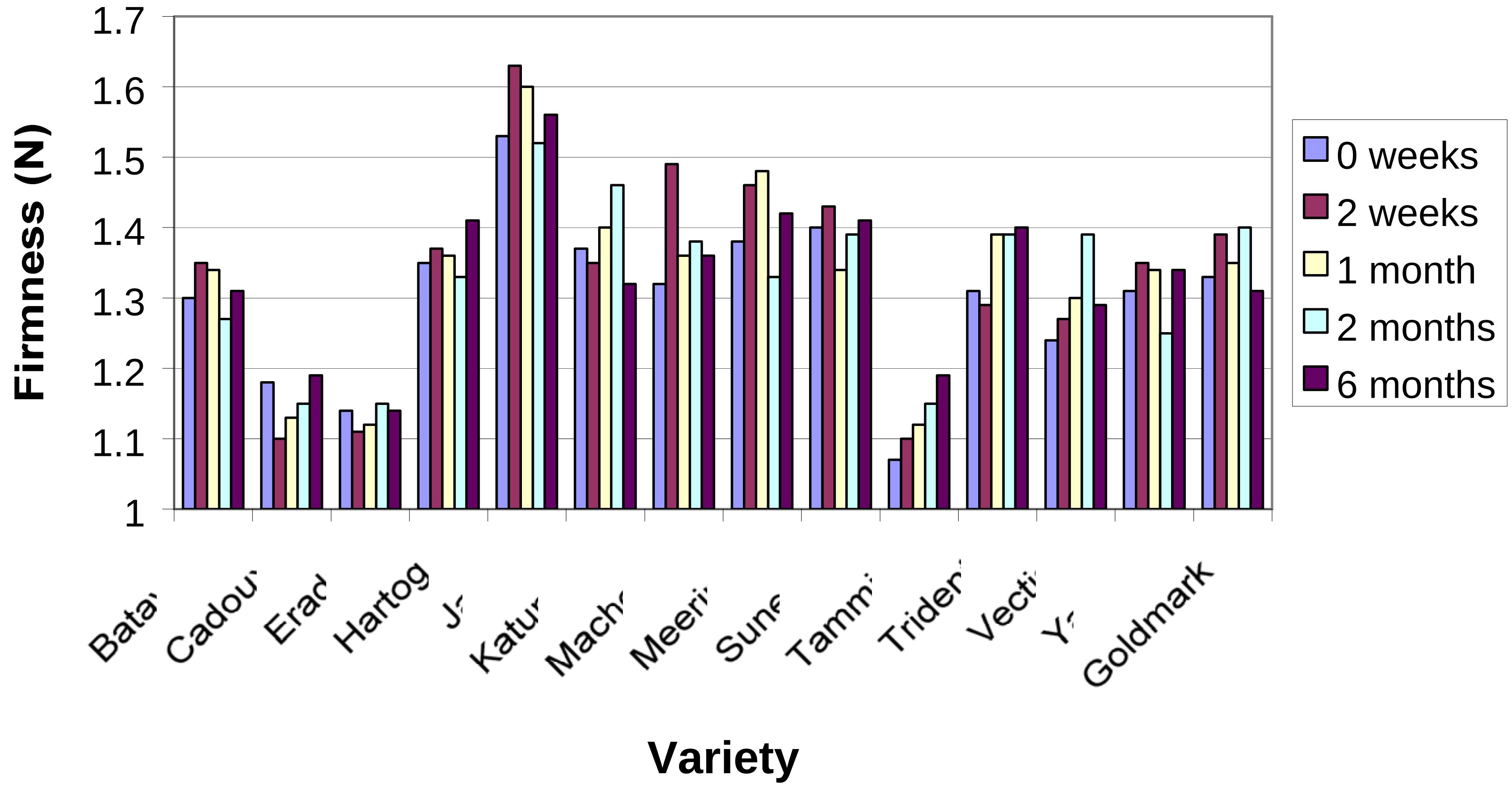


Figure 3. Effect of Variety on LLU Firmness 95/96



The harvest in 96/97 was unusual to the previous year resulting in some varieties not being available for testing and an average reduction in protein content of 3-4% in most sites. However, Yeelanna (VIC) recorded similar protein levels over 2 seasons and provided near complete set of varieties.
Table 11 demonstrates the effect of similar varieties from Yeelanna in 96/97.

Table 11 Effect of wheat varieties from Yeelanna (96/97) on firmness of LLU noodle quality

Variety	**Firmness (N)**				
	0 week	**2 weeks**	**1 month**	**2 months**	**6months**
Batavia	**1.25**	**1.07**	**1.19**	**1.16**	**1.10**
Cadoux	**1.08**	**0.96**	**1.02**	**1.05**	**0.92**
Eradu	**-**	**-**	**-**	**-**	**-**
Hartog	**1.13**	**1.00**	**1.17**	**1.11**	**1.11**
Janz	1.34	1.18	1.38	1.35	1.38
Katunga	**1.19**	**1.29**	**1.30**	1.38	1.33
Machete	1.33	**1.21**	1.36	1.35	1.32
Meering	1.31	**1.23**	**1.20**	**1.26**	**1.30**
Suneca	**1.26**	**1.19**	**1.26**	**1.19**	**1.23**
Tammin	**-**	**-**	**-**	**-**	**-**
Trident	**1.15**	**1.19**	**1.17**	**1.21**	**1.24**
Vectis	**-**	**-**	-	-	**-**
Yanac	**1.07**	**1.24**	**1.16**	**1.15**	-
Goldmark	**1.20**	**1.09**	**1.25**	1.33	**1.27**

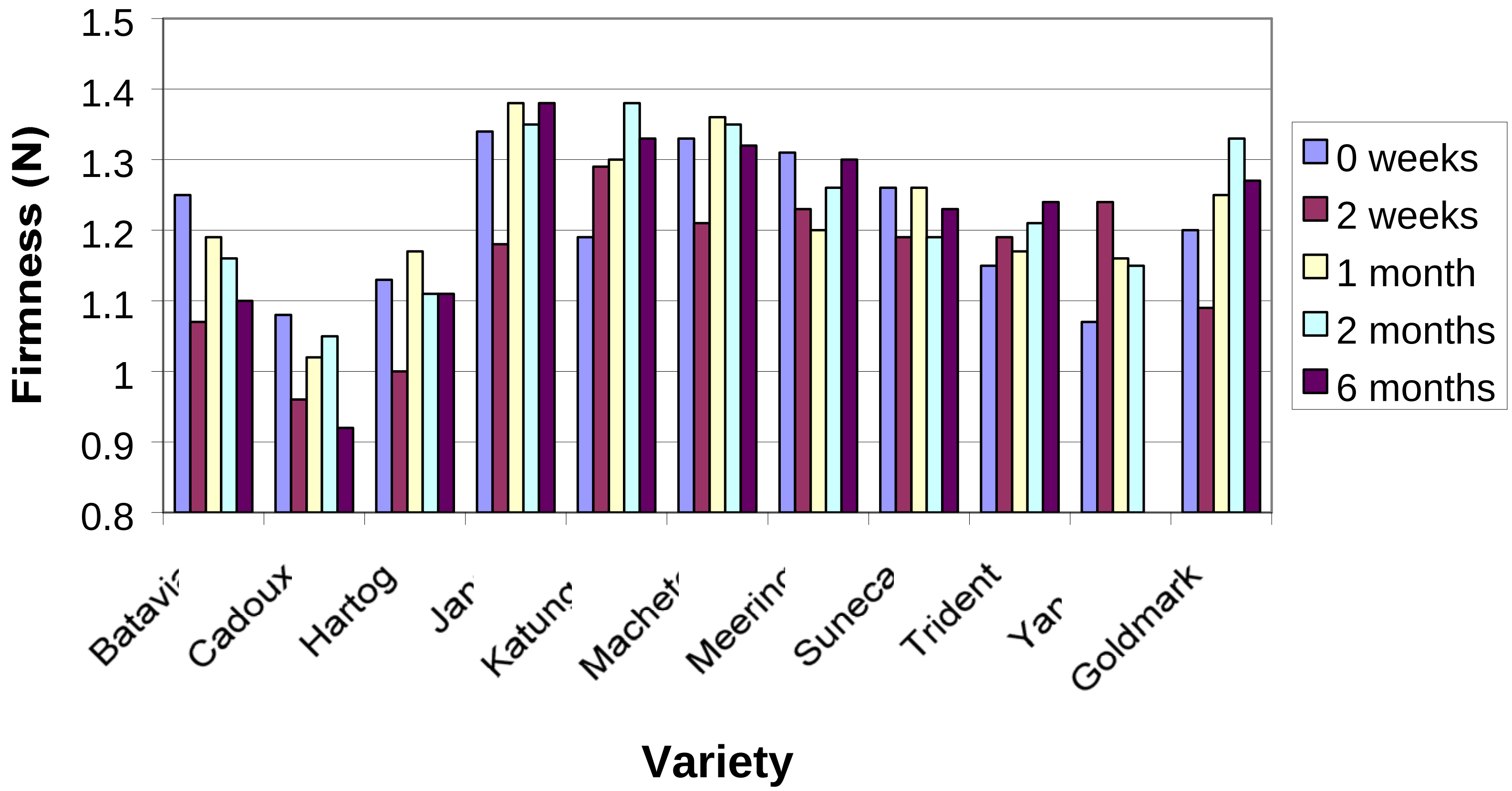
LLU noodles from Cadoux had firmness values less than 1.3 N for both the seasons. Samples of Eradu, Tammin and Vectis could not be collected in 96/97 and hence seasonal effect on firmness of LLU noodles could not be made. However, in 1996/97 the firmness of LLU noodles made from several varieties was lower than 1.3 N through out the storage trial and these included Batavia, Hartog, Suneca, Trident and Yanac. The maximum firmness value for LLU noodle from all varieties in 96/97 was lower (1.38 N) than in 95/96, which was probably a seasonal effect.
Katunga and Goldmark had firmness values less than 1.3 N during the first month of storage followed by a slight increase in firmness with storage. Figure 4 highlights the effect of varieties in 96/97 from Yeelanna on firmness of LLU noodles.

4.2.3 Effect of wheat varieties on fresh noodles quality

The varieties that were tested for LLU noodle quality were also tested for fresh noodle quality over 2 seasons. Dough sheet colour at zero time and 24 hours after sheeting, cooked noodle colour, firmness and cooking yield for the 95/96 season of select varieties are presented in Table 12.

The L* value at T=0 spanned a narrow range from 85.8 – 87.3, which was much higher than the 0 week value obtained for LLU noodles.

Figure 4. Effect of Variety on LLU Firmness 96/97



The processing steps causes a considerable reduction in whiteness of the LLU noodles when tested 24 hours after production. However, the L* values of the fresh noodle dough sheet after 24 hours was very similar to the 0 week value for LLU noodle blocks. In other words, the loss of brightness in the dough sheet after 24 hours is similar to the loss in brightness due to processing.

Table 12 Colour, firmness and cooking yield of fresh noodles from the 95/96 season

Varieties	**T=0**		**T= 24 hours**		**Cooked Noodle**		**Firmness**	**Cooking yield**
	L*	**b***	**L***	**b***	**L***	**b***	**(N)**	**(%)**
Batavia	85.8	22.5	79.8	28.5	83.0	24.4	1.70	171
Cadoux	86.6	22.5	79.0	27.5	82.9	24.8	1.65	190
Eradu	87.0	17.4	77.3	19.5	82.3	18.5	1.67	193
Hartog	86.3	19.9	77.7	26.3	81.6	22.6	1.82	170
Janz	87.2	17.5	79.9	22.7	81.2	20.9	1.60	167
Katunga	86.3	20.9	80.0	25.3	81.7	22.9	1.67	193
Machete	86.7	18.4	78.2	23.9	81.9	21.8	1.92	180
Meering	86.7	20.1	80.6	23.6	84.3	22.3	1.67	174
Suneca	86.0	20.7	78.3	22.6	82.2	21.4	1.87	166
Tammin	87.3	17.9	80.7	21.6	82.6	19.1	1.44	188
Trident	86.6	22.1	79.7	27.9	82.5	24.4	1.72	178
Vectis	86.2	24.4	79.6	26.5	82.7	25.4	1.79	184
Yanac	86.1	17.4	78.8	22.6	82.5	18.7	1.75	183
Goldmark	86.6	20.5	78.6	26.4	81.8	23.0	1.81	179

As can be seen in Tables 8 & 9, whiteness of LLU increases on storage, however, the trend is reversed with fresh noodles because of poor colour and deteriorating microbial quality.

Table 13 presents dough sheet colour at zero time and 24 hours after sheeting, cooked noodle colour, firmness and cooking yield for select varieties from Yeelanna collected the 96/97 season.

The b* value at T=0 for all samples tested in 96/97 were lower than their 95/96 counterparts, however, there were no differences in whiteness. Twenty four hours after production L* value of the 96/97 varieties were slightly higher in all cases except Meering, which showed a small decrease .while the b* value was lower than the corresponding values for yellowness, with the exception of Suneca and Katunga that showed a slight improvement in yellowness.
Irrespective of seasons and varieties, whiteness of dough sheet appears to decrease over 24 hours, but yellowness increases, however, in most cases the resultant whiteness and yellowness values after cooking were intermediate to T=0 and T=24 values.

Firmness of LLU noodles in 95/96 ranged from 1.60 – 1.92 N, while in 96/97 firmness was higher for most samples ranging from 1.78 – 1.99 N. Firmness of fresh noodles were significantly higher than LLU noodles at all storage times.

Cooking yields were significantly low, in 96/97, with Katunga registering a 33% decrease and Goldmark a 22% decrease in yield. Seasonal variation on cooking yield was not expected to this extent.

Table 13 Colour, firmness and cooking yield of fresh noodles from the 96/97 season

Varieties	T=0		T= 24 hours		Cooked Noodle		Firmness	Cooking yield
	L*	b*	L*	b*	L*	b*	(N)	(%)
Batavia	85.9	20.1	79.8	25.6	83.3	21.7	1.87	157
Cadoux	86.3	20.3	80.1	25.4	82.6	21.8	1.80	166
Eradu	-	-	-	-	-	-	-	-
Hartog	86.8	18.3	80.4	23.5	83.5	18.8	1.81	151
Janz	86.9	16.9	80.7	21.5	83.4	18.7	1.86	137
Katunga	86.8	20.2	81.4	25.8	81.0	22.6	1.9	130
Machete	86.4	17.7	79.5	22.6	82.1	19.4	1.86	143
Meering	85.9	17.9	80.3	22.8	82.2	19.2	1.83	139
Suneca	85.9	19.7	80.3	24.7	82.9	19.8	1.84	147.3
Tammin	-	-	-	-	-	-	-	-
Trident	86.9	19.4	82.0	24.8	84.4	21.3	1.78	142.9
Vectis	-	-	-	-	-	--	-	-
-Yanac	85.9	16.7	81.1	21.7	83.5	17.8	1.85	143
Goldmark	85.8	19.2	80.7	25.6	81.9	20.5	1.99	141

4.2.3 Effect of variety on ease of separation of LLU noodles

Table 14 depicts the ease of separation of LLU noodles made from 14 varieties that were collected over 2 seasons from Yeelanna, at the end of 6 months of storage.

Table 14 Ease of separation of LLU noodles made from 14 varieties collected in 95/96 and 96/97

Varieties	Ease of Separation	
	95/96	96/97
Batavia	8	7
Cadoux	5	4
Eradu	4	-
Hartog	7	7
Janz	8	8
Katunga	6	4
Machete	6	5
Meering	6	6
Suneca	5	6
Tammin	3	-
Trident	4	6
Vectis	5	-
Yanac	3	3
Goldmark	3	2

Suneca and Trident showed a slight improvement in ease of separation of LLU noodles in 96/97, compared to the previous year, while 36% of the varieties tested (Hartog, Janz Meering and Yanac) exhibited no change. However, 5 of the 11 varieties tested over 2 seasons had marginally deteriorated in quality with respect to ease of separation, in 96/97.
Overall, Yanac and Goldmark had poor ease of separation while Batavia and Janz demonstrated optimal ease of separation at the end of the storage trial. Although results are not provided most varieties showed good ease of separation up to 1 month of storage, before deterioration set in at different rates.

4.3 Effect of protein level on LLU noodle quality

4.3.1 Effect of protein content on LLU noodle colour during storage

The variation in protein content in flour did not appear to impact the whiteness of noodles at 0 week (average L* = 79.4) nor were there any major differences in L* value at the end of the storage study (average L* = 80.9).
Mean L* value at 0 week of LLU noodles made from different extraction rate was higher (Table 4) than the mean L* value obtained for LLU noodles made from varying protein contents.
As was observed with LLU noodles made from different extraction flours, there was a small increase in whiteness on storage for all LLU noodles made from different protein contents, probably due to the presence of acid.
Table 15 shows the effect of protein content on whiteness and yellowness of LLU noodles with time. The b* value at 0 week was the highest for LLU noodle made from high protein flour (24.4) and lowest for LLU noodle made from medium protein flour. The b* value decreased in all LLU noodles over time, however, the most significant decrease was after 2 months of storage.

Table 15 Effect of protein content on colour of LLU noodle during storage

Test Time	**Batavia High**		**Batavia Medium**		**Batavia Low**	
	L*	**b***	**L***	**b***	**L**	**b***
0 week	78.8 ± 0.3	24.4 ± 0.19	79.6 ± 0.22	22.1 ± 0.17	79.9 ± 0.34	22.4 ± 0.25
2 weeks	79.8 ± 0.52	22.8 ± 0.5	81.4 ± 0.81	22.3 ± 0.27	80.8 ± 0.65	21.8 ± 0.3
1 month	80.9 ± 1.06	21.8 ± 0.5	80. 9 ± 0.36	20.7 ± 0.06	81.0 ± 0.61	21.4 ± 0.13
2 months	81.2 ± 0.1	16.0 ± 0.11	80.6 ± 0.15	18.6 ± 0.09	81.6 ± 0.35	16.1 ± 0.14
6 months	81.0 ± 0.43	15.4 ± 0.32	81.2 ± 0.12	16.9 ± 0.13	80.6 ± 0.43	14.0 ± 0.31

Mean ± SD

4.3.2 Effect of protein content on LLU noodle firmness

Table 16 depicts the effect of protein content on the firmness of LLU noodles with time. The mean firmness of LLU noodle made from high and medium protein contents were similar (1.30 N) and significantly higher than that obtained for LLU noodle made from low protein.

At the end of 2 months LLU made from high protein Batavia was significantly firmer than similar samples stored for varying periods, whereas, LLU made from medium protein Batavia was significantly softer than similar samples stored for varying periods.
LLU noodles tended to become less firm for all extraction rates, except 60%, with storage (Table 5), however, the trend with firmness at the high and medium protein contents seems to be the reverse. There was no change to firmness of LLU noodles made from low protein flour with time.

Table 16 Effect of protein content on the firmness of LLU noodles with time

Test Time	Batavia High	Batavia Medium	Batavia Low
0 week	1.24**a** ± 0.03	1.24 ± 0.03	1.09 ± 0.01
2 weeks	1.36**ac** ± 0.05	1.35**a** ± 0.03	1.12 ± 0.01
1 month	1.34**ac** ± 0.04	1.35 ± 0.03	1.12 ± 0.01
2 months	1.35**bc** ± 0.02	1.25**b** ± 0.03	1.10 ± 0.03
6 months	1.22**ac** ± 0.06	1.32 ± 0.04	1.15 ± 0.02
Mean	1.30 ± 0.07	1.30 ± 0.05	1.12 ± 0.02

Means in the same column not followed by the same letter are significantly different at $p<0.05$.
Mean ± SE

The effect of storage on firmness of LLU noodles made from varying protein contents is compared in Table 17. The mean firmness at 0 week was lowest (1.19 N) for LLU noodles made from flours with varying range of protein content. LLU noodles made from low protein Batavia were significantly softer than the other 2 samples for all storage times. However, significant differences were observed at 2 months between LLU noodles made form the 3 protein types.

The results obtained suggests that low protein flours does not enhance firmness of LLU noodles.

4.3.3 Effect of protein content on ease of separation of LLU noodles

Protein content in flour impacted on the definition of the noodle strands and ease of separation. LLU noodles made from high protein sample were well defined and separated easily through out the storage trial, while the medium protein samples had good definition but poor ease of separation.

LLU noodles made from low protein flour had extremely poor definition and were very hard to separate as they were clumped. Stirring the noodle block to separate the noodle strand resulted in the strands fragmenting.

Table 17 Effect of storage on firmness of LLU noodles made from varying protein content

Sample	0 week	2 weeks	1 month	2 months	6 months
Batavia High	1.24**a** ± 0.03	1.36**a** ± 0.05	1.34**a** ± 0.04	1.35**a** ± 0.02	1.22**a** ± 0.06
Batavia Medium	1.24**a** ± 0.03	1.35**a** ± 0.03	1.35**a** ± 0.03	1.25**b** ± 0.03	1.32**a** ± 0.04
Batavia Low	1.09**b** ± 0.01	1.12**b** ± 0.01	1.12**b** ± 0.01	1.10**c** ± 0.03	1.15**b** ± 0.02
Mean	1.19 ± 0.09	1.28 ± 0.07	1.27 ± 0.13	1.23 ± 0.13	1.23 ± 0.09

Means in the same column not followed by the same letter are significantly different at $p<0.05$.
Mean ± SE

4.4 Effect of water addition on LLU noodle quality

4.4.1 Effect of water addition on LLU noodle colour during storage

The effect of water addition on colour of LLU noodles during storage is shown in Table 18. The L* value increased with an increase in water addition for all storage times, with the exception of L* value of LLU noodles made with 35% water when tested at the end of 2 weeks (80.8). For any given water addition level, the L* value increased on storage, with LLU noodles at 45% water addition recording the highest value after 6 months of storage (82.1).
The L* value obtained at 0 week for all water levels was lower than that observed for LLU noodles made from different extraction rates and varying protein contents, (Tables 4 and 15, respectively) measured at the same time.

The b* value had the opposite effect to L* value, with yellowness decreasing considerably for all water levels on storage. LLU noodles made at 40% water addition had the highest b* value at 0 week and recorded a 12 point drop in yellowness at the end of 6 months. The b* value at 6 months of LLU noodles made with 45 parts water was the lowest (13.0) (Table 18).

4.4.2 Effect of water addition on LLU noodle firmness

Table 19 shows the effect of water addition during production on firmness of LLU noodles during storage. The mean firmness (N) of LLU noodles, regardless of water addition was higher than that observed for LLU noodles made from flours with different extraction rate or protein contents (Table 5 and 16, respectively).

The firmness of LLU noodles at 35% water addition was significantly lower, immediately after production (0 week and 2 weeks) than on storage, whereas LLU noodles at 40% water addition had significantly higher firmness value at 1 month and 2 months after storage. At 45% water addition, LLU noodles were considerably firmer (1.97 N) after 1 month of storage and were softest at 6 months.

Table 18 Effect of water addition on colour of LLU noodles during storage

Test Time	**35 % water**		**40 % water**		**45 % water**	
	L*	**b***	**L***	**b***	**L***	**b***
0 week	75.4	26.3	76.6	27.2	78.4	25.9
2 weeks	80.8	22.0	77.6	24.2	78.4	23.4
1 month	76.3	22.7	77.6	22.3	78.2	21.2
2 months	-	-	77.5	18.5	-	-
6 months	77.5	15.5	78.0	14.9	82.1	13.0

Table 19 Effect of water addition during production on firmness of LLU noodles during storage

Test Time	**35% water**	**40% water**	**45% water**
0 week	2.41**a** ± 0.18	2.13**a** ± 0.05	1.71**a** ± 0.05
2 weeks	2.01**a** ± 0.11	2.23**a** ± 0.04	1.81**abc** ± 0.14
1 month	2.52**b** ± 0.1	2.57**b** ± 0.08	1.97**b** ± 0.07
2 months	2.61**b** ± 0.19	2.61**b** ± 0.05	-
6 months	2.47**b** ± 0.11	2.23**a** ± 0.05	1.44**bc** ± 0.07
Mean	2.40 ± 0.23	2.35 ± 0.22	1.73 ± 0.22

Means in the same column not followed by the same letter are significantly different at $p<0.05$.
Mean ± SE

4.4.3 Effect of water addition on ease of separation of LLU noodles

The ease of separation of LLU noodles was significantly affected with increasing water content in the formulation. At higher water levels, dough sheet tended to become sticky and soft, impairing the surface appearance of freshly cut noodles. At 35% water addition, LLU noodles separated well without needing too much stirring and retained their shape. Overall quality of LLU noodles made with 35% water in the formulation was exceptional compared to those with higher water content.

The ease of separation of LLU noodles made with 40% water in formula can be best described as being above average. As these noodles had poor definition to start with, the definition did not improve during the production of LLU or storage.

LLU noodles that contained 45% water in formulation not only had poor definition after cutting, but fragmented during the parboiling stage. On storage, the ease of separation deteriorated resulting in a low score.

Table 20 presents the effect of storage on firmness at different water addition levels. LLU noodles at 45% water addition were significantly softer than the LLU noodles made with lower amounts of water for all storage times. The data suggests that 35 parts of water in the formulation is more suited to producing firmer noodles.

Table 20 Effect of storage on firmness at different water addition levels

Sample	**0 week**	**2 weeks**	**1 month**	**2 months**	**6 months**
35% water	2.41**a** ± 0.18	2.01**a** ± 0.11	2.52**a** ± 0.1	2.61 ± 0.19	2.47**a** ± 0.11
40% water	2.13**a** ± 0.05	2.23**a** ± 0.04	2.57**a** ± 0.08	2.61 ± 0.05	2.23**a** ± 0.05
45% water	1.71**b** ± 0.05	1.81**b** ± 0.14	1.97**b** ± 0.07	-	1.44**b** ± 0.07

Means in the same column not followed by the same letter are significantly different at $p<0.05$.
Mean ± SE

4.5 Effect of acid type on LLU noodle quality

4.5.1 Effect of acid type on LLU noodle colour during storage

The effect of 2 different acids on the brightness and yellowness of LLU noodles on storage are shown in Tables 21 and 22, respectively.

Table 21 Effect of acetic and lactic acid on the L* value of LLU noodles on storage

Test Time	**Control L***	**5M Acetic**	**5M Lactic**	**10M Acetic**	**10M Lactic**	**15M Acetic**
0 week	79.3	79.2	79.4	79.4	79.8	78.3
2 weeks	79.6	79.7	79.5	79.9	78.7	79.4
1 month	79.4	80.6	80.0	79.8	79.5	79.3
2 months	78.5	79.9	80.0	80.2	79.3	79.2
6 months	78.9	80.3	80.6	79.3	79.7	79.3

L* values are average of 2 readings

The L* value of control and experimental LLU noodles were similar (average = 79.6), except for those treated with 15M acetic acid (78.3), at 0 week. However, on storage L* value for control and LLU noodles treated with 10 M acetic and lactic acids did not change considerably, while samples treated with 5 and 15 M acetic and 5 M lactic acid increased marginally.

Increasing the strength of the acid did not appear to increase L* value of LLU noodles on storage. In fact the highest L* value was recorded by samples that were treated with 5M acetic and lactic acids at 6 months.

Table 22 Effect of acetic and lactic acid on the b* value of LLU noodles on storage

Test Time	Control	Acetic 5M	Lactic 5M	Acetic 10M	Lactic 10M	Acetic 15M
0 week	22.6	18.9	24.2	19.7	24.8	19.0
2 weeks	19.2	18.2	21.7	18.2	22.5	17.8
1 month	19.9	17.5	19.9	17.9	20.3	17.5
2 months	18.5	15.5	17.5	16.4	18.0	15.4
6 months	18.5	14.4	14.9	14.6	16.5	14.8

b* values are average of 2 readings

The yellowness of control LLU noodle was intermediate to those treated with acetic and lactic acid up to1 month of storage and finished with the highest b* value at the end of the storage study. All acid treated samples showed a steady drop in b* value on storage, with the reduction in yellowness being most severe in LLU noodles treated with lactic acid.

4.5.2 Effect of acid on firmness of noodles

4.5.2.1 Effect of varying strength of acetic acid on LLU noodle firmness

The effect of varying strengths of acetic acid on firmness of LLU noodle over time and the effect of storage at different acid strengths is compared in Tables 23 and 24, respectively.

Control LLU noodles after 2 weeks of storage were significantly firmer than control LLU noodles after 6 months of storage. The mean firmness of control LLU noodles was the highest (1.51 N) compared to any of the treated samples. The mean firmness of LLU noodles decreased with an increase in the strength of the acid used to rinse them in.

LLU noodles treated with 5M acetic acid was significantly firmer after 1 and 2 months of storage than the corresponding sample after 6 months of storage. However, LLU noodles treated with 10 M acetic acid was significantly firmer 2 weeks after storage compared to those evaluated at 0 week.

The firmness of LLU noodles treated at 15 M acetic acid was lower than all other treatments and no significant changes to firmness was observed with time.

Control LLU noodles had significantly higher firmness at all storage times and the firmness did not alter significantly with time and increasing strength of the acetic acid.

Table 23 Effect of acetic acid on the firmness of LLU noodles over time

Test Time	Control	5M	10M	15M
0 week	1.46**ab** ± 0.03	1.27**a** ± 0.02	1.19**a** ± 0.03	1.19 ± 0.02
2 weeks	1.58**a** ± 0.03	1.34**ac** ± 0.06	1.28**bc** ± 0.02	1.16 ± 0.05
1 month	1.56**ab** ± 0.04	1.37**bc** ± 0.02	1.27**ac** ± 0.02	1.15 ± 0.04
2 months	1.47**ab** ± 0.04	1.37**bc** ± 0.01	1.26**ac** ± 0.04	1.14 ± 0.03
6 months	1.46**b** ± 0.02	1.27**ad** ± 0.03	1.3**ac** ± 0.06	1.11 ± 0.04
Mean	1.51 ± 0.06	1.32 ± 0.05	1.26 ± 0.04	1.15 ± 0.03

Means in the same column not followed by the same letter are significantly different at p<0.05.
Mean ± SE

Table 24 Effect of storage on the firmness of LLU noodles treated at different strengths of acetic acid

Sample	0 week	2 weeks	1 month	2 months	6 months
Control	1.46**a** ± 0.03	1.58**a** ± 0.03	1.56**a** ± 0.04	1.47**a** ± 0.04	1.46**a** ± 0.02
5M	1.27**b** ± 0.02	1.34**b** ± 0.06	1.37**b** ± 0.02	1.37**ac** ± 0.01	1.27**b** ± 0.03
10M	1.19**b** ± 0.03	1.28**b** ± 0.02	1.27**bc** ± 0.02	1.26**bc** ± 0.04	1.30**ab** ± 0.06
15M	1.19**b** ± 0.02	1.16**b** ± 0.05	1.15**bd** ± 0.04	1.14**b** ± 0.03	1.11**ab** ± 0.04

Means in the same column not followed by the same letter are significantly different at p<0.05.
Mean ± SE

4.5.2.2 Effect of varying strength of lactic acid on LLU noodle firmness

Tables 25 and 26 show the effect of increasing strength of lactic acid on firmness of LLU noodles with time and the effect of storage on firmness of control and treated LLU noodles, respectively.

As observed for acetic acid, mean firmness of control was the highest (1.30 N) and the firmness value decreased with increasing acid strength. Control LLU noodles recorded the maximum firmness after 2 months of storage, while treated LLU noodles had the lowest firmness values on storage, suggesting that treatment does affect LLU noodle firmness on storage.

Firmness of control LLU noodle was the highest for all storage times and decreased with an increasing strength of lactic acid, which was similar to the trend observed with acetic acid. However, the decrease in firmness was much higher with lactic acid than acetic acid.

A 28% drop in firmness was observed for LLU noodles treated with 10 M lactic acid after 6 months of storage compared to control LLU noodles tested after 0 week of production.

Table 25 Effect of lactic acid treatment on firmness of LLU with time

Test Time	Control	5M	10M
0 week	1.26**a** ± 0.03	1.12**a** ± 0.02	1.04**a** ± 0.02
2 weeks	1.28**a** ± 0.03	1.19**b** ± 0.01	1.1**bc** ± 0.01
1 month	1.17**b** ± 0.06	1.13**ab** ± 0.02	0.99**acd** ± 0.06
2 months	1.37**c** ± 0.02	1.04**abc**±0.08	1.03**acd** ± 0.04
6 months	-	1.00**c** ± 0.03	0.91**ad** ± 0.04
Mean	1.30 ± 0.08	1.10 ± 0.08	1.01 ± 0.07

Means in the same column not followed by the same letter are significantly different at $p<0.05$.
Mean ± SE

Table 26 Effect of storage on firmness of control and lactic acid treated LLU noodles

Sample	0 week	2 weeks	1 month	2 months	6 months
Control	1.26**a** ± 0.03	1.28**a** ± 0.03	1.17**a** ± 0.06	1.37**a** ± 0.02	-
5M	1.12**b** ± 0.02	1.19**b** ± 0.01	1.13**a** ± 0.02	1.04**b** ± 0.08	1.00 ± 0.03
10M	1.04**c** ± 0.02	1.10**c** ± 0.01	0.99**b** ± 0.06	1.03**b** ± 0.04	0.91 ± 0.04

Means in the same column not followed by the same letter are significantly different at $p<0.05$.
Mean ± SE

For LLU noodles to be a commercially viable product, desired shelf life is 6 months. The results obtained so far suggests that the acid treatment;

- increases the L* value (brightness) causing a whitening or bleaching effect,
- decrease b* value (yellowness)
- decreases firmness of LLU noodles over time, when compared to control LLU noodle.

4.5.3. Effect of acid on ease of separation of LLU noodles

Treatment with 5 M acetic acid resulted in some difficulty during strand separation, however, the process eased with time during storage. LLU noodles treated with 5M acetic acid had the highest overall score for ease of separation compared to samples treated with increasing strengths of the same acid.

LLU noodles dipped in 10M acetic acid initially had a better ease of separation than those immersed in 5M, however, there was a significant increase in degree of difficulty to separate the strands within the block, over time.
Acetic acid (15M) had a detrimental effect on the surface appearance of LLU noodles making them pitted and rough. Separating the noodles in the boiling water caused the strands to fragment reducing the overall acceptability.

LLU noodles treated with lactic acid had better ease of separation when compared to the acetic acid treated samples. Lactic acid (5M) samples separated more easily than control samples, while the 15 M treated samples were marginally harder to separate. Lactic acid treatment appeared to aid the ease of separation of LLU noodles.

4.6 Effect of storage conditions on LLU noodle quality

4.6.1 Effect of light storage on LLU noodles

Tables 27 a and b shows the effect of whiteness and yellowness of LLU noodles stored in light at room temperature, respectively.

Table 27 a Effect on L* of LLU noodles stored in light at room temperature

	0 Week	**1 Week**	**2 Weeks**	**3 Weeks**	**1 Month**	**2 Months**	**3 Months**	**4 Months**	**5 Months**
Blend	**L***	**L***	**L***	**L***	**L***	**L***	**L***	**L***	**L***
1	80.4	79.2	81.1	79.8	79.8	81.6	81.3	80.7	81.2
2	80.3	80.1	81.2	80.5	80.5	81.3	80.8	80.6	80.7
3	81.3	80.3	82.5	81.3	80.9	82.3	82.3	82.5	82.2
Mean	**80.1**	**79.9**	**81.6**	**80.5**	**80.4**	**81.7**	**81.5**	**81.3**	**81.4**

Values are averages of 2 readings
1 = Cadoux/Eradu, 60:40, 2 = Cadoux/Eradu, 40:60, 3 = Rosella/Yanac, 80:20

The L* value of LLU noodles spanned a narrow range from 79.2 to 82.5. For any given blend, the L* value alternatively increased and decreased for the first month, then showed a slight increase before levelling off. At any given time, only small differences in L* value was observed between the LLU noodles made from different blends.

Mean yellowness decreased markedly for all blends over time, with blend 3 recording a 47% drop at the end of 5 months. Blend 2 recorded an increase in yellowness after 2 weeks, which was higher than that at 0 week. The rate of decrease in yellowness was similar to LLU noodles treated with acetic and lactic acids at different strengths for the same time period.

Table 27b Effect on b* of LLU noodles stored in light at room temperature

	0 Week	1 Week	2 Weeks	3 Weeks	1 Month	2 Months	3 Months	4 Months	5 Months
Blend	**b***	**b***	**b***	**b***	**b***	**b***	**b***	**b***	**b***
1	24.2	21.4	20.9	20.3	20.1	17.5	18.6	15.4	15.0
2	22.9	20.1	23.3	19.0	19.0	18.8	18.0	14.6	13.6
3	25.5	22.4	21.5	21.0	21.0	20.2	19.5	18.5	13.6
Mean	**24.2**	**21.3**	**21.9**	**20.1**	**20.0**	**18.8**	**18.7**	**16.2**	**14.1**

Values are averages of 2 readings
1 = Cadoux/Eradu, 60:40, 2 = Cadoux/Eradu, 40:60, 3 = Rosella/Yanac, 80:20

4.6.2 Effect of dark storage on LLU noodle colour

Tables 28 a and b depicts the change to whiteness and yellowness of LLU noodles with time when stored in dark at room temperatures. Colour readings could not be taken at 3 weeks and 1 month. At the end of the storage trial LLU noodles were slightly whiter than at 0 week, but storing in dark at room temperature did not improve or affect whiteness compared to LLU noodles stored in light.

Table 28 a Effect on L* of LLU noodles stored in dark at room temperature

	0 Week	1 Week	2 Weeks	2 Months	3 Months	4 Months	5 Months
Blend	**L***	**L***	**L***	**L***	**L***	**L***	**L***
1	80.4	79.5	81.8	81.2	81.1	81.1	81.0
2	80.3	79.6	80.5	81.9	80.2	80.8	80.7
3	81.3	80.3	81.3	81.8	82.1	81.9	82.2
Mean	**80.1**	**79.8**	**81.2**	**81.6**	**81.1**	**81.3**	**81.3**

Values are averages of 2 readings
1 = Cadoux/Eradu, 60:40, 2 = Cadoux/Eradu, 40:60, 3 = Rosella/Yanac, 80:20

The b* value of LLU noodles made from all blends decreased considerably with in one week of storing in the dark and then showed a very slight decrease with storage.

The decrease in mean b* value of LLU noodles stored in the dark after 1 week was about 15% greater than those stored in light, however the b* value at the end of 5 months was marginally better. The mean b* value of LLU noodles were similar at 4 months regardless of storage conditions.

Table 28b Effect on b* of LLU noodles stored in dark at room temperature

	0 Week	**1 Week**	**2 Weeks**	**2 Months**	**3 Months**	**4 Months**	**5 Months**
Blend	**b***	**b***	**b***	**b***	**b***	**b***	**b***
1	24.2	17.8	17.7	17.1	16.6	16.3	15.7
2	22.9	16.9	17.0	16.3	16.3	15.6	15.1
3	25.5	18.5	18.3	17.5	17.0	16.9	16.4
Mean	**24.2**	**17.7**	**17.7**	**17.0**	**16.6**	**16.3**	**15.7**

Values are averages of 2 readings
1 = Cadoux/Eradu, 60:40, 2 = Cadoux/Eradu, 40:60, 3 = Rosella/Yanac, 80:20

4.6.3 Effect of light storage on firmness of LLU noodles

Table 29 presents the firmness of LLU noodles stored in light at room temperature.

Table 29 Effect of storage in light at room temperature on firmness of LLU noodles

Blend	**0 Week**	**1 Week**	**2 Weeks**	**3 Weeks**	**1 Month**	**2 Months**	**3 Months**	**4 Months**	**5 Months**
1	1.57 ± 0.10	1.74 ± 0.06	1.77 ± 0.06	1.68 ± 0.06	1.79 ± 0.05	1.16 ± 0.04	1.18 ± 0.05	1.25 ± 0.08	1.13 ± 0.02
2	1.69 ± 0.10	1.88 ± 0.04	1.92 ± 0.08	1.82 ± 0.07	1.88 ± 0.09	1.23 ± 0.08	1.07 ± 0.20	1.35 ± 0.06	1.30 ± 0.06
3	1.64 ± 0.07	1.75 ± 0.08	1.78 ± 0.03	1.67 ± 0.04	1.82 ± 0.02	1.15 ± 0.03	1.13 ± 0.06	1.26 ± 0.07	1.15 ± 0.09
Mean	**1.63**	**1.79**	**1.82**	**1.71**	**1.83**	**1.18**	**1.13**	**1.29**	**1.19**

Mean ± SD
1 = Cadoux/Eradu, 60:40, 2 = Cadoux/Eradu, 40:60, 3 = Rosella/Yanac, 80:20

The mean firmness of LLU noodles increased marginally after 1 week of storage in light and then decreased sharply after 1 month of storage. There was, however, not much difference in firmness at the end of 5 months.

Among the 3 blends, firmness of LLU noodles made from blend 2 was consistently the highest, except at 3 months when the firmness value was the lowest, probably due to an experimental artefact. The highest firmness value was obtained for blend 2 after 2 weeks of storage (1.92 N).
Effect of storing LLU noodles in dark at room temperature on firmness was not conducted.

4.6.4 Effect of storage conditions on ease of separation

Overall, blends 1 and 2 had similar ease of separation and were marginally better than blend 3. Noodle strands tended to disintegrate more in LLU noodle made from a Rosella/Yanac blend.

4.7 Effect of starches on fresh and LLU noodle quality

4.7.1 Effect of starches on fresh and LLU noodle colour in Japanese blends

Table 30 shows the effect of starch on the whiteness and yellowness of fresh and LLU noodle on storage made from Japanese blends.

Table 30 Effect of starch on the L* and b* of fresh and LLU noodles made from Japanese blends

Test Time	**ASWN:APW, 60:40**		**ASWN:APW, 40:60 + 10% Tapioca**		**ASWN:APW, 40:60 + 10% Purity N1**	
	L*	**b***	**L***	**b***	**L***	**b***
Fresh/cooked	82.3	22.5	80.2	21.6	82.5	23.2
0 week	80.2	22.6	78.8	20.8	80.4	21.6
6 Months	80.7	17.1	79.3	18.4	80.9	17.2

Values are averages of 2 readings

The whiteness (82.5) and yellowness (23.2) of fresh noodles containing 10% Purity N1 was the highest among all samples tested. In all instances L* value decreased at 0 week compared to fresh noodles, probably due to the effect of processing. However, at 6 months all noodle samples showed a slight increase in whiteness.
The L* value obtained for LLU noodles made from ASW:APW blend and that containing 10% Purity N1, at 0 week was higher than that obtained for any of the other trials, such as effect of protein (Table 15) or water addition (Table 18), while the L* value obtained at the end of 6 months was not dissimilar to the other experiments, suggesting that perhaps the starch contributed to the whiteness soon after production, but its effect was minimal over time.

Yellowness decreased with time, for all sample types, but the ASWN:APW blend showed a slight increase at 0 week. The blend containing 10% tapioca starch had the lowest L* value and highest b* value at the end of 6 months.

4.7.2 Effect of starches on fresh and LLU noodle colour in Korean blends

The effect of starch on the whiteness and yellowness of fresh and LLU noodle on storage made from Korean blends is presented in Table 31.

Table 31 Effect of starch on the L* and b* of fresh and LLU noodle made from Korean blends

Test Time	ASWN:ASWT:APW 30;30:40		ASWN:ASWT:APW, 10:30:60 + 10% Amioca		ASWN:ASWT:APW, 10:30:60 + 10% Purity N1	
	L*	b*	L*	b*	L*	b*
Fresh/cooked	81.3	23.9	82.4	23.1	83.2	24.1
0 week	80.3	22.5	79.9	22.7	80.2	22.0
6 Months	80.8	19.3	80.3	18.7	80.6	17.7

Values are averages of 2 readings

As observed with the Japanese blends, fresh noodles containing Purity N1 had the highest whiteness and yellowness values. LLU noodle at 0 week showed a decrease in L* value for all blends and then showed a slight increase at the end of 6 months. Yellowness decreased on storage and the biggest drop in b* value was detected at 6 months in LLU containing Purity N1. The different blends did not appear to affect whiteness or yellowness significantly.

4.7.3 Effect of starch on TPA of fresh and LLU noodles made from Japanese blends

TPA provides objective information on chewiness, gumminess, springiness and cohesiveness of fresh and LLU noodles all of which are inter related attributes and can be difficult to distinguish by even trained panellists. The problem is further compounded by the fact that text book definitions of these terms and the meaning it conjures in a panellist's mind versus the mathematical formulae to calculate them can be quite complex to fully comprehend and make meaningful interpretations. Tables 32 a, b and c present the chewiness, gumminess, springiness, cohesiveness and firmness of the 3 Japanese blends for fresh and LLU noodles.

The b* value of LLU noodles made from all blends decreased considerably with in one week of storing in the dark and then showed a very slight decrease with storage. The decrease in mean b* value of LLU noodles stored in the dark after 1 week was about 15% greater than those stored in light, however the b* value at the end of 5 months was marginally better. The mean b* value of LLU noodles were similar at 4 months regardless of storage conditions.

Table 32 a TPA of fresh and LLU noodle made from ASWN:APW (60:40) blend

ASWN:APW	Chewiness (N.mm)	Gumminess (N)	Springiness (mm)	Cohesiveness	Firmness (N)
Fresh/cooked	4.53**a** ± 0.16	3.65**a** ± 0.22	1.25**a** ± 0.05	0.47**a** ± 0.01	1.99**a** ± 0.05
0 week	3.55**b** ± 0.18	2.44**b** ± 0.21	1.46**b** ± 0.05	0.43**ab** ± 0.05	1.17**b** ± 0.02
6 Months	3.90**ab** ± 0.41	2.73**ab** ± 0.27	1.43**b** ± 0.01	0.39**b** ± 0.03	1.08**b** ± 0.04

Means in the same column not followed by the same letter are significantly different at $p<0.05$.
Mean ± SE

The chewiness and gumminess of the fresh noodles were significantly higher than LLU noodles at 0 week, while springiness and firmness of fresh noodles was significantly higher than LLU at 0 week and 6 months. LLU noodles at 6 months had the lowest cohesiveness.

Table 32 b TPA of fresh and LLU noodle made from ASWN:APW (40:60) blend containing 10% tapioca

ASWN:APW + 10% Tapioca	Chewiness (N.mm)	Gumminess (N)	Springiness (mm)	Cohesiveness	Firmness (N)
Fresh/cooked	3.23 ± 0.39	2.68 ± 0.3	1.21 ± 0.01	0.56 ± 0.05	1.50**a**±0.01
0 week	3.19 ± 0.58	2.82 ± 0.47	1.13 ± 0.12	0.43 ± 0.01	1.10**b**±0.03
6 Months	4.14 ± 0.55	3.08 ± 0.15	1.34 ± 0.12	0.46 ± 0.01	1.19**c**±0.02

Means in the same column not followed by the same letter are significantly different at $p<0.05$.
Mean ± SE

Chewiness, gumminess and firmness of fresh noodles containing 10% tapioca was higher than fresh noodle samples that contained no added starch (Table 32 b), while cohesiveness was marginally low. The added starch, however, had no significant impact on any of the TPA attributes for fresh or LLU noodles. Fresh noodles were significantly firmer than LLU at 0 week and 6 months.

Chewiness of LLU noodle containing 10% Purity N1 at 0 week (4.77 N.mm) was the highest among all Japanese blends. Springiness of fresh noodles were significantly lower than LLU at 0 week, while firmness of fresh noodles were significantly higher than LLU at 0 week or 6 months.

Table 32 c TPA of fresh and LLU noodle made from ASWN:APW (40:60) blend containing 10% Purity N1

ASWN:APW + 10% Purity N1	Chewiness (N.mm)	Gumminess (N)	Springiness (mm)	Cohesiveness	Firmness (N)
Fresh/cooked	3.85 ± 0.29	3.09 ± 0.25	1.25**a** ± 0.03	0.47 ± 0.02	1.69**a** ± 0.04
0 week	4.77 ± 0.29	3.16 ± 0.18	1.51**b** ± 0.01	0.52 ± 0.04	1.08**b** ± 0.01
6 Months	4.42 ± 0.09	3.23 ± 0.12	1.37**ab** ± 0.06	0.46 ± 0.02	1.23**c** ± 0.03

Means in the same column not followed by the same letter are significantly different at $p<0.05$.
Mean ± SE

4.7.4 Effect of starch on TPA of fresh and LLU noodles made from Korean blends

The chewiness, gumminess, springiness, cohesiveness and firmness for fresh and LLU noodles made from the 3 Korean blends at 0 weeks and 6 months is shown in Tables 33 a, b and c.

Table 33 a TPA of fresh and LLU noodle made from ASWN:ASWT:APW (30:30:40) blend

ASWN:ASWT:APW	Chewiness (N.mm)	Gumminess (N)	Springiness (mm)	Cohesiveness	Firmness (N)
Fresh/cooked	3.86 ± 0.27	3.34**a** ± 0.11	1.15**a** ± 0.04	0.55 ± 0.04	1.74**a** ± 0.01
0 week	3.71 ± 0.24	2.63**b** ± 0.18	1.41**b** ± 0.03	0.49 ± 0.05	1.21**b** ± 0.03
6 Months	-	-	-	-	1.24**b** ± 0.04

Means in the same column not followed by the same letter are significantly different at $p<0.05$.
Mean ± SE

Fresh noodles made from the Korean blend (ASWN:ASWT:APW) had significantly high gumminess, springiness and firmness only compared to LLU at 0 week, unlike the fresh noodles made from the Japanese blend (ASWN:APW) which had all textural attributes higher than LLU at 0 week (Table 32 a). Chewiness and firmness of fresh noodles from the Korean blend were lower than that of similar noodles made from the Japanese blend.

Table 33 b TPA of fresh and LLU noodle made from ASWN:ASWT:APW (10:30:60) blend containing 10% Amioca

ASWN:ASWT:APW + 10% Amioca	Chewiness (N.mm)	Gumminess (N)	Springiness (mm)	Cohesiveness	Firmness (N)
Fresh/cooked	3.86 ± 0.27	3.34**a** ± 0.11	1.16**a** ± 0.04	0.55 ± 0.04	1.50**a** ± 0.01
0 week	3.89 ± 0.07	2.73**b** ± 0.11	1.43**b** ± 0.03	0.49 ± 0.05	1.06**b** ± 0.02

Means in the same column not followed by the same letter are significantly different at p<0.05.
Mean ± SE, TPA at 6 months was not measured.

Significant differences in gumminess, springiness and firmness were observed in fresh noodles made from the Korean blend containing 10% Amioca, which were similar to the findings in the Korean blend with out the added starch (Table 33 a). This could suggest that the added starch has not altered the textural attributes of the blend.
The TPA values obtained for the Korean blend containing 10% Amioca was similar to the Japanese blend containing 10% tapioca starch (Table 32 b).

Table 33 c TPA of fresh and LLU noodle made from ASWN:ASWT:APW (10:30:60) blend containing 10% Purity N1

ASWN:ASWT:APW + 10% Purity N1	Chewiness (N.mm)	Gumminess (N)	Springiness (mm)	Cohesiveness	Firmness (N)
Fresh/cooked	3.26 ± 0.22	2.50 ± 0.16	1.30 ± 0.04	0.55 ± 0.05	1.59**a** ± 0.02
0 week	3.89 ± 0.84	3.10 ± 0.74	1.26 ± 0.07	0.46 ± 0.07	1.14**b** ± 0.21

Means in the same column not followed by the same letter are significantly different at p<0.05.
Mean ± SE, TPA at 6 months was not measured.

Ten percent Purity N1 significantly increased only the firmness of fresh noodles in the Korean blend compared to LLU at 0 week.

Irrespective of the blends, the magnitude of the attributes obtained from TPA were the same and the data in Tables 32 a, b and c and 33 a, b, and c have been tabulated to reflect that feature. In other words, chewiness was always higher than gumminess, which in turn was bigger than springiness and cohesiveness was the smallest. A close look at the formula used to calculate this aspect explains this phenomenon partially. The most important reason for this trend is the nature of the product under scrutiny.

Although a lot of data was collected in this study, the net effect of starches on the textural properties of fresh and LLU noodles could not be conclusively proved. No obvious trends were observed and the added starches, at the 10% level did not enhance any one attribute.

These findings challenge the initial hypothesis (based on industry practices) of the significance of starch addition in noodle formulations in improving or enhancing textural quality of fresh &/or LLU noodles. It does appear that the level at which it was tested was probably not high enough to observe any significant change.

Crosbie et al (1992) note that the quality of the starch component is an important factor that influences the eating quality and texture of white noodles consumed in Japan and Korea, along with protein content, protein quality and hardness of the grain (PSI). Table 34 shows the peak viscosity (RVU) of the 3 Japanese and Korean blends.

Table 34 RVA of Japanese and Korean blends

Blends	Blend Ratios	RVA (RVU)
Japanese	ASWN:APW	206
	ASWN:APW + 10% Tapioca	209
	ASWN:APW + 10% Purity N1	208
Korean	ASWN:ASWT:APW	191
	ASWN:ASWT:APW+ 10% Amioca	194
	ASWN:ASWT:APW+ 10% Purity N1	194

The Japanese blends had higher peak viscosity than the Korean blends and in both instances peak viscosity improved slightly on the addition of starch. The type of starch (native or chemically modified) did not affect the final viscosity in either blend. Moss (1980) found starch peak viscosity to be a useful indicator of noodle eating quality and these findings suggest that perhaps the Japanese blends had better eating quality.
There is little information available on the relation between peak viscosity and TPA attributes.

4.7.5 Ease of separation of LLU noodles made from different blends

For the sake of simplicity, the effect of starch on ease of separation of LLU at 0 week and 6 months made from the 6 blends have been tabulated in one table, Table 35.

Table 35 Effect of starch on ease of separation of LLU made from Japanese and Korean blends

	Japanese Blends			Korean Blends		
Test time	**A**	**B**	**C**	**D**	**E**	**F**
0 week	7	7	6	7	5	6
6 Months	6	5	4	7	3	3

A = ASWN:APW, **B** = ASWN:APW+10% Tapioca, **C** = ASWN:APW +10% Purity N1
D = ASWN:ASWT:APW, **E** = ASWN:ASWT:APW+10% Amioca, **F** = ASWN:ASWT:APW +10% Purity N1

Blends without the added starch appear to have better ease of separation both at 0 week and on storage. The Japanese blend containing 10% tapioca had good ease of separation immediately after LLU production but, the noodles strands fragmented on storage. Amioca and Purity N1 in the Korean blends had a detrimental effect on ease of separation on storage. Toyokawa et al (1989) confirm that noodles made from flour containing Amioca starch tend to be sticky and hence can easily break when separated. These results do not favour the addition of commercial starches in noodle formulation to assist in ease of separation of noodle strands.

4.8 Preparation of LLU

Detailed analyses of the data from supporting experiments authenticates the laboratory test method to produce LLU noodles. Wheat varieties that belong to the AWB's commercial classification of ASWN and ASWT are most suited to LLU noodle production when milled to 60% extraction rate. Specifically, medium to high protein Batavia, Goldmark, Cadoux and Rosella, to name a few at 60% extraction was a good starting point. The first step in the production of LLU is the production of fresh noodles which is detailed in 3.1. Fresh noodles are then systematically processed to produce LLU.

4.8.1 Parboiling

Freshly cut noodles were parboiled for 5 minutes in a large utensil in excess water to prevent them from being water stressed and to facilitate uniform parboiling. Parboiling results in surface gelatinisation which would result in surface softening of the noodles. Parboiling helps in making the noodles more pliable, facilitates easy handling and helps to reduce the microbial load.

4.8.2 Washing

Parboiled noodles were placed in colander and immediately immersed in cold water for 30 seconds, to remove excess starch from the surface of the noodles and to prevent any latent cooking. Excess water from the noodles was removed by tapping the colander about 5 times.

4.8.3 Acid Treatment

The drained noodles were immersed in a weak acetic acid solution (7.5 M) for one minute at room temperature. The acid treatment increases the shelf life by lowering the surface pH of the noodles and improves microbial quality. Excess acid was drained by straining the noodles over a colander and tapping the colander several times on the bench.

4.8.4 Oiling

The acid treated noodles were oiled using vegetable oil equivalent to 2% of cooked noodle weight.
The oil serves as a lubricant and prevents the moist noodle strands sticking to each other. The oiled noodles were packed in 150 g packs in food grade clear pouches and heat sealed using a mini commercial heat sealer.

4.8.5 Heat Treatment

Heat sealed noodle packs were subjected to a secondary heat treatment by way of heating the samples in water for 20 minutes at 90 ^{O}C. LLU noodle blocks were then stored for 6 months at room temperature or stored under accelerated storage conditions before analysing its quality characteristics. The heat treatment ensures the microbial safety of the product and eliminates contamination that may have occurred during the acid-treatment and the oiling stages.

4.8.6 Microbial quality

Table 36 Microbial quality represented as cfu/g of samples from different processing steps in the preparation of LLU noodles

Processing step	Standard plate count (cfu/g)
Fresh noodles (raw)	4.2 x 10^6
Parboiled 5min	< 10
Parboiled 5min, 10 min 90°C	<10
Parboiled 5min, 20 min 90°C	<10
Parboiled 5min, 30 min 90°C	<10

The results in Table 36 clearly demonstrate a significant decrease in the cfu/g of sample after the first processing step. The fresh noodle sample recorded a total count of 4.2 x 10^6, however, the total count dropped to <10 cfu/g after the first processing step. It is worthy of mention that the sensitivity limits of the test is <10.

5.0 General Discussion

Detailed research work carried out in the laboratory has led to the development of a procedure for a laboratory scale test method for production and evaluation of LLU and fresh noodles. The effect of a range of raw materials and several important processing steps were examined in detail to study their impact on end product quality, however, there is potential to conduct work in the area of percent oil addition including type of oil, secondary heat treatment, and packaging.

Three main criteria (colour, firmness and ease of separation) that were used to measure end product quality provided considerable information on effects of ingredients or processes.

A lot of emphasis is placed on colour of noodles by the end users and according to Crosbie (1990) low flour ash and good colour grade in the flour are essential prerequisites for the production of noodles that retain a clean, bright and uniform appearance after cooking. Wheats that were milled to a low extraction rate (40%) provided the low ash flour, however, there were two major drawbacks: LLU noodles made from 40% flour tended to be softer than the high extraction flours and was not an economically viable option for the flour miller. Varieties with a good colour grade milled to 60% extraction were suited to LLU production.

The effect of protein content in flour, water addition to dough, type and strength of acid used in the acid rinse significantly impacted on end product quality, but the effect of storage conditions and role of added starch did not have a conclusive influence on end quality.

LLU noodles retrograde with time; in non-technical terms get brittle and loose their elasticity. This attribute was hard to measure as the retrogradation is corrected when the LLU noodles are immersed in boiling water to study ease of separation. Furthermore, the noodles are equilibrated in cold water before conducting the TPA. One of the suggested (Personal communication, Wu 1998) advantages of starch addition is to minimise the rate of retrogradation, however, this attribute could not be easily measured in the noodles.

There is, however, sufficient evidence in the literature (Moss 1979) to prove that addition of waxy corn or potato starch increases starch paste viscosity and improves eating quality of noodles but information on the effect of added starch on LLU noodle quality is scarce. Studies conducted as part of this research project did not necessarily clarify the role of starch in improving noodle quality.

6.0 Conclusions

A laboratory method to produce LLU with a 6 month shelf life when stored in light at room temperature has been developed, using flour from sound grain at 60% extraction and medium protein content.

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Appendix I. Analytical Results for ASWN blend.

Wheat

Test	Result
Test Weight (kg/hl)	81.5
Moisture (as is)	9.5
Protein (as is)	10.5
1000 Kernel Weight	32.6
Ash (as is)	1.26

Flour.

Test	ASWN
Moisture (%)	13.0
Protein (%) (as is)	9.47
Ash (%) (as is)	0.38
Diastatic Activity (mg)	90
Colour Grade (KJ)	-2.0
Minolta Flour L	94.00
Minolta Flour a	-2.50
Minolta Flour b	9.24
Farinograph	
Water Abs (%)	53.1
Development Time (min)	2.5
Stability (min)	10
Breakdown (BU)	65
Extensograph	
Extensibility (cm)	18.3
Max. height (BU)	415
Area (sq.cm)	106
Amylograph	
Peak (BU)	1030
Gel. Time (min)	67.5
Gel .Temp (°C)	25
Breakdown (BU)	200

Test	ASWN 40	ASWN 50	ASWN 60	ASWN 70
Ash (%) (as is)	0.30	0.29	0.37	0.36

Appendix II. Varietal Analytical Results Yeelanna 95/96 and 96/97.

Yeelanna 95/96

Test	Batavia	Cadoux	Eradu	Hartog	Janz	Katunga	Machete
Test Weight (kg/hl)	81	81.5	83	80	83	79.5	81
1000 Kernel Weight (%)	29.38	34.16	38.98	28.38	30.18	30.32	37.72
Oven Moisture (%)	10.9	12	11.9	11.2	11	11.8	11.2
Ash (%) (as is)	1.47	1.18	1.24	1.39	1.31	1.32	1.21

Test	Meering	Suneca	Tammin	Trident	Vectis	Yanac	Goldmark
Test Weight (kg/hl)	83.5	84	83	83	78	81	82.5
1000 Kernel Weight (%)	29.8	32.1	39.5	33.8	36.58	29.2	31.58
Oven Moisture (%)	11	11.4	11.7	10.9	12.1	11.1	11.5
Ash (%) (as is)	1.28	1.32	1.17	1.25	1.39	1.32	1.16

Test	Batavia	Cadoux	Eradu	Hartog	Janz	Katunga	Machete
Moisture (%)	14.3	13.5	13.6	14.1	14.4	13.6	13.7
Protein (%) (as is)	9.97	9.2	9.21	10.6	9.11	9.79	9.97
Ash (%) (as is)	0.44	0.38	0.35	0.41	0.41	0.35	0.44
Diastatic Activity (mg)	195	80	85	251	176	71	231
Minolta Flour L	92.99	94.18	94.21	92.93	93.63	94.17	92.93
Minolta Flour a	-2.49	-2.58	-2.03	-2.29	-2.03	-2.25	-2.11
Minolta Flour b	10.52	9.29	7.19	10.23	8.4	8.4	9.12
Farinograph							
Water Absorption (%)	59.7	54	54.6	62.5	59.6	52.2	63.5
Development time (min)	3.8	3	4.5	7.9	18.2	3	5.2
Stability (min)	11.8	9.2	8.1	>15	>15	5.8	>15
Breakdown (BU)	35	65	60	15	0	70	35
Extensograph 45							
Extensibility (cm)	18.3	18.9	18.5	21.5	18.9	22.1	20.4
Max. height (BU)	410	400	435	475	400	375	470
Area (sq.cm)	107	104	113	143	102	117	132
Amylograph							
Peak	1240	910	1440	1070	550	630	990
Gel. Time (min)	22	28	26	21	22	28	20
Gel. Temp (^oC)	63	72	69	61.5	63	72	60
Breakdown (BU)	250	180	280	130	0	0	120

Test	Meering	Suneca	Tammin	Trident	Vectis	Yanac	Goldmark
Moisture(%)	14.1	14.3	14	13.9	135	13.6	14
Protein (%) (as is)	9.46	11.39	8.95	9.6	9.61	10.39	9.67
Ash (%) (as is)	0.42	0.4	0.38	0.46	0.41	0.44	0.43
Diastatic Activity (mg)	176	161	106	257	76	182	171
Minolta Flour L	93.25	93.18	94.45	93.02	94.45	93.19	93.15
Minolta Flour a	-2.24	-2.29	-2.12	-2.62	-2.54	-17.5	-2.34
Minolta Flour b	9.17	9.48	7.36	11.19	9.10	7.78	9.65
Farinograph							
Water Absorption (%)	59.2	55.9	56.2	62.7	53.9	59.9	61.8
Development time (min)	4.2	8.7	5.2	5.7	3.5	3.7	4.7
Stability (min)	>15	>15	10.1	>15	4.6	>15	>15
Breakdown (BU)	25	5	35	20	70	35	10
Extensograph 45							
Extensibility (cm)	19.7	24.1	17	17.5	22.6	20.6	20.3
Max. height (BU)	320	570	350	400	265	380	340
Area (sq.cm)	90	184	85	99	89	113	102
Amylograph							
Peak	520	570	1200	600	480	1300	1090
Gel. Time (min)	22	22	26	21	30	20	21
Gel. Temp (°C)	63	63	69	615	75	60	61.5
Breakdown (BU)	0	60	220	190	0	220	90

Yeelanna 96/97

Test	Batavia	Cadoux	Hartog	Janz	Machete	Meering	Katunga
Test Weight (kg/hl)	83.5	80.5	84.5	83.5	81.0	83.0	81.5
1000 Kernel Weight (g)	41.7	43.1	41.3	40.8	44.5	39.3	36.7
Oven Moisture (%)	12.2	13.2	12.7	12.8	12.3	12.5	12.4
Ash (%) (as is)	1.32	1.08	1.32	1.38	1.37	1.34	1.24

Test	Suneca	Trident	Yanac	Goldmark
Test Weight (kg/hl)	85.5	83.5	82.5	84.0
1000 Kernel Weight (g)	46.0	48.1	42.8	40.8
Oven Moisture (%)	11.3	12.5	12.1	12.0
Ash (%) (as is)	1.42	1.32	1.28	1.34

Yeelanna 96/97. Analytical Results for 60% extraction.

Test	Batavia	Cadoux	Hartog	Janz	Machete	Meering	Katunga
Moisture (%)	13.4	13.1	14	13.8	13.7	13.9	13.3
Protein (%) (as is)	7.6	7.64	7.82	7.75	7.94	7.76	6.75
Ash (%) (as is)	0.45	0.38	0.43	0.39	0.44	0.43	0.32
Diastatic Activity (mg)	207	111	231	188	231	171	90
Minolta Flour L	93.18	94.10	93.61	93.73	93.28	93.34	94.39
Minollta Flour a	-2.46	-2.58	-2.31	-2.06	-2.17	-2.19	-2.50
Minolta Flour b	9.93	9.07	8.87	7.97	8.75	8.61	8.53
Farinograph			.				
Water Absorption (%)	58.5	54.2	61.2	59	61.2	57.2	51.1
Development time (min)	1.8	1.8	2.1	2.0	1.8	3.7	1.3
Stability (min)	5.1	8.2	10.8	12.4	9.0	6.9	5.8
Breakdown (BU)	85	70	45	35	60	65	80
Extensograph 45							
Extensibility (cm)	16	17.3	17.3	15.6	15.9	18.7	17.3
Max. Height (BU)	285	345	430	375	430	320	310
Area (sq.cm)	67	85	105	83	96	85	80
Amylograph							
Peak	1260	980	1020	580	960	460	620
Gel. Time (min)	22	28	21	24	23	25	29
Gel. Temp (°C)	63	72	61.5	66	64.5	67.5	73.5
Breakdown (BU)	320	280	200	20	250	20	0

Test	Suneca	Trident	Yanac	Goldmark
Moisture (%)	13.9	13.7	14.1	13.4
Protein (%) (as is)	8.31	7.67	7.23	8.03
Ash (%) (as is)	0.46	0.48	0.44	0.43
Diastatic Activity (mg)	218	302	207	218
Minolta Flour L	93.52	93.29	93.55	93.44
Minollta Flour a	-2.33	-2.56	-1.93	-2.33
Minolta Flour b	9.08	10.15	7.77	9.10
Farinograph				
Water Absorption (%)	56.9	62.6	59.1	61.4
Development time (min)	2.1	2.0	3.8	3.3
Stability (min)	10.7	7.8	6.2	8.1
Breakdown (BU)	40	65	65	55
Extensograph 45				
Extensibility (cm)	18.8	15.6	16.1	16.6
Max. Height (BU)	390	330	285	325
Area (sq.cm)	102	74	69	81
Amylograph				
Peak	470	400	1020	1040
Gel. Time (min)	24	24	22	21
Gel. Temp (°C)	66	66	63	61.5
Breakdown (BU)	80	220	230	200

Appendix III. Analytical Results For Batavia.

Test Type	Batavia Walpeup 96/97	Batavia Avondale 96/97	Batavia Horsham 96/97
Moisture (%)	13.9	14.3	14.2
Protein (% as is)	13.9	9.13	7.02
Ash (% as is)	0.43	0.38	0.39
Diastatic Activity (mg)	145	207	166
Colour Grade (KJ)	-0.9	-2.4	-3.5
Minolta Flour L	92.86	93.38	93.6
Minolta Flour a	-2.35	-2.45	-2.6
Minolta Flour b	11.16	10.23	10.03
Farinograph			
Water Absorption (%)	62.2	61.8	57.5
Development Time (min)	9.9	3.5	1.6
Stability (min)	>15	7.6	5.1
Breakdown (BU)	0	77	70
Extensograph			
Extensibility (cm)	23.9	18.8	14.8
Max. height (BU)	500	250	340
Area (sq.cm)	168	69	74
Amylograph			
Peak	1460	1090	1300
Gel. Time (min)	20	22	22
Gel. Temp (^{0}C)	60	63	63
Breakdown (BU)	370	200	320

Appendix IV. Analytical Results for Rosella, Yanac, Cadoux and Eradu.

Test	Rosella	Yanac	Cadoux	Eradu
Moisture (%)	13.9	14.0	13.7	13.5
Protein (%) (as is)	8.85	9.28	8.66	9.25
Ash (%) (as is)	0.40	0.39	0.38	0.33
Diastatic Activity (mg)	111	176	85	80
Colour Grade (KJ)	-1.8	-2.0	-2.1	-2.1
Minolta Flour L	94.18	93.24	93.99	94.14
Minolta Flour a	-2.56	-1.76	-2.57	-2.14
Minolta Flour b	9.55	7.80	9.61	7.52
Farinograph				
Water Abs (%)	54.9	58.9	54.4	53.3
Development Time (min)	3.0	3.8	2.3	2.1
Stability (min)	4.4	6.9	6.3	9.1
Breakdown (BU)	90	60	75	70
Extensograph				
Extensibility (cm)	20.8	20.4	17.6	20
Max. height (BU)	280	355	300	430
Area (sq.cm)	87	105	78	120
Amylograph				
Peak (BU)	760	1260	870	1310
Gel. Time (min)	27	21	27	23.5
Gel .Temp (°C)	70.5	61.5	70.5	65.3
Breakdown (BU)	100	300	190	220

Appendix V. Analytical Results for Korean Blend

Wheat

Test	Result
Test Weight (kg/hl)	79.0
Moisture (as is)	10.7
Proetin (%) (as is)	10.6
1000 Kernel Weight	38.5
Ash (%) (as is)	1.3

Flour

Test	Result
Moisture (%)	13.4
Protein (%) (as is)	9.26
Ash (%) (as is)	0.38
Diastatic Activity (mg)	188
Colour Grade (KJ)	-3.0
Minolta Flour L	93.21
Minolta Flour a	-2.33
Minolta Flour b	9.35
Farinograph	
Water Abs (%)	56.9
Development Time (min)	4.8
Stability (min)	8.6
Breakdown (BU)	45
Extensograph	
Extensibility (cm)	18.6
Max. height (BU)	350
Area (sq.cm)	91
Amylograph	
Peak (BU)	600
Gel. Time (min)	25
Gel .Temp (°C)	77.5
Breakdown (BU)	180