M ELiSSA

Technical Note

Memorandum of Understanding 19071/05/NL/CP

UNIVERSITEIT GENT

FACULTEIT WETENSCHAPPEN

MELiSSA Food Characterization: phase 1

Technical note: 98.5.2

Preliminary trade-off of food processing technologies: Test performances

prepared by/*préparé par*	Michel Timsit / Katrien Molders
reference/*réference*	Contract number 22070/08/NL/JC
issue/*édition*	1
revision/*révision*	1
date of issue/*date d'édition*	26.10.2010
status/*état*	Final
Document type/*type de document*	Technical Note
Distribution/*distribution*	

C O N F I D E N T I A L   D O C U M E N T

A P P R O V A L

Title *titre*	Preliminary trade-off of food processing technologies: Test performances	issue 1 *issue*	revision 1 *revision*

author *auteur*	FC1 Consortium	date *date*	23.08.2010
GEM	Michel Timsit		
UGent	Katrien Molders,		
UCL	Muriel Quinet		
IPL	Serge Pieters		
UNap	Vincenzo Fogliano		
UBern	Urs Feller		
ETHZ	Erich Windhab		

Reviewed by (UGent) approved by (UGent) *approuvé by*	Katrien Molders Dominique Van Der Straeten	date *date*	22.10.2010 27.10.2010

C H A N G E L O G

reason for change /*raison du changement*	issue/*issue*	revision/*revision*	date/*date*

C H A N G E R E C O R D

Issue: 1 Revision: 1

reason for change/*raison du changement*	page(s)/*page(s)*	paragraph(s)/*paragraph(s)*

TABLE OF CONTENTS

Table of Figures

List of Tables

List of Abbreviations

AOAC	Association Of Analytical Communities
ANOVA	ANalysis Of VAriance (statistics)
CSIRO	Australian Commonwealth Scientific and Research Organisation
DW	Dry Weight
TS	Trockensubstanz (German) = dry matter

1 Presentation

- This work package gathers the results of the tests which have been proposed in the TN 98.5.1, with the aim of starting the selection of the appropriate processing technologies for the four selected crops.
  The test plan included the various criteria which must be tested, because they are relevant and because the resulting value for each criteria (using Melissa crops) is not known.

- The Melissa products to be processed are hydroponics crops which composition and technological behavior is not known. Therefore, when available, the tests had to be done with hydroponic crops.

- The number of cultivars per crop that are considered for processing depends on the priorities set by the different labs and on the quantities available for tests processing (samples from field or hydroponics).

- The different processes which have been selected depend upon the equipment available in each lab:
  - Potato based: microwave cooked potato and boiled potato will be considered. These products can be processed with existing equipment; the results will also give indications for mashed or diced potatoes; fried potatoes and flakes will not be considered here because of lack of suited equipment and reduced availability of samples.
  - Wheat based : the tests has not been done on elaborated processed products but only on grain and flour, with comparison between market products and hydroponic crops.
  - Soya based : soya juice, okara, and soy sprouts have been selected in TN98.3.31. Soy sprouts, will only be studied through literature references.

- Here are the tests results obtained for the different criteria; the analysis and evaluation of these results will be done in WP 5300.

Note: On few occasions, comparative analyses are performed on hydroponically obtained and field obtained raw products. Differences on macronutrients as well as micronutrients can seem to be rather important (sometimes 2-fold for macronutrients and up to 7-fold for micronutrients). Considering that the menu elaborated today relies on data from field crops, we can assume that those differences might have an impact on the menu definition. However, due to the fact that at this moment the procedures for hydroponic culture are not yet optimized and the degree of maturity of the plants at harvest time needs to be further investigated, it is too premature to make conclusions on these difference wrt the menu definition.

2 Potato based products

2.1 Test of the different processes

The processing tests have been done on Désirée, Annabelle and Bintje varieties.
The processing analysis results will use the format defined in TN98.5.1. The standard deviation on the analytical results was included in analytical reports, which are included in the annexes of this TN.

Tab. 1 Microwave cooked potatoes

Processing step	Process device	Control parameters	Measured criteria	Remarks
Raw crop		Size and unit weight of raw potatoes	*The biggest raw potato obtained for each variety: ~ 45g per potato*	*Average market potato weight is 100-200g*
		Weight (before cooking)	*a) (HZPC) Désirée Rechts* with skin : 142g* *b) (HZPC) Désirée rechts* with skin : 137 g* *c) (HZPC) Désirée Links* with skin 146g without sprout*** *d) (HZPC) Désirée Links* with skin 140g without sprout***	
		Chemical food analysis (macronutrients, fibers, cations)	*See table 7*	

		(AOAC)		
Cooking***	Microwave-oven : Whirlpool Input 2500 W Frequency 2450 Mhz	Cooking time :	*a) 5'00'' (too long)* *b) 3'30''* *c) 5'00'' (too long)* *d) 3'30''*	*Cooling conditions : ambient air*
		Cooking temperature	*High intensity Jet (900w)* *Temperature not registred*	
		Delivered power	*Energy consumption 0.033 kwh for 3'30" at high intensity jet 900w.* *Peak of energy is 1524 w*	
End product	Sensorial analysis (based on a small panel of testers)		➢ *Visual aspect* *For all : good aspect, skin thin but strong, crumpled*	*Sensory test done on whole processed potatoes from hydroponic crops*
			➢ *Taste:* *For all strange taste. After 1 minute, perception of a bitter-metallic taste in the back of the mouth*	
			➢ *Flavor :* *nothing special*	
			➢ *Palatability:* *Strong skin and dried flesh*	
		Chemical food analysis (macronutrients, fibers, cations) (AOAC)	*Global Processing yield for each main component* *a) no analysis***** *b) table 7* *c) no analysis***** *d) table 7*	*No nutrient preservation yield calculated*

		Weight after cooking	***After cooking** yield :* *a) –n.a.* *b) 97g* *c) – n.a.* *d) 100g* *yield :* *b) 0.708* *d) 0.714*	

<u>Table 1 comments</u>:
**'Links' is Dutch for 'left' and 'Rechts' for 'right'. It is referring to the position of the plants in the HZPC green house. A different position (gully) in the greenhouse causes slightly different conditions (e.g. one position has more sunlight in the morning and another position has more sunlight in the afternoon).*
*** We noticed that during storage many varieties have developed sprouts. Sprout formation can reduce the storage time, have an impact on the gross weight and alter the taste.*
**** Cooking step: the potatoes were all cooked at the same time in different containers with cover. The microwave oven was equipped with a turning plate, the container was placed in the centre of the turning plate.*
***** no analysis: Because the cooking time was too long, we obtained severely reduced potatoes with a hard structure due to dehydration. No analysis could be performed on these potatoes.*

Tab. 2 Boiled potato

Processing step	Process device	Control parameters and tools	Measured criteria	Remarks
Raw crop		Unit size and weight of raw potatoes	*The biggest raw potato obtained for each variety: ~ 45g per potato* *A) Désirée Rechts* with skin : 108 g, cooked 109 g* *B) Désirée peeled boiled : raw 130 g, 95 peeled, cooked 97g* *C) Désirée peeled diced (1cm) and boiled :*	

			raw 158 g, 113 peeled, cooked 118g *D) Désirée Links* with skin : 109 g, cooked 111g* *E) Désirée peeled boiled : raw 150 g, 105 peeled, cooked 110g* *F) Désirée peeled diced (1cm) and boiled : raw 145 g, 106 peeled, cooked 117g*	
		Chemical food analysis (macronutrients, fibers, cations) (AOAC	*(see chemical analysis results above)*	
Cooking (500 ml of water used per cooking session)	Electric cooker	Cooking time	15 min	
		Delivered power	Energy consumption *Not available*	Water recycling :*no Water stored for further analyses*
		(process optimization based on sensory testing results)		Cooling conditions ? *Ambient air*
End product		Chemical food analysis (macronutrients, fibers, cations) (AOAC)	Global Processing content for each main component *(See analytical results above)*	*No nutrient preservation yield calculated*
		Sensorial analysis (based on a small panel of testers) (questionnaire) *Not possible due to the small available*	Visual aspect : *For all : good aspect, skin thin but strong, crumpled* Taste: *For all strange taste. After 1 minutes perception of a bitter-metallic taste in back of*	

		quantities and particular taste.	*the mouth* Flavor : *nothing special* Palatability: *Strong skin and dried flesh*	
		Water chemical analysis. *Not performed during this study as no samples were available.*	Yield analysis	Some soluble components are in the cooking water
		Cooking yield	***After cooking*** *yield :* *a-101%* *d- 102 %* ***After peeling and cooking*** *b- 74%* *c- 75%* *e- 73%* *f- 81%* ***Cooking yield for peeled potato*** *102 to 104%* *110% for diced potato (f)*	

2.2 Chemical analysis

The analyses have been done on the following cultivars:

- *Desirée,*
- *Innovator,*
- *Bintje,*
- *Saline**
- *and Annabelle*

* HZPC had a 'Saline' sample available for analysis. The Saline cultivar does not belong to the selected MFC1 cultivars and has in theory no specifically interesting characteristics, but as we had a sample, we decided to analyze it out of curiosity. The results of the analysis can be found in Annex 5.5 (analysis N°22113) of this TN.

2.2.1 *Raw potatoes*

Here are the main results obtained for the different varieties, comparing field and hydroponic culture. The comprehensive analytical results including the standard deviations (SD) can be found in the annex of this TN.

For table 3-7: the unity is expressed 'per 100g of raw wet or cooked wet product'

For a better understanding of the tables 3-7 we herewith explain that 'hydroponics low light' are tubers from plants cultivated in hydroponic culture at a photosynthetic photon flux of 100-250 µmol/m²s and that 'hydroponics high light' are tubers from plants cultivated in hydroponic culture at photosynthetic photon flux of 200-320 µmol/m²s.

Tab. 3 Chemical analysis of the Annabelle variety

RAW POTATOES		Annabelle	Annabelle	Annabelle	Annabelle	Annabelle	Annabelle	Annabelle
		UCL	UCL	Gent	Gent	HZPC	HZPC	UCL
		Hydroponic low-light	Hydroponic High-light	Hydroponic low-light	Hydroponic low-light	Hydroponic rechts	Hydroponic low-light	Field
Energy (standardized)	kJ	262	279	263	307	223	229	244
Energy (standardized)	kcal	63	67	63	73	53	55	58
Water	g	82,2	81,3	82,4	79,4	84,8	83	81,8
Nitrogen, total	g	0,22	0,22	0,18	0,20	0,27	0,28	0,21
protein, total; calculated from total nitrogen	g	1,38	1,38	1,11	1,24	1,70	1,78	1,33
protein from plant origin	g	1,38	1,38	1,11	1,24	1,70	1,78	1,33
protein from animal origin	g							
fat, total (standardized)	g	0,08	0,10	0,10	0,11	0,09	0,08	0,07
carbohydrate, available		13,19	14,04	13,45	15,62	10,36	11,73	14,42
fibre, total dietary,		1,85	2,02	1,80	2,47	2,02	2,44	1,66
ash	g	1,34	1,19	1,19	1,12	0,99	0,98	0,75
calcium	mg	1,82	3,80	10,20	7,20	13,00	12,80	14,90
iron	mg	1,34	0,90	1,50	1,20	1,00	1,00	2,40
magnesium	mg	24,60	27,20	23,87	26,80	28,10	29,40	19,30
phosphorus	mg	94,00		100,00		84,00	28,00	
potassium	mg	551,00	561,00	486,00	536,00	365,00	428,00	312,00
sodium	mg	9,20	-	11,70	-	18,00	-	23,00
Chloride	mg							
Zinc	mg	0,60	0,60	1,16	1,00	2,39	1,90	0,26
copper	mg	0,49	0,40	0,51	0,40	0,38	0,40	0,30
manganese	mg	0,27	0,23	0,42	0,38	0,23	0,29	0,10

For Annabelle, as well as for the different analyzed varieties, it appears that the field produced potato contains more Ca and Fe, often more available carbohydrates, and less ashes, Mg, K, Zn and Mn.

Tab. 4 Chemical analysis of the Bintje variety

RAW POTATOES		Bintje	Bintje	Bintje	Bintje
		UCL	Ugent	HZPC	HZPC
		Hydroponic low light	Hydroponi low-light	Hydroponic rechts	Field
Energy (standardized)	kJ	260	339	276	361
Energy (standardized)	kcal	62	81	66	86
Water	g	82,3	77,1	78,2	76,5
Nitrogen, total	g	0,26	0,24	0,33	0,25
protein, total; calculated from total nitrogen	g	1,62	1,53	2,07	1,57
protein from plant origin	g	1,62	1,53	2,07	1,57
protein from animal origin	g				
fat, total (standardized)	g	0,06	0,05	0,07	0,08
carbohydrate, available		12,70	17,40	16,30	18,75
fibre, total dietary;		2,04	2,40	2,17	2,14
ash	g	1,27	1,44	1,22	0,93
calcium	mg	1,80	1,10	8,70	16,40
iron	mg	1,30	1,50	1,48	1,90
magnesium	mg	23,40	21,60	26,80	20,60
phosphorus	mg			32,00	
potassium	mg	769,00	842,00	682,00	432,00
sodium	mg	*5,49*	*6,66*	9,41	3,96
Chloride	mg				
Zinc	mg	0,36	0,74	2,50	0,30
copper	mg	0,38	0,53	0,60	0,30
manganese	mg	0,23	0,32	0,25	0,15

Table 4 comment: Due to a misinterpretation, phosphorus was not viewed as part of the basis set of analysis on the first samples. Therefore phosphorus has not been analysed for the UCL and UGent products.

Tab. 5 Chemical analysis of the Innovator variety

RAW POTATOES		Innovator	Innovator	Innovator	Innovator
		UCL	Ugent	HZPC	HZPC
		Hydroponic low-light	Hydroponic low-light	Hydroponic rechts	field
Energy (standardized)	kJ	324	355	256	303
Energy (standardized)	kcal	77	85	61	72
Water	g	78,1	76,5	77,8	77,6
Nitrogen, total	g	0,29	0,18	0,40	0,23
protein, total; calculated from total nitrogen	g	1,84	1,13	2,53	1,43
protein from plant origin	g	1,84	1,13	2,53	1,43
protein from animal origin	g				
fat, total (standardized)	g	0,08	0,06	0,07	0,07
carbohydrate, available		16,00	18,80	15,20	17,92
fibre, total dietary;		2,71	2,22	3,23	2,09
ash	g	1,27	1,30	1,24	0,90
calcium	mg	1,30	1,24	9,48	22,90
iron	mg	1,30	1,54	1,57	4,70
magnesium	mg	26,10	25,10	30,00	21,20
phosphorus	mg			34,00	108,00
potassium	mg	738,00	780,00	715,00	381,00
sodium	mg	67,00	62,00	66,00	25,90
Chloride	mg				
Zinc	mg	0,39	0,94	3,10	0,40
copper	mg	0,30	0,41	0,53	0,16
manganese	mg	0,21	0,28	0,19	0,13

Tab. 6 Chemical analysis of the Désirée variety

RAW POTATOES		Désirée	Désirée	Désirée	Désirée
		UCL	UGent	HZPC	HZPC
		hydroponic low light	hydroponic sub-opt-light	hydroponic rechts	field
Energy (standardized)	kJ	227	237	266	311
Energy (standardized)	kcal	54	57	63	74
Water	g	84,1	83,5	81,9	79,7
Nitrogen, total	g	0,32	0,33	0,35	0,24
protein, total; calculated from total nitrogen	g	2,02	2,05	2,19	1,49
protein from plant origin	g	2,02	2,05	2,19	1,49
protein from animal origin	g				
fat, total (standardized)	g	0,10	0,11	0,10	0,07
carbohydrate, available		10,26	10,84	12,29	15,98
fibre, total dietary;		2,17	2,03	2,34	1,86
ash	g	1,33	1,43	1,17	0,87
calcium	mg	8,10	8,10	15,60	21,00
iron	mg	4,10	5,40	2,30	2,50
magnesium	mg	25,10	26,30	30,30	17,00
phosphorus	mg	121,00	102,00	24,00	138,00
potassium	mg	631,00	665,00	521,00	404,00
sodium	mg	19,40	23,70	25,90	22,50
Chloride	mg				
Zinc	mg	0,43	0,75	0,60	0,20
copper	mg	0,27	0,77	0,40	0,40
manganese	mg	0,25	0,48	0,27	0,11

In Tab. 5 and Tab. 6 we see a hugh difference in phosphorus, potassium and calcium content of the field production compared to the hydroponics production. We assume that this is linked to the composition of the nutritive solution of the hydroponic culture that might contain less calcium and phosphor but more potassium than the soil or the fertilizer (HZPC). In the tuberisation solution (second solution of hydroponic culture) used there is no more or little calcium, it could explain the difference in calcium. It is not surprising that the concentration of potassium is high in case of the hydroponic culture because the solutions used to adjust the EC were K_2SO_4 and KH_2PO_4 and thus potassium was added regularly to the solution. Concerning the field culture, fertilizers (if any were used) are usually N-P-K (nitrogen, phosphor and potassium) fertilizers. The nature and composition of the soil used by the field crop suppliers are unknown.

2.2.2 Processed potatoes

Microwave and boiling processes results have been analyzed in the case of the Désirée variety. The following table gathers the available results and compare hydroponics to field crops.
The comprehensive analytical results including the standard deviations (SD) can be found in the annex of this TN.

Tab. 7 Analytical results for processed products from the Désirée variety

IMPACT OF THE COOKING PROCESS		Désirée	Désirée	Désirée	Désirée	Désirée	Désirée	Désirée	Désirée	Désirée	Désirée
		HZPC	HZPC	HZPC	HZPC	HZPC	HZPC	HZPC	HZPC	HZPC	HZPC
		raw	raw	microwave	microwave	boiled with skin	boiled with skin	peeled and boiled	peeled and boiled	peeled, diced and cooked	peeled, diced and cooked
		hydroponic rechts	field	hydroponic rechts	field	Hydroponic links	hydroponic rechts	Hydroponic links	hydroponic rechts	Hydroponic links	hydroponic rechts
Energy (standardized)	kJ	266	311	308	391	309	288	346	289	229	197
Energy (standardized)	kcal	63	74	74	93	74	69	83	69	55	47
Water	g	81,9	79,7	73,4	70,4	79,2	80,4	77,4	80,9	82,1	84
Nitrogen, total	g	0,35	0,24	0,52	0,36	0,37	0,35	0,32	0,32	0,26	0,26
protein, total; calculated from total nitrogen	g	2,19	1,49	3,24	2,26	2,32	2,16	1,99	2,01	1,62	1,60
protein from plant origin	g	2,19	1,49	3,24	2,26	2,32	2,16	1,99	2,01	1,62	1,60
protein from animal origin	g										
fat, total (standardized)	g	0,10	0,07	0,13	0,09	0,09	0,07	0,07	0,07	0,06	0,05
carbohydrate, available		12,29	15,98	18,13	23,14	14,74	13,53	17,38	14,02	13,57	11,67
fibre, total dietary;		2,34	1,86	3,71	3,03	2,43	2,69	2,33	2,20	2,13	2,15
ash	g	1,17	0,87	1,42	1,13	1,23	1,12	0,86	0,82	0,55	0,52
calcium	mg	15,60	21,00	12,30	14,50	6,80	9,20	17,10	24,80	23,70	12,40
iron	mg	2,30	2,50	1,00	1,90	0,50	0,70	0,60	0,60	0,50	0.7
magnesium	mg	30,30	17,00	42,30	25,30	24,90	28,40	24,10	26,20	17,30	18,70
phosphorus	mg	24,00	138,00	40,00		107,00	97,00	89,00	84,00	65,00	59,00
potassium	mg	521,00	404,00	685,00	543,00	554,00	474,00	350,00	316,00	209,00	203,00
sodium	mg	25,90	22,50	-	-						
Chloride	mg										
Zinc	mg	0,60	0,20	2,50	0,40	1,20	0,90	0,60	0,40	0,90	0.9
copper	mg	0,40	0,40	0,40	0,40	0,40	0,40	0,60	0,30	0,40	0.4
manganese	mg	0,27	0,11	0,36	0,17	0,22	0,23	0,25	0,27	0,24	0.23

For Désirée, the field potato contains more carbohydrates. Diced potatoes have more losses. Microwave cooking tends to lower the water content; the same, but less effective, for potatoes boiled with skin.

Concerning the impact of microwave cooking on other varieties, the following table gathers some results for Bintje (microwaved), Annabel (microwaved) and Désirée (raw): the main impacts of microwave cooking are the water evaporation, which gets proteins and fats higher, and the improved availability of carbohydrates.

Tab. 8 Analytical results of microwave cooking for different varieties

		Bintje, HZPC r, microw.	Bintje, HZPC l microw.	Annabelle, HZPC r, microw.	Désirée, HZPC r,2 months, raw
Water (%)		67,6	70,4	74,8	82,4
Protein (%)		2,98	2,76	3,1	2,4
Fat (%)		0,12	0,1	0,12	0,09
Available carbohydrates (%)		24,29	22,01	16,64	11,55
TDF (%)		3,34	3,14	3,87	2,45
Minerals (%)		1,66	1,56	1,5	1,11
Of which (mg/100 g)	Sodium	12	13	14,3	12,6
	Potassium	719	692	639	489
	Calcium	8,6	10,8	9,3	9,2
	Magnesium	34,3	34	44,2	29,7
	Iron	0,7	0,7	0,9	0,7
	Copper	0,5	0,7	0,7	0,6
	Zinc	2,8	2,2	2,8	1,7
	Manganese	0,3	0,32	0,38	0,3
	Phosphorus	149	140	148	103
Energy (for 100g)	kcal	116,8	106,2	87,7	61,5
	kJ	488,7	444,4	367,1	257,5

Table 8 comments:

- Any kind of cooking method will enhance the availability of carbohydrates, this due to changes in the spatial structure of starch and partial hydrolization of starch.
- The last column reports the composition of the HZPC raw Desiree. Those results are from analysis of desiree after 2 months of conservation and are to be compared with the previous analysis of the same cultivar.
- Innovator cultivar is not reported in this table. As its hydroponic yield was low, there was no more sample left at this stage.
- % = % of Fresh Weight (FW). % FW is the common unit for nutritional values. The data can be expressed in function of Dry Weight (DW) by simply multiplying the FW by (100/(100-%water))

2.3 Conclusions concerning qualitative or quantitative aspects of the different studied processes for potatoes

As a first conclusion, it is important to stress that the little size of the cropped potato plays a large part in the rather low yield which is observed: this can prompt to use non peeled potatoes.
Bintje variety leads to the highest caloric result.

Potato presentation: The majority of hydroponic potatoes are quite small and greatest ones are only 40-50 g. Due to the small size of the potatoes, the skin is about 30% of the weight of the potato.
Macronutrients preservation: Regarding the potatoes cooked in the microwave, there is a direct loss of weight during cooking of about 30% caused by dehydration. Regarding the boiled potatoes: the decrease corresponds to 1-3% of water. On the other hand, diced potatoes have absorbed water (2%) certainly by increasing the contact area.
Micronutrients preservation: Regarding the potatoes cooked in the microwave: For undetermined reasons, we find a lower content in calcium and iron in potatoes after cooking. It will be interesting to analyze further potential losses of vitamins. Regarding boiled potatoes: As expected the cooked diced peeled potatoes nutrient losses are more important than peeled potatoes and potatoes with skin
Sensory analysis: Initial evaluations were done internally but directly demonstrated a very unpleasant taste of all the potatoes tested.
Energy consumption evaluation per Kcal obtained end product: For 100 kcal, we can extrapolate the energy requirement to 0,044 kwh for microwaved potatoes.

The results will be further commented in TN 98.5.3.

3 Wheat based products

The TN 98.5.1 proposed to test, from one side, the processing of freekeh burger and bulgur made from durum and, from another side, the processing of bread and wheat sprout from bread wheat.
Taking into account the available quantities of hydroponic wheat, it has been decided to give priority to the comparison of field and hydroponic wheat composition and to technological testing during milling procedure.
For the processing of wheat-based products the mass of hydroponic wheat samples available so far has been too small (150-200g per cultivar). This is why for end-product processing we restricted to field samples of the same cultivar (Greina) and the processing of bread samples being the most complex. The processing steps for the bread making include the milling steps for bulgur production as well as processing conditions during fermentation coming close to the ones relevant for wheat grain sprouting.

The freekeh study was depending on the availability of milky stage harvest. In order to get bread wheat in the milky state, a wet fraction was imported from Australia (CSIRO) in November 2010. After harvesting the ears, the green wheat had to be frozen which was expected to be the quickest solution to keep its maturation state. However after receiving the samples we had to detect, that the cold storage shipping was obviously not well controlled. As a consequence the grains were already starting to germinate. This eliminated our freekeh production trials again. We propose now to get green wheat harvesting at specific maturation states from the new pre-harvest starting in the second half of May 2011. This will be too late to include in this specific study.

Note 1: So far no difficulties appeared during testing, because the applied test procedures are well adapted and trained standard procedures. Statistics about equipment failure are not yet available due to the small number of tests performed with the relevant wheat cultivars until now.

Note 2: Statistics about errors in the quantitative results evaluated so far was limited due to the small amounts of Hydroponic Wheat samples. However for the analytical methodologies applied the following error ranges can be given from experience:
Minerals: +/- 0.05 %; Protein: +/- 0.1 %; Fat: +/- 0.075%; Carbohydrates: +/- 0.05% and Water: +/- 0.025%

3.1 Test of different processes

Tab. 9 Processing steps and evaluation criteria for wheat based products

Processing step	Process device	Control parameters	Measured criteria	Remarks
Crushing / Milling	Agromatic Lab-4 roller Mill (best for small samples) compared with Attrition mill & Roller Mill	Material: Weight and water content of raw wheat grains Water content adjusted by pre-conditioning to 16,2%. Device: roller speed (1-1,5 m/s) Milling gab size (gabs: 1000, 800, 500, 250, 180, 125 microns)	*Grain size distribution* *Flour particle size by:* Laser Diffraction Analyzer LDSA (LS133201, Beckman Coulter, Brea, California, USA)	*Quantification of starch damage & related water holding capacity*
		Chemical food analysis (micronutrients, macronutrients, fibers) (AOAC)	Starch damage by: SDmatic (Tracomme AG (Adliswil, Schweiz) for quantitativen Analysis of starch damage by Iodine absorption	
Kneading (dough making)	SANTOS 10 Quart Dough Mixer (Kneader) Power 600W 1800 rpm Gärschrank (GS20, Wiesheu Affalterbach) Gärschrank (GS20, Wiesheu Affalterbach)	Rotational speed Mixing time (1500 rpm) Mixing time (25 min)	Mixing efficiency Dough quality (falling number, Fainograph, Extensiograph, Maturograph)	*Physical dough characteristics* *See figures*
1. Fermentation	Gärschrank (GS20, Wiesheu Affalterbach)	Fermentation time (18h, 25°C)	Dough volume	
Portioning				
Relaxation	Gärschrank (GS20,	Relaxation time (1 hour)		

	Wiesheu Affalterbach)			
2. Fermentation	Gärschrank (GS20, Wiesheu Affalterbach)	Fermentation time (2 hours, 25°C)	Dough volume	
Baking	IS600, Wiesheu GmbH, Affalterbach, Deutschland; Backmastere lectronic, Beer GrillAG, Villmergen, CH	Baking time Baking temperature Steam volume 245°C / 200°C 10 min / 35 min	Baking volume Bread freshness (by iodine binding) Texture analysis DSC (aging)	28min at 210°C and 300ml steam baking quality chracteristics, see figures

Milling tests and macronutrient composition (flour and partially total grain) comparisons have been done for the following cultivars: Greina, Fiorina, Rubli and Aletsch.
Baking tests were carried out for field samples of the Greina cultivar.

Taking into account the available quantities of hydroponic wheat, it has been decided to give priority to the comparison of field and hydroponic wheat composition and to technological testing during milling procedure.

3.2 Technological test details

3.2.1 Milling

A laboratory milling procedure has been set up based on a Agromatic Lab-4 roller mill which has been pre-tested being best for small sample milling.
Conditioning (or tempering) is necessary before grinding: it strengthens the bran, allows better separation and makes endosperm more friable.
After analysis of the water content of wheat and wetting, the wheat has been tempered for 24h (equilibration to 16% water content). Flour milling has been done on a modified Agromatic Lab-4 roller mill; Sifting has been done in 3 fractions.

3.2.2 Granulation

Granulation figures show the mass percent for each particle size class (size in **µm)** after roller milling.

Fig. 1 to Fig. 4 give the respective granulation curves for the four investigated wheat cultivars Greina, Fiorina, CH Rubli and Aletsch. The References given in each of the diagrams relate to the field samples, the other two samples denoted with either A, B, C and D (1,2) represent the hydroponic samples each from the two different gullies they originate from.

Fig. 1 Granulation curve for Greina

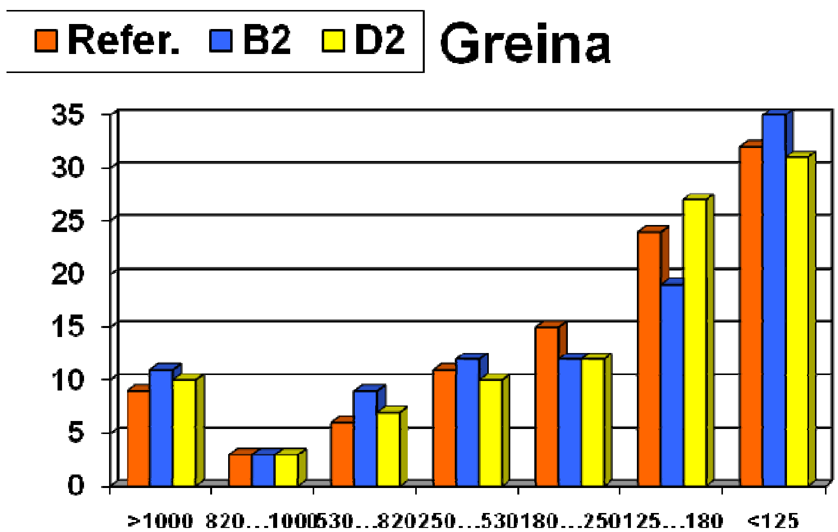


Fig. 2 Granulation curve for Fiorina

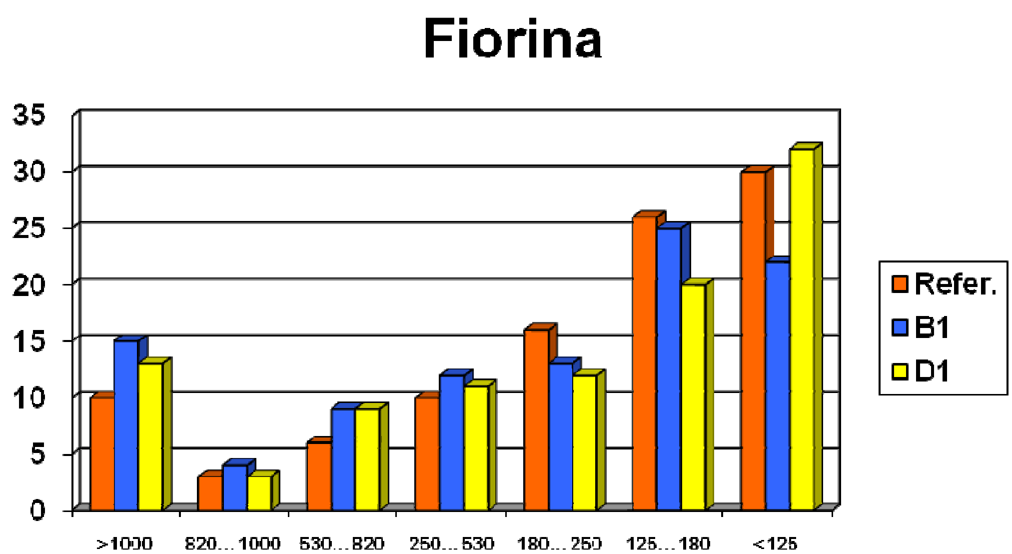


Fig. 3 Granulation curve for CH Rubli

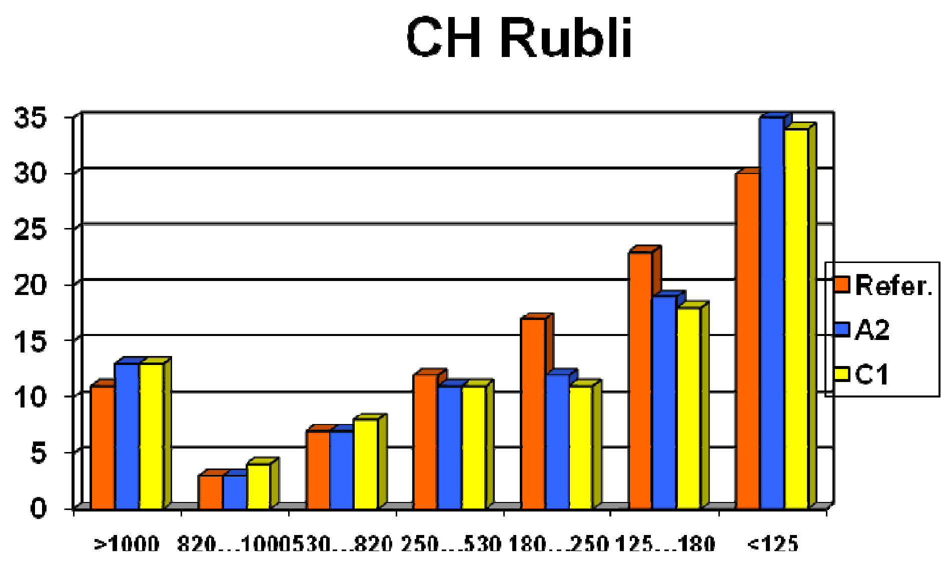
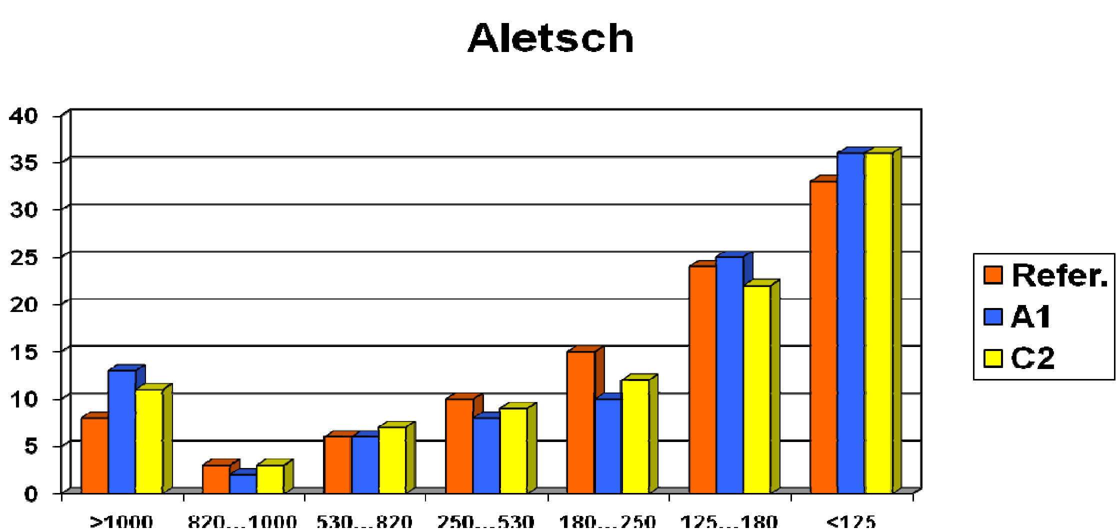


Fig. 4 Granulation curve for Aletsch



3.2.3 Ash curve

For each variety, the ash curve (Fig. 5 - Fig. 8) shows the percent of ashes in the grain, from the centre of the grain to the bran (standards for flour are based on ash content, which is greater in bran). This is directly linked to the possible yield of extraction. Furthermore the ash content in a flour fraction is linked to its mineral content.

Fig. 5 Ash curve Greina

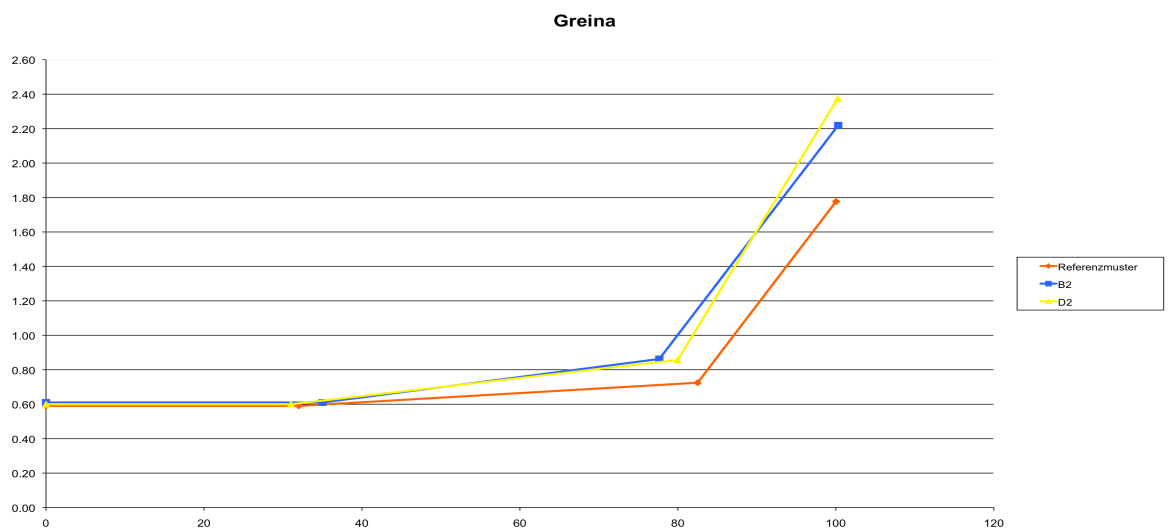


Fig. 6 Ash curve Fiorina

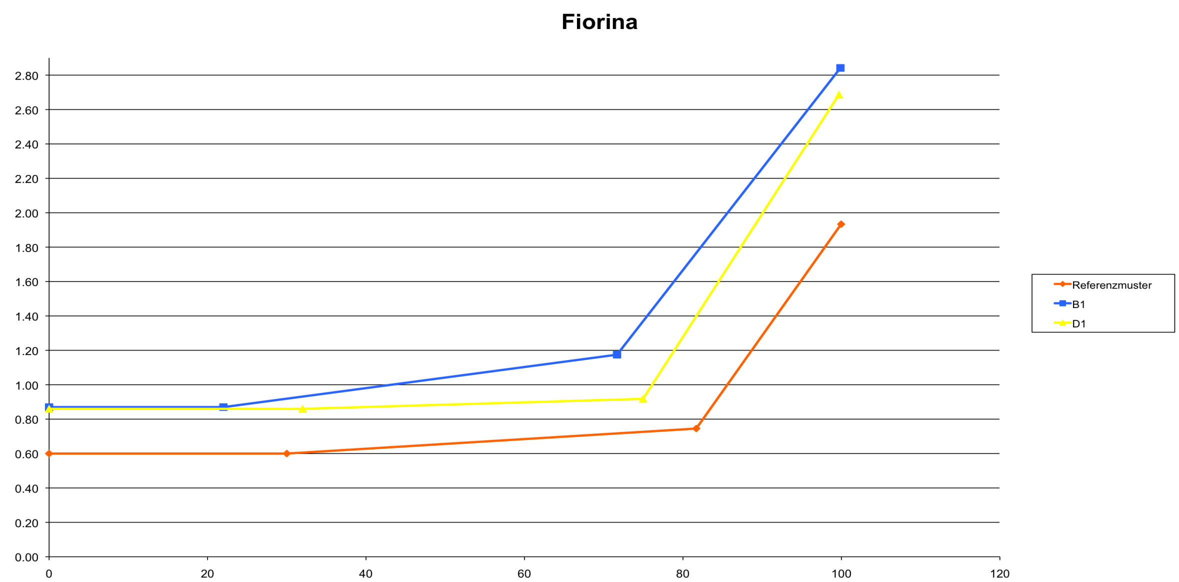


Fig. 7 Ash curve CH Rubli

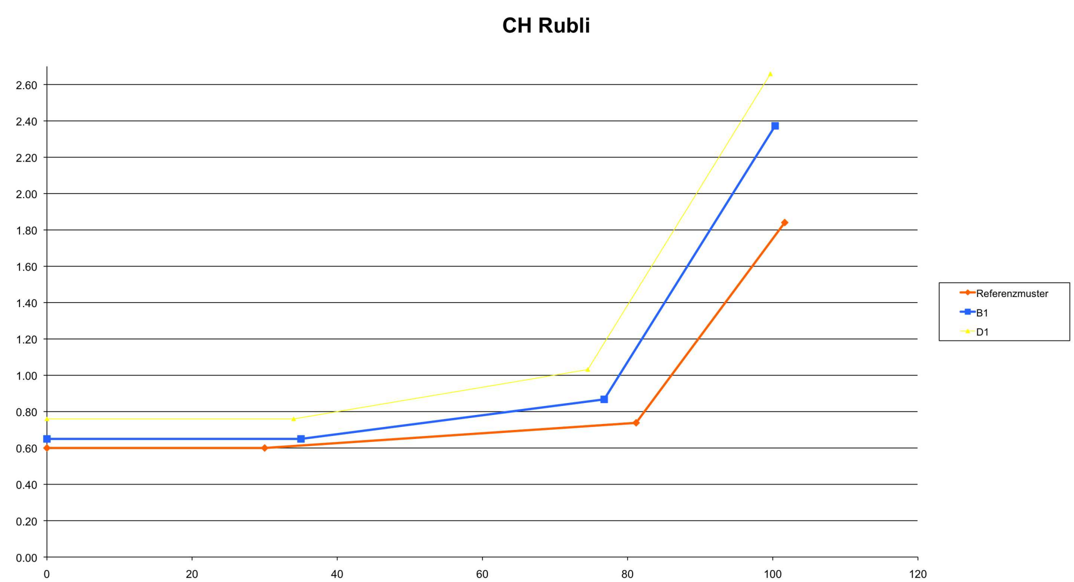
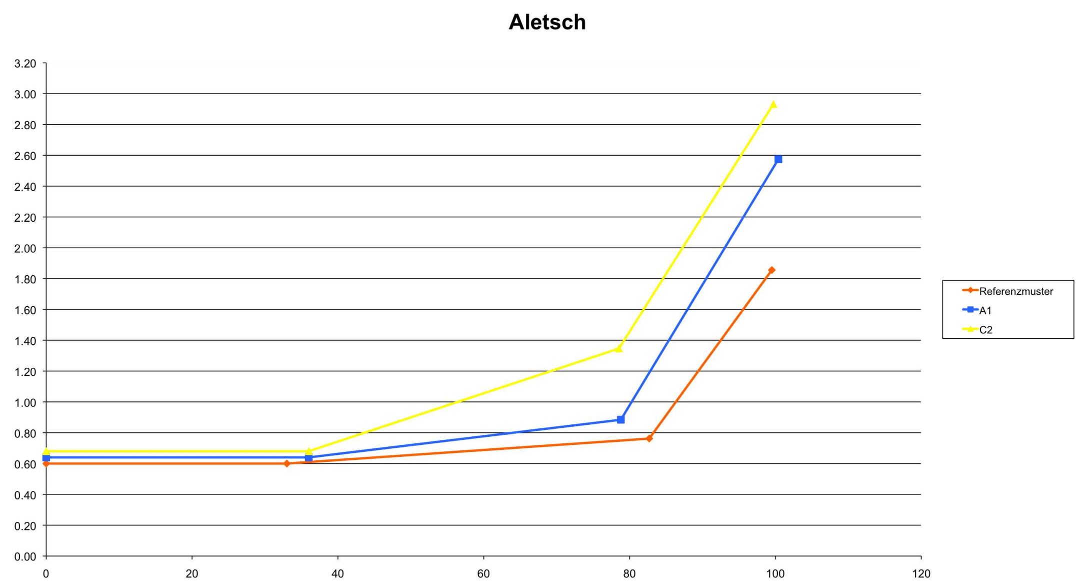


Fig. 8 Ash curve Aletsch



As can be derived from the above Figures, there is a significant increase in ash content within the hydroponic wheat samples compared to the reference. This seems to be due to:
a) the slightly reduced grain volume of the hydroponic wheat kernels and
b) some impact of the watery solution composition used in hydroponic cultivation of the wheat, which consequently deliver a larger fraction of bran and ash.
However from a nutritional point of view the increased mineral content in the full grain flour that can be achieved from the hydroponically grown bread wheat is favourable.
One may note that for Greina, the results for hydroponic production are rather close from the reference; for Rubli, ashes are more important for hydroponic product; even higher difference for hydroponic Rubli. Concerning Aletsch, no difference till forty percent weight but, for 80% cumulated weight, ashes are < 0,80 % for the reference but close to 0,90 % for A1 and to 1,4% for C2.

Depending on the milling characteristics there is strong impact on the dough making and baking quality. As a consequence it can be expected that the milling can also be used for adaptation of flour quality in case of deviation of hydroponically grown from field grown wheat.
In particular milling impacts on the functionality of the two major functional components in the wheat flour, (i) starch and (ii) gluten protein. Both can be degraded mechanically. Degrading the starch can have benefit in improved bread freshness respectively prolonged freshness time. Gluten protein damage has the opposite impact. In order to explore the impact

of the milling characteristics in further detail. Optimizing dough making, baking and final product quality , particularly prolonged freshness and shelf life will be of major importance for an efficient wheat cultivation and bread production during space missions.

In order to explore the impact of the milling parameters on the before-mentioned dough and bread quality characteristics we modified the specific milling energy impact on three levels (100%, 125%, 150%) within our selected lab milling equipment (Agromatic Lab-4 roller mill (experience based 100% standard: 25 kJ/kg) by increasing roller pressure and friction (by roller speed difference). These experiments are also seen as crucial for exploring the “part milling conditions” as they have to be applied in bulgur and Freekeh production.

3.2.4 Dough analytics

3.2.4.1 Physical dough characterisation

The dough analytical methods applied exemplarily to the bread dough sample produced with „Greina“ field samples are listed in Tab. 10 to Tab. 12.

Tab. 10 Methods for semi-empirical physical characterization of bread dough

Method	Measured characteristics
Farinograph	water absorption
	dough development
	dough stability
	dough resistence
	dough softening
Extensiograph	spec. dough extension energy
	elongation resistance
	characteristic elong. strain
	extension ratio
Maturograph	water absorption
	end fermentation time
	fermentation tolerance
	max. doughlevel
	structure strength

Tab. 11 Methods for semi-empirical characterization of starch complex in bread wheat

Method	Measured characteristics
Amylograph	max. viscosity
	start of gelatinazation
	end of gelatinazation

Tab. 12 Further complementary methods for semi-empirical characterization of bread dough

Method	Measured characteristics
Falling number	Enzyme activity
Maltose number	Enzyme activity
Sedimentation	Proteinquality
Wetted gluten content	Proteinquality
Dried gluten content	Proteinquality
Protein content	Proteinquality
Drying loss	Water content
Mineral content	Miling degree
Bread baking volume	Baking behaviour
Bread pore	Baking behaviour

Summarized results on the protein received for the bread dough produced from Greina field samples is given in the following Tab. 13.

Tab. 13 Protein quality of Greina field sample

Table 3.2.3-4: Protein quality characteristics of Greina (field sample) bread dough

milling Intensity P/Pn*	protein content [% i. TS]	wetted gluten [g/100]	max. elongation [mm]	structure strength [BE**]	sediment. value [ml]
100%	12.4	28.9	166	180	42
125%	12.7	23.6	134	145	74
150%	10.5	17.6	88	n.m.	66
required	13.0-12.5 ±0.2	31-34 ±0.5	-	-	44-55 ±2

* Pn = standard power input in Agromatic Lab-4 roller mill (experience based: 25.0 kJ/kg)
** BE = Brabender Units (Extensiograph)

Tab. 14 Protein quality of Greina hydroponic sample

For the Greina hydroponic wheat the available sample material was not sufficient for carrying out satisfying protein quality analysis.

From Tab. 13 it is obvious that the increase in spec. milling energy input leads to decrease in protein quality characteristics. As a consequence one has to expect, that the baking quality, in particular the baking volume will be negatively affected. This is exeplarily demonstrated in Fig. 10 below.

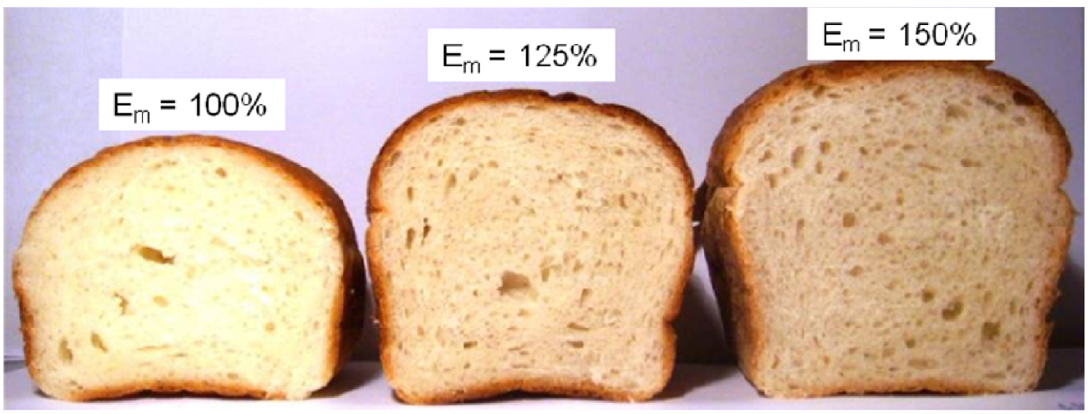


Fig. 10 Baking volume and baking bread structure received for different grades of specific energy input in wheat grain milling on lab scale milling device (Agromatic Lab-4; Greina, field samples)

Concerning the impact of milling on mechanical starch damage and related bread properties most significant results were received from comparing the functional relationship of (i) the Compression Modulus (CM) for the baked bread, which is a measure fort the freshness of the bread versus (ii) the Iodine Absorption (IA) which is a good indicator fort the mechanical starch damage. Respective functional dependencies (CM = f(IA)) are given in figure 10 for breads of different age (1,2 and 3 days).
As Fig. 11 clearly indicates, there is increased starch damage with increasing specific milling energy input as expected. However there is also significantly lower Compression moduli for increased starch damage indicating improved freshness. This trend is the more pronounced the older the bread gets.

From this it can be summarized that there are contrary effects on protein and starch by milling energy input concerning quality charcteristics of bread. Knowing the respective quantitative relationships this gives access to improved process optimization.

Concerning the application of the technologies investigated here it is recommended that for future space missions the freshness / shelf life aspect is specifically addressed in order to ensure the most efficient use of hydroponically grown biomass.

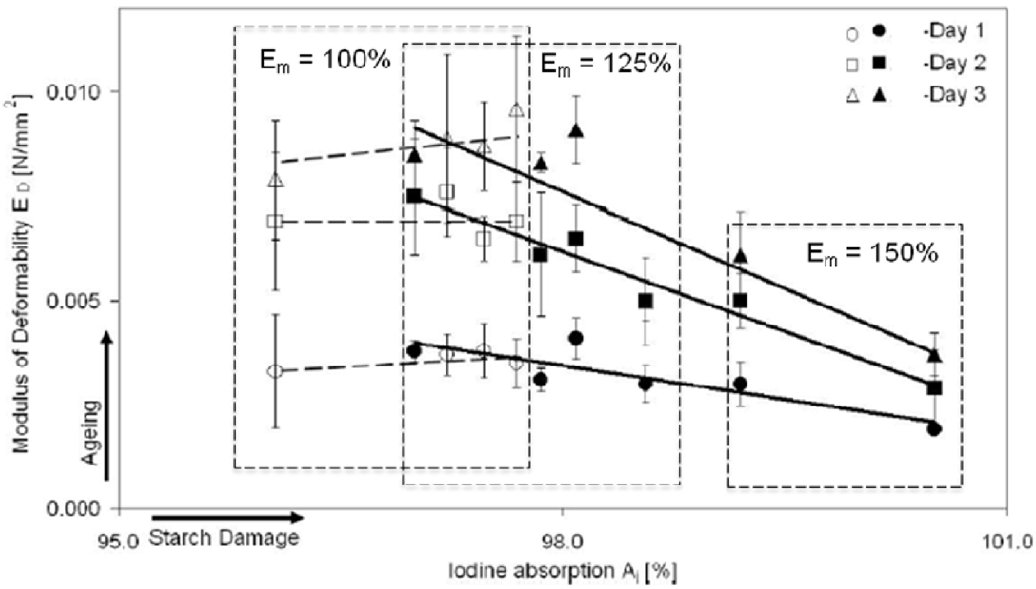


Fig. 11 Bread freshness indicated by compression modulus as a function of starch damage (indicator: Iodine absorption) as a function of bread age.

3.3 Chemical analysis

The analysis presented here focuses on the macronutrient composition of the raw wheat.

Tab. 15 presents the analytical results fort the four different cultivars investigated, comparing the reference field crop to the hydroponic products.

Macronutrient preservation during the processes investigated (milling, baking) is not a real issue (no losses for whole grain product, fibre loss directly related to bran separation in case of non whole grain product), however the baking process does have an impact on digestibility / bioavailability of respective components. But which has not been investigated here.

Micronutrient composition of the non-processed and processed samples were measured by the Prof. U. Feller (Universit of Bern) and included in his report.

Tab. 15 Macronutrient composition of wheat cultivars

wheat		Fiorina Ref.	Fiorina B1	Fiorina D1		Rubli Ref.	Rubli A2	Rubli C1
Comp.								
minerals (ash)	total grain/% TS	1.93	2.84	2.69		1.84	2.37	2.66
	flour / % TS	0.6	0.87	0.86		0.6	0.66	0.76
protein	flour / % TS	14.8	17.7	18.5		14.2	17.7	20
fat	flour / % TS	1.2	1.4	1.4		1.2	1.3	1.3
carbohydrates +	flour / % TS	82.07	78.06	77.41		82.76	78.63	76.04
raw fibre								
water b. wetting	% (grain)	8.33	8.51	8.82		8.77	8.5	8.74
water a. wetting	% (flour)	15.5	14.9	14.2		15.5	15.5	15

wheat		Aletsch Ref.	Aletsch A1	Aletsch C2		Greina Ref.	Greina B2	Greina D2
Comp.								
minerals (ash)	total grain/% TS	1.86	2.57	2.93		1.78	2.22	2.37
	flour / % TS	0.6	0.64	0.68		0.5	0.61	0.6
protein	flour / % TS	15.4	20	20.8		15.1	16.8	17.8
fat	flour / % TS	1.2	1.2	1.2		1.2	1.2	1.2
carbohydrates +	flour / % TS	81.54	76.23	75.07		81.92	79.78	78.63
raw fibre								
water b. wetting	% (grain)	8.97	8.87	9.22		8.85	8.6	9.16
water a. wetting	% (flour)	14.9	14.5	14.5		15.5	15.1	14.7

TS (German: Trockensubstanz) = dry matter

b wetting = before wetting; a wetting = after wetting (in flour) - (the grain after wetting always adjusted to 16.2%)

3.4 Conclusions concerning qualitative or quantitative aspects of the wheat processes

The two processes (milling, baking) investigated for wheat bread production delivered good sensory quality of the produced bread as evaluated by a non-trained sensory panel at ETH Zürich. This result relates to the field samples of the Greina cultivar.

As can be derived for the analytics done on the four cultivars of the hydroponic wheat samples there was a strongly pronounced increase of the ash content as a result of smaller grains and most probably the mineral composition of the hydroponic media used.

The nutritional data comparing the field samples and the hydroponically grown samples can mostly be related to the bran fraction concerning micronutrients. Concerning the macronutrient composition it was remarkable that the hydroponically grown samples provided an increased fraction of protein and a complementarily reduced fraction of carbohydrates in comparison to the respective field samples of the same cultivars.

4 Soya based products

The tests have been realized on soy milk and okara.
The tests have been done on the following cultivars :

Atlantic
Cresir
PR91M10
Regir

4.1 Soymilk test results

The main points of the TN 98.5.1 proposed test plan have been realized:

Tab. 16 Soymilk test plan

Processing step	Control parameters (and tools)	Measured criteria	Realization of the test
Raw product	Chemical food analysis (macronutrients, fibers, cations)		*- Analytical measures on raw and processed soya allow to precise the processing yields.* *- All tests done with soybeans market samples (and not from hydroponic crops)*
		Energy and water consumption	*Not available at a lab scale*
End product Soya milk	Chemical food analysis (AOAC methods) (macro-/micronutrients, fibers)	macro-/micronutrients, fibers Phytic acid content	*- Macronutrients which have been measured: proteins and fat* *- Micronutrient measured : isoflavones*
		Process yield on protein content Fat content Isoflavones	*Calculated*
	sensory characteristics	Flavor	*Choice of formulation made on one market available*
		Palatability	

	(sensory panel tests)	Taste	*variety, comparing with market soy milk ; sensory test (10 criteria) to compare the different cultivars on the basis of the selected formulation*

Soymilk was extracted from soybeans market samples of the 4 cultivars used for bench test 2, as described in Fig. 12

Soybeans seeds

Washing

Soaking

Milling

Paste boiling

Filtration

SOYMILK | **OKARA**

Sanitization

Fig. 12 Samples preparation

Soybeans were soaked in distilled water (in the ratio 1/10 weight /volume) at room temperature for 24 h and soaked soybeans were milled with the same amount of distilled water. The obtained paste was boiled for 30 minutes, in order to extract soymilk. After extraction the paste was filtered to separate soymilk from okara. The last step was soymilk sanitization (15 min boiling).

The soymilk produced from the each cultivar was extracted, performing two repetitions.

4.1.1 Macronutrient preservation

4.1.1.1 Protein content

The following table reports the average protein content in each cultivar.
Analysis was performed in two repetitions per extraction.

Tab. 17 Protein content (dry basis %) in soymilk samples

CULTIVAR	Average value (% dry basis)	Standard deviation
Atlantic	36,3	1,5
Cresir	39,6	0,9
PR91M10	38,0	3,2
Regir	36,2	0,3

Fig. 13 reports statistic analysis (ANOVA*) on protein content data. Soymilk obtained from Cresir seeds shows the highest protein content. There are not significant differences between soymilk obtained from Atlantic and Regir seeds.

**Data were subjected to ANOVA statistical analysis (Duncan test) and the results were expressed as "letters of significance". When samples are marked with, at least, one letter in common, they cannot be considered statistically different based on the selected confidence level (95% in our case).*

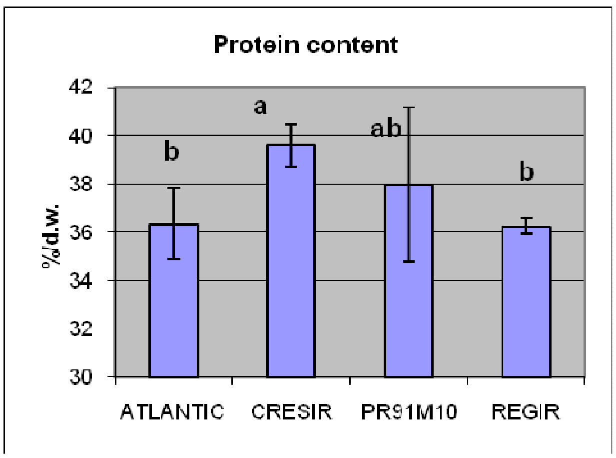


Fig. 13 Protein content (dry basis %±s.d.) in soymilk samples (confidence level=95%)

Protein yield was calculated as percentage ratio: protein in soymilk obtained / protein in seeds. The following table reports these values as average of two extractions.

Tab. 18 Protein yield (% protein in seeds / protein in soymilk obtained) as average of two extractions

	Protein yield
Atlantic	35,1%
Cresir	37,1%
PR91M10	39,9%
Regir	42,7%

4.1.1.2 Fat content

The following table reports average values of fat amount.
Analysis was performed in two repetitions per extraction.

Tab. 19 Fat content (dry basis %) in soymilk samples

CULTIVAR	Average value (% dry basis)	Standard deviation
Atlantic	16,9	3,1
Cresir	10,9	1,8
PR91M10	15,2	3,7
Regir	18,9	2,9

Fig. 14 reports statistic analysis (ANOVA*) on fat content data. There are no significant differences among samples.

**Data were subjected to Anova statistical analysis (Duncan test) and the results were expressed as "letters of significance". When samples are marked with, at least, one letter in common, they cannot be considered statistically different based on the selected confidence level (95% in our case).*

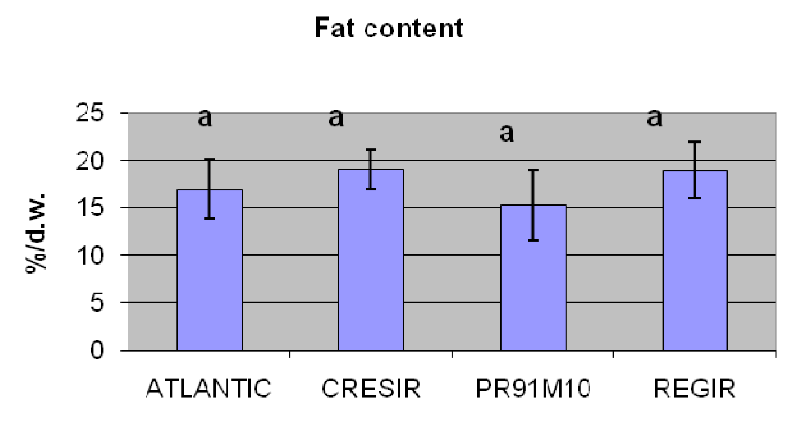


Fig. 14 Fat content (dry basis %±s.d.) in soymilk samples (confidence level=95%)

Fat yield was calculated as percentage ratio: fat in seeds / fat in soymilk obtained. The following table reports these values (average of two extractions).

Tab. 20 Fat yield (% fat in seeds / fat in soymilk obtained) as average of two extractions.

	Fat yield
Atlantic	36,7%
Cresir	38,7%
PR91M10	34,6%
Regir	31,3%

4.1.2 Micronutrient preservation: total concentration of isoflavones

The following table reports average values of total isoflavones.
Analysis was performed in two repetitions per extraction.

Tab. 21 Total isoflavones content (mg/100 g d.w.) in soymilk samples

CULTIVAR	Average value (mg/ 100 g dry mass)	Standard deviation
Atlantic	411,9	39,8
Cresir	470,1	27,3
PR91M10	335,8	38,7
Regir	407,2	44,9

Fig. 15 reports statistic analysis (ANOVA*) on total isoflavones data. Soymilk obtained from PR91M10 seeds shows the lowest total isoflavones content.

**Data were subjected to ANOVA statistical analysis (Duncan test) and the results were expressed as "letters of significance". When samples are marked with, at least, one letter in common, they cannot be considered statistically different based on the selected confidence level (95% in our case).*

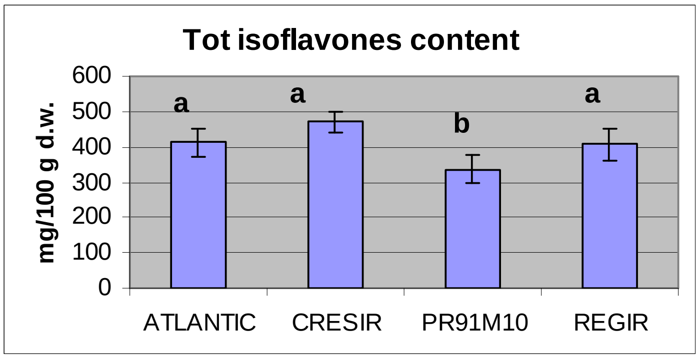


Fig. 15 Total isoflavones content (mg/100 g dry mass ±s.d) in soymilk samples (confidence level=95%)

Total isoflavones yield was calculated as percentage ratio: total isoflavones in soymilk obtained / total isoflavones in seeds. The following table reports these values as average of two extractions.

Tab. 22 Total isoflavones yield (% total isoflavones in seeds / total isoflavones in soymilk obtained) as average of two extractions.

	Total isoflavones yield
Atlantic	0,4%
Cresir	0,2%
PR91M10	0,6%
Regir	0,3%

4.1.3 Food acceptability: sensory analysis

Different soymilk formulations with different amounts of salt, sugar and vanilla sugar were analyzed. Soymilk was extracted running out the recipes described above. The seeds used were food grade and were purchased on the market (Fertitecnica Colfiorito).

Formulation 1	In 1 soymilk litre: salt 1.5 g (~½teaspoon) + 5 g sugar (~2 teaspoon)
Formulation 2	In 1 soymilk litre: salt 1.5 g (~½teaspoon) + 2.5 g sugar (~1 teaspoon)
Formulation 3	In 1 soymilk litre: salt 1.5 g (~½teaspoon) + 2 g vanilla sugar (~1 teaspoon)

Thirteen panellists (staff and students of the university) were prepared to judge the soymilk: the pleasantness (Fig. 16) and 10 different attributes of appearance, flavour and taste (Fig. 17) were evaluated.

Results were expressed as percentage comparing it against a market soymilk sample (Valsoia).

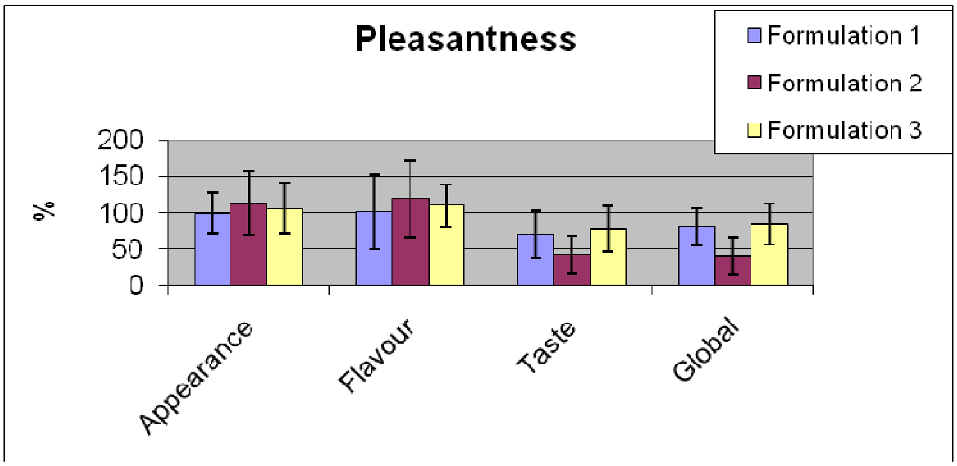


Fig. 16 Pleasantness of the 3 different soymilk formulations (% respect to market sample±s.d)

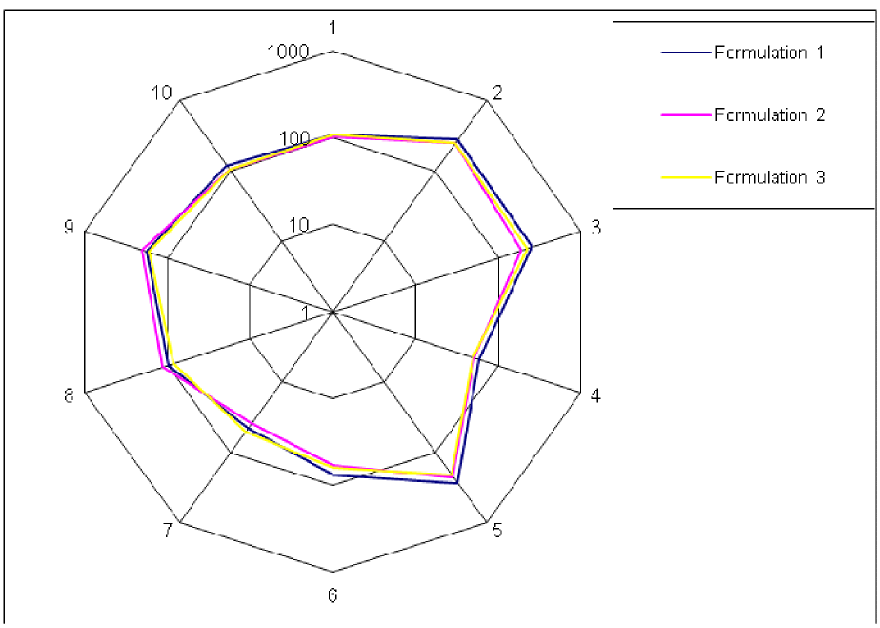


Fig. 17 Attributes of the 3 different soymilk formulations (% respect to market sample – logarithmic scale)

1: Yellow colour intensity
2: Raw bean flavour
3: Cooked bean flavour
4: Vanilla flavour
5: Bean taste
6: Sweetness
7: Vanilla taste
8: Chalkiness
9: Astringency
10: Taste persistence

"Formulation 3" was selected as the best one and was used to produce the soymilk from different cultivars and then the different soymilks obtained were evaluated. Results were expressed as percentage as compared to the soymilk obtained with the same ingredients ("Formulation 3") from seeds food grade.

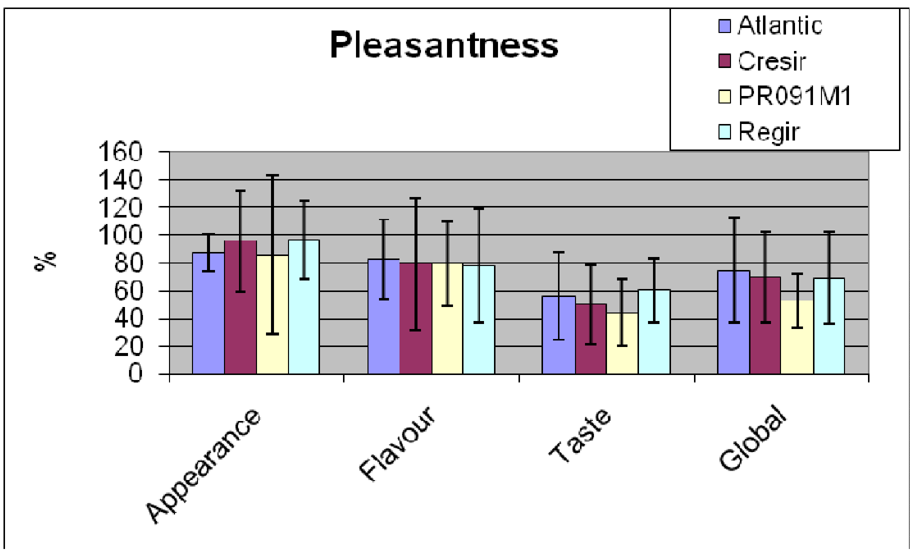


Fig. 18 Pleasantness of soymilk obtained from 4 cultivars (% respect to sample obtained from "for food" seeds±s.d)

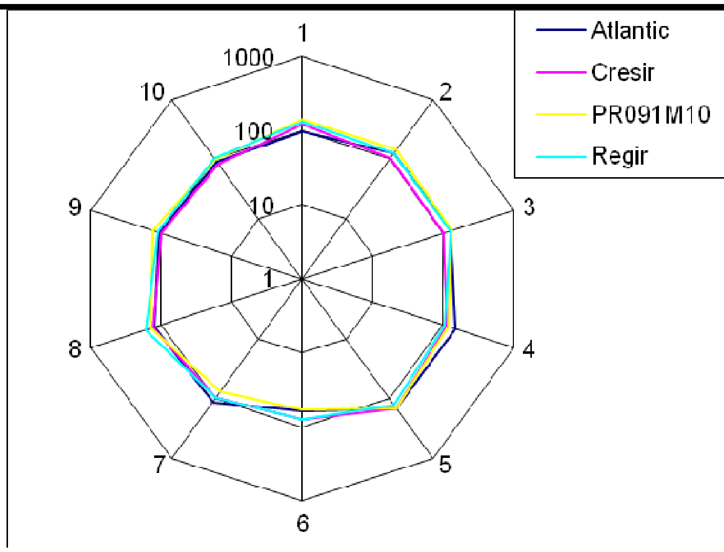


Fig. 19 Attributes of soymilk obtained from 4 cultivars (% respect to sample obtained from "for food" seeds - logarithmic scale)

1: Yellow colour intensity
2: Raw bean flavour
3: Cooked bean flavour
4: Vanilla flavour
5: Bean taste
6: Sweetness
7: Vanilla taste
8: Chalkiness
9: Astringency
10: Taste persistence

The pleasantness is, as an average, lower than the reference one: this maybe due to a possible "psychological effect" because the panellists did not swallow soymilk samples obtained from seeds Atlantic, Cresir, PR91M10, Regir (these seeds are not food grade).

4.1.4 Risk to human: evaluation of phytic acid content

The following table reports average values of phytic acid content.
Analysis was performed per extraction, with four repetitions.

Tab. 23 Phytic acid content (% dry basis) in soymilk samples

CULTIVAR	Average value (% dry basis)	Standard deviation
Atlantic	1,5	0,2
Cresir	1,2	0,4
PR91M10	1,3	0,3
Regir	0,9	0,2

The following table reports statistic analysis (ANOVA*) on phytic acid data. Soymilk from Atlantic seeds shows the highest phytic acid content, soymilk from Regir seeds the lowest one.

**Data were subjected to Anova statistical analysis (Duncan test) and the results were expressed as "letters of significance". When samples are marked with, at least, one letter in common, they cannot be considered statistically different based on the selected confidence level (95% in our case).*

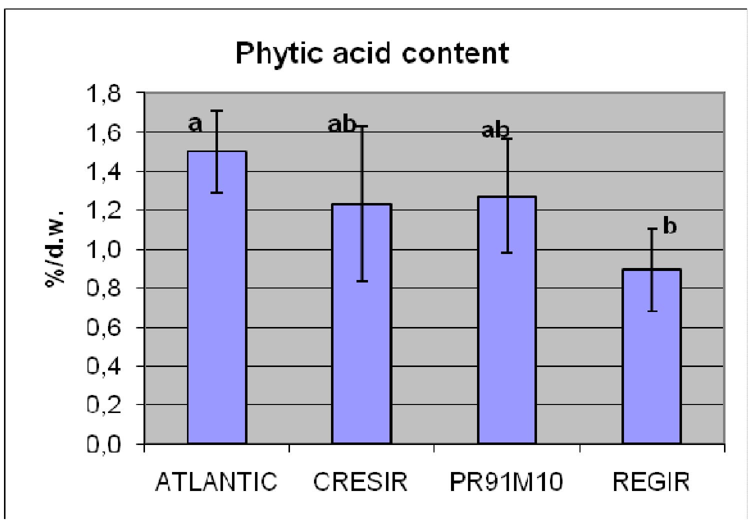


Fig. 20 Phytic acid content (% dry basis ±s.d) in soymilk samples (confidence level=95%)

Phytic acid yield was calculated as percentage ratio: phtyic acid in soymilk obtained / phytic acid in seeds. The following table reports these values as average of the two extractions.

Tab. 24 Phytic acid yield (% phytic acid in seeds / phytic acid in soymilk obtained) as average of two extractions

	Phytic acid yield
Atlantic	38,3%
Cresir	42,6%
PR91M10	38,4%
Regir	40,0%

4.1.5 Water and energy consumption

As an average, 550 ml soymilk is obtained from 1L water and 100 g soy seeds.
Water consumption, therefore is 1800 ml / 1 l soymilk.

To approximate the theoretical energy consumption, properties of soymilk (and intermediate processing) will be considered equal to that of water.
To obtain 1 L soymilk, the first is step water boiling (1800 mL).
Water must be heated at 100°C from room temperature (~25°C): the amount of energy required is:

$Q = a * h * \Delta T$

where a = water amount = 1800 g
h= specific heat of water = 4,2 J/g °C
ΔT = temperature variation = 100-25= 75 °C

Q1= (1800 g) * (4,2 J/g °C) * (75 °C) = 565,1 KJ

During the heating time of 30 min (extraction step) + 15 min (soymilk sanitization step) the evaporation of 800 mL water takes place.
The energy required for this step is:

$Q = a * h_v$

where a = water amount = 800 g
h_v = heat of vaporization = 2261 J/g

Q2= (800 g) * (2261 J/g) = 1808,8 KJ

Total energy consumption is:

Q= Q1+Q2= 565,1 + 1808,8 = 2373,9 KJ

4.2 Okara test results

Pulp residue from filtration during soymilk extraction from soybeans market samples of the 4 cultivars used for bench test 2 has been analyzed.

4.2.1 Macronutrient preservation

4.2.1.1 Protein content

The following table presents the value of the protein content for each cultivar.
Analysis was performed per extraction, with two repetitions.

Tab. 25 Protein content (dry basis %) in okara samples

CULTIVAR	Average value (% dry basis)	Standard deviation
Atlantic	34,4	0,6
Cresir	43,3	0,8
PR91M10	33,6	3,2
Regir	32,9	0,9

Fig. 21 reports statistic analysis (ANOVA*) on protein data.
Okara obtained from Atlantic seeds shows the lowest protein content. There are not significant differences among soymilks obtained from other soybean cultivars. This is the same trend observed in soymilk samples.

**Data were subjected to ANOVA statistical analysis (Duncan test) and the results were expressed as "letters of significance". When samples are marked with, at least, one letter in common, they cannot be considered statistically different based on the selected confidence level (95% in our case).*

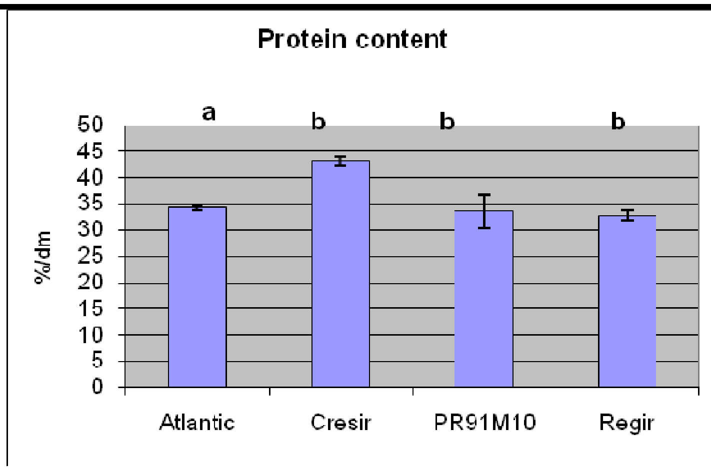


Fig. 21 Protein content (dry weight %±s.d.) in okara samples (confidence level=95%)

Protein yield has been calculated as percentage ratio: protein in okara residue / protein in seeds Tab. 26 reports these values as average of two extractions.

Tab. 26 Protein yield (% protein in seeds / protein in okara residue) as average of two extractions

	Protein yield
Atlantic	64,4%
Cresir	51,2%
PR91M10	63,6%
Regir	54,5%

The sum of the protein yield from soymilk and okara should be closed to 100% if there is no loss during the processing. However, when doing the operation one reaches a very low protein conservation (88,3%) for the Cresir test results. This phenomenon could be caused by a different composition and a different heat sensitivity in the protein fraction.

4.2.1.2 Fat content

The following table reports average fat contents according to the cultivar.
Analysis was performed per extraction, with two repetitions.

Tab. 27 Fat content (dry basis %) in okara samples

CULTIVAR	Average value (% dry basis)	Standard deviation

Atlantic	12,0	0,8
Cresir	9,4	0,7
PR91M10	9,4	1,2
Regir	12,6	0,4

Fig. 22 reports statistic analysis (ANOVA*) on fat data. Okara obtained from Atlantic and Regir seed show the highest fat content, soymilks obtained from Cresir and PR91M10 seed show the lowest fat content.

**Data were subjected to ANOVA statistical analysis (Duncan test) and the results were expressed as "letters of significance". When samples are marked with, at least, one letter in common, they cannot be considered statistically different based on the selected confidence level (95% in our case).*

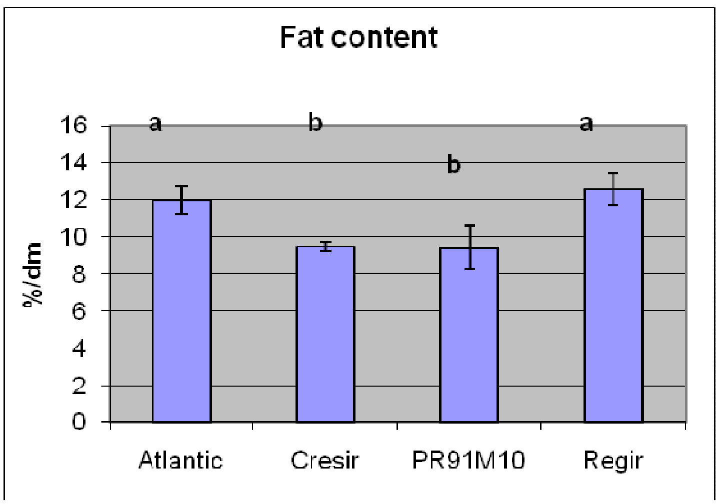


Fig. 22 Fat content (dry basis %±s.d.) in okara samples (confidence level=95%)

Fat yield was calculated as percentage ratio: fat in seeds / fat in okara residue. Tab. 28 reports these values as average of two extractions.

Tab. 28 Fat yield (%fat in okara residue / fat in seeds) - average of two extractions.

	Fat yield
Atlantic	40,6%
Cresir	20,9%
PR91M10	37,6%
Regir	29,1%

4.2.2 Micronutrient preservation: concentration of total isoflavones

The following table presents the average isoflavones content of Okara according to the cultivar. Analysis has been performed per extraction with two repetitions.

Tab. 29 Total isoflavones content (mg/100 g d.w.) in okara samples

CULTIVAR	Average value (mg/ 100 g dry mass)	Standard deviation
Atlantic	92,1	3,8
Cresir	156,8	2,0
PR91M10	79,7	4,7
Regir	99,3	5,1

The table here above reports statistic analysis (ANOVA*) on total isoflavones data. As for milk, as for okara the product obtained from PR01M10 seeds shows the lowest total isoflavones content. Okara obtained from Cresir seeds shows the highest total isoflavones amount.

**Data were subjected to ANOVA statistical analysis (Duncan test) and the results were expressed as "letters of significance". When samples are marked with, at least, one letter in common, they cannot be considered statistically different based on the selected confidence level (95% in our case).*

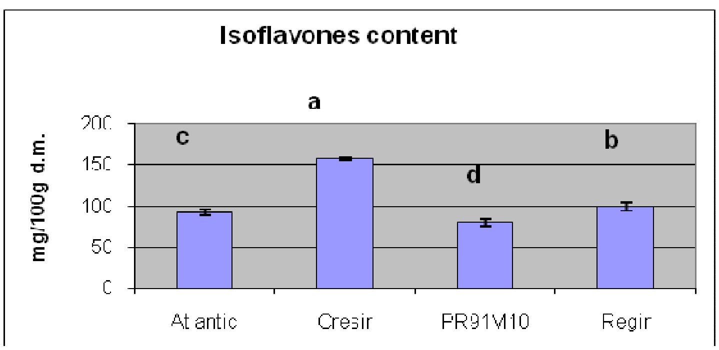


Fig. 23 Total isoflavones content (mg/100 g d.w.) in okara samples (confidence level=95%)

Total isoflavones yield was calculated as percentage ratio: total isoflavones in okara residue/ total isoflavones in seeds. The following table reports the yield value as average of two extractions.

Tab. 30 Total isoflavones yield (% total isoflavones in seeds / total isoflavones in okara residue) as average of two extractions

	Total isoflavones yield
Atlantic	45,1%
Cresir	24,7%
PR91M10	51,9%
Regir	28,6%

The total isoflavone yield for Cresir and Regir are noticeably lower than for the other 2 cultivars. This phenomenon could be explained as follows. Total isoflavones include different forms (aglycones, glucosides, malonyl-glucisodi, acetyl-glucoside) with different heat sensitivity: their concentration in each cultivar can be different.

4.2.3 Risk to human: evaluation of the phytic acid content

The following table gathers the average values for the phytic acid content, according to the cultivar.
Analysis was performed per extraction with four tests.

Tab. 31 Phytic acid content (% dry basis) in okara samples

CULTIVAR	Average value (% dry basis)	Standard deviation
Atlantic	1,3	0,2
Cresir	1,4	0,1
PR91M10	1,0	0,1
Regir	1,0	0,1

The above figure reports statistic analysis (ANOVA*) on phytic acid data: products from Atlantic and Cresir seeds show the lowest phytic acid contents.

**Data were subjected to ANOVA statistical analysis (Duncan test) and the results were expressed as "letters of significance". When samples are marked with, at least, one letter in common, they cannot be considered statistically different based on the selected confidence level (95% in our case).*

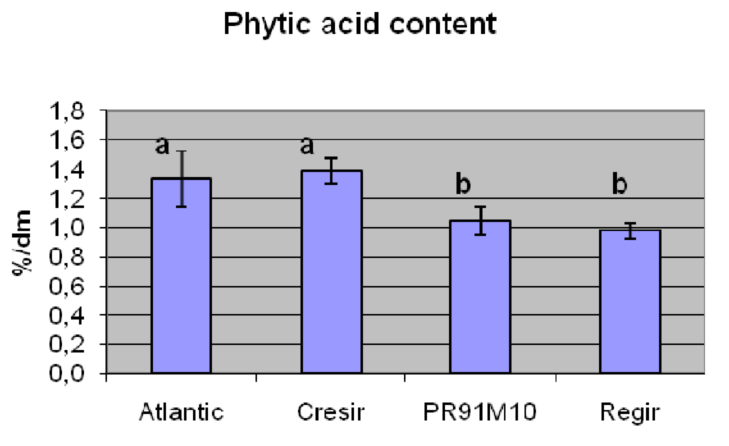


Fig. 24 Phytic acid content (% dry basis±s.d.) in okara samples (confidence level=95%)

Phytic acid yield was calculated as percentage ratio: phtyic acid in okara residue / phytic acid in seeds. The following table presents these values (average of two extractions).

Tab. 32 Phytic acid yield (% phytic acid in seeds / phytic acid in okara residue) as average of two extractions

	Phytic acid yield
Atlantic	56,7%
Cresir	51,5%
PR91M10	58,4%
Regir	56,1%

The following table summarizes macro, micro and anti-nutrients distribution between okara and soymilk during soy seeds transformation process. Yield data (as average of four cultivar analyzed) are compared.

Tab. 33 Soymilk/okara nutrients distribution (as average of the four analyzed cultivars)

	Recovery in soymilk	Recovery in okara
Protein	38,7%	58,4%
Fat	32,1%	35,3%
Total isoflavones	0,4%	37,6%
Phytic acid	55,7%	39,8%

During soymilk extraction, the highest percentage of proteins residues is in the pulp.
Fat is shared between soymilk and residue pulp; fat in okara is lightly higher.

Isoflavones are thermo sensitive molecules and they are destroyed during soy seeds processes (paste boiling step and soymilk sanitization). Nevertheless, total isoflavones yield is higher in okara than in soymilk: okara undergoes only one thermal treatment (while soymilk undergoes two thermal treatments) and isoflavones are not completely hydrophilic molecules (extraction for analysis was carried out with MetOH/H_2O 70/30).
During soymilk extraction, the highest percentage of phytic acid goes in juice.

4.2.4 Water and energy consumption

Okara is the "by-product" of soy juice extraction, so there is no additional water and energy consumption.

Freeze-drying is a possible way to increase okara preservation time, but it requires a great amount of energy.
Okara dry content is, as an average, 80%; so 1Kg of product contains 200 ml of water.

First step in freeze-drying process is water freezing.
Water must be cooled from room temperature (~25°C): the amount of energy required is:

$Q= (a * h * \Delta T)$

where a = water amount = 200 g
h= specific heat of water = 4,2 J/g °C
ΔT = temperature variation = 25 °C

Q1= (200 g) * (4,2 J/g °C) * (25 °C) = 20,9 KJ

The energy required for water freezing is:

$Q= a * h_f$

where a = water amount = 200 g
h_f = water heat of freezing = 333,7 J/g

Q2= (200 g) * (333,7 J/g) = 66,7 KJ

Sublimation takes place at -30°C, so there is a second step of ice cooling. The amount of energy required is:

$Q= a * h * \Delta T$

where a = ice amount = 200 g
h= specific heat of ice = 2,1 J/g °C
ΔT = temperature variation = 30 °C

Q3= (200 g) * (2,1 J/g °C) * (30 °C) = 12,5 KJ

The amount of energy required for ice sublimation is:
$Q = a * h_s$

where a = water amount = 200 g
h_s = ice heat of sublimation = 2833 J/g

Q4= (200 g) * (2833 J/g) = 566,6 KJ

Water vapour from okara is caught on condensers where water freezes. Total amount of energy required for this process is:

$Q = (a * h * \Delta T) + (a * h_f)$

where a = water vapour removed from okara = 200 g
h= specific heat of water vapour = 1,9 J/g °C
ΔT = temperature variation = 30 °C
h_f = water heat of freezing = 333,7 J/g

Q5= [(200 g) * (1,9 J/g °C) * (30 °C)] + [(200 g) * (333,7 J/g)] = 78,1 KJ

Total energy consumption is:

Q= Q1+Q2+Q3+Q4+Q5= 20,9 + 66,7 + 12,5 + 566,6 + 78,1 = 774.8 KJ

Comment from ESTEC: In all the quantitative results provided, no error (due to technique precision) is mentioned and this is felt to be missing. Indeed, error on the analytical result could support a better evaluation of the results: significance of the difference between cultivars composition. In addition, it could explain the apparent loss of certain element after processing. Please clarify the data obtained and conclude on the significance of the cultivars differences.
Requested clarification: The Standard deviation was given in the tables and reported in the figures, moreover the statistical analysis to evaluate the significance of cultivar differences was performed.
In term of protein content, soymilk from Cresir seeds is statistically different from other samples (it is the best one), okara from Atlantic seeds is statistically different from other samples (it is the worst one). In term of fat content, there are not important differences:

soymilk samples are not statistically different, okara from Atlantic and Regir are statistically equal as well as okara from Cresir and PR91M10.
In term of phytic acid, Atlantic products show the highest values (but in okara there are not significant difference with Cresir) and Regir products show the lowest values ((but in okara there are not significant difference with PR91M10).
In term of total isoflavones, all okara samples are different but only soymilk from Cresir seeds is statistically lowest.

4.3 Soy sprouts literature references

Germination is an economical and effective technology which involves physiological changes, synthesis and breakdown of macromolecules, improving the digestibility and nutritive value of legumes.
Seed is an embryonic, dehydrated plant and it contains all reserve nutrients. In presence of water, seed adsorbs water (imbibitions) and swells: subsequently, there are demolition of reserve nutrient, increasing of protein synthesis and increasing of respiration.

4.3.1 Macronutrient preservation: concentration of protein

Donangelo et al. (1995) report, in *Glicine max* after 48 germination (in the darkness at 28°C), a small increase in crude protein, from 41,1 % dry basis to 45,6 % dry basis.
Germination process causes, in soybean seeds, hydrolysis of proteins and increase of free amino-acid.
Martínez-Villaluenga et al. (2006), germinated seeds of *Glicine max* (var. *merit* and var. *jutro)* at 20°C in darkness: they report a significant increment of total free protein amino acid content up to seven-fold in. var. *merit* and three-fold in var. *jutr*o, mainly at later stages of germination (see Table 17)

Tab. 34 Total free proteic amminoacid in raw and germinated soybean (mg/g dry basis ± standard deviation)- Martínez-Villaluenga et al. (2006)

	Cv. *merit*	Cv. *Jutro*
Raw	2,8±0,1	1,6±0,1
2 day germination	5,0±0,4	3,3±0,1
3 day germination	4,8±0,4	3,6±0,2
4 day germination	6,4±0,5	4,9±0,2
5 day germination	10,9±0,6	
6 day germination	19,0±1,3	

4.3.2 Macronutrient preservation: concentration of fat

Soybean seeds germination process lead to a slight decrease in the oil content: it could be probably ascribed to consumption of oil as energy and/or synthesis of certain structural constituent in the young seedling (Singh et al., 1968).
Mostafa et al., (1987) germinated *Glicine max* (var. *Calland*) in darkness at room temperature (23-25°C): in 6 days, oil content decreases from 20.67% dry basis to 19.08% dry basis. As germination progressed, changes in fatty acid distribution occurred: palmitic acid increases while linoleic and linolenic acid decrease fatty acids do not show a linear trend (see Tab. 35)

Tab. 35 Free fatty acid composition (%) of soybean oil during germination of seeds- Mostafa et al. (1987)

Germination day	0 (Raw)	1	2	3	4	5	6
Palmitic acid	10,8	12,8	13,0	14,6	15,2	17,8	20,2
Stearic acid	2,7	2,2	2,4	2,1	2,2	1,9	2,8
Oleic acid	18,0	15,2	16,0	14,2	13,9	14,5	18,1
Linoleic acid	63,6	64,4	63,1	63,4	64,4	60,2	55,0
Linolenic acid	5,0	5,4	5,6	5,8	4,3	5,7	3,9

4.3.3 Micronutrient preservation: concentration of total isoflavones

Total isoflavones content increases rapidly during the early stage of germination.
Lin & Lai (2006) evaluated isoflavones profile in soybeans sprout (cultivar *KS1*, *KS2*, *KS8*) obtained by germination in complete darkness, at 25°C for 1 day and for 4 days: results are reported in Tab. 36

Tab. 36 Total isoflavones (µg/g of dry mass ± standard deviation) in raw and germinated soybeans - Lin & Lai (2006)

	Raw soybeans	1 day germination	4 day germination
KS1	4333,5±25,3	5572,7±58,7	415,8±7,6
KS2	3712,9±82,0	5159,14±297,4	861,1±44,7
KS8	1952,8±15,6	1710,277±42,3	372,3±26,7

In a similar study, Zhu et al (2005) evaluated isoflavone profile in soybeans sprout at different germination steps (lengths of hypocotyls from seed coat): they worked on varieties *Hutcheson* and *Caviness* and germination was performed at 40°C and they obtained similar results (see following table.)

Tab. 37 Total isoflavones contents in soybean during various stages of germination (mg/g ground seed, dry basis) - Zhu et al., 2005

	Hutcheson	*Caviness*
Raw	2,0	2,2
Germinated (hypocotyls 0.5 mm)	2,5	2,7
Germinated (hypocotyls 0.5 mm)	2,4	2,8
Germinated (hypocotyls 0.5 mm)	2,3	2,5

4.3.4 Risk to human: evaluation of phytic acid content

A number of experts have observed a reduction in phytic acid during germination of different legume seeds apparently as a result of a large increase in phytase activity.
Trugo et al. (1999) germinated seeds of *Glicine max* (cv. *BR16)* at 30°C in darkness: they report a decrease in total inositol phosphate content from 478 mg/100g dry mass to 485 mg/100g dry mass in 1 day germination, to 482 mg/100g dry mass in 2 day germination.
Bau et al. (1997) also observed a decrease of 17% in soya bean phytic acid content after five days of germination.

4.3.5 LITERATURE REFERENCES

Bau H.M., Villaume C., Nicolas J.P. & Mejean L. (1997). Effect of germination on chemical composition, biochemical constituents and antinutritional factors of soya bean (*Glycine max*) seeds. J. Sci. Food Agric., 74, 1-9.

Donangelo C.M., Trugo L.C., Trugoa N.M.F. & Eggum B.O. (1995) Effect of germination of legume seeds on chemical composition and on protein and energy utilization in rats. Food Chemistry, 53, 23-27

Lin P.Y. & Lai H.M. (2006) Bioactive Compounds in Legumes and Their Germinated Products J. Agric. Food Chem., 54, 3807-3814

Martínez-Villaluenga C., Kuo Y.H., Lambein F., Frías J. & Vidal-Valverde C. (2006) Kinetics of free protein amino acids, free non-protein amino acids and trigonelline in soybean (*Glycine max L.*) and lupin (*Lupinus angustifolius L.*) sprouts. Eur Food Res Technol, 224, 177–186

Mostafa M.M., Rahma E.H. & Rady A.H. (1987) Chemical and nutritional changes in soybean during germination. Food Chemistry, 23, 257-275

Singh B.B., Hadely H.H. & Collins R.I. (1968) Distribution of fatty acids in germinating soybean seeds. Crop Science, 8, 171-173

Trugo L.C., Muzquiz M., Pedrosa M.M., Ayet G., Burbano C., Cuadrado C. & Cavieres E. (1999) Influence of malting on selected components of soya bean, black bean, chickpea and barley. Food Chemistry, 65, 85-90

Zhu D., Hettiarachchy N.S., Horax R. & Chen P. (2005) Isoflavone Contents in Germinated Soybean Seeds. Plant Foods for Human Nutrition, 60, 147–151

The process for soymilk and okara production is very effective because of absence of waste and high recovery of macronutrients. The simultaneous production of both products allows the complete utilization of fat and protein present in the soy seeds.

On the other hand thermal processes cause energy consumption and they determine a marked decrease of isoflavones concentration..

Soymilk is increasingly used and accepted by European consumers; it can be diary drunk for breakfast and it has not laxation effect. Okara is an ingredient for several recipes and it can be contribute to an appropriate menu cycle rotation.

The production of soya sprouts is a very simple and economical technology. Respect to the seeds part of macronutrient is lost and this can be considered a weakness. On the other hand germination causes a reduction in phytic acid and an increase in total isoflavones content.

Sprouts can be can be eaten in salads of various kinds so they have not laxation effect

5 Annexes

5.1 Potato – Analysis Report N°22210

Commercial dehydrated potato flakes were used as a reference sample to be analysed by different laboratory for comparison sake. The present document reports analysis results.

Sample name	lot number	conservation limit	IPL code
Maggi Mousline classic	932703470A	feb 2011	10-442

Sample was analysed twice, starting respectively on June 9th and June 25th, 2010. Each analysis was run in duplicate. Sodium values are given for completion sake since sodium analysis has given several aberrant values in the past and contamination source has not been identified yet.

5.1.1 Analysis Methods

- **Dry weight**: 100°C oven until constant weight (assays 1 &2); 50°C, <50 mbar oven until constant weight (assays 3&4).
- **Protein content**: Kjeldahl method; N x 6.25
- **Fat content**: Weibuhl method; acid digestion followed by Soxhlet extraction with petroleum benzine 40-60
- **Total Dietary Fibre content**: AOAC 985.29, Enzymatic-Gravimetric Method.
- **Minerals content**: 24h, 550°C furnace
- **Sodium, potassium content**: Flame photometry of solution of the minerals.
- **Ca, Mg, Fe, Zn, Cu, Mn content**: Atomic absorption of solution of the minerals.
- **Phosphorus content**: Colorimetry of the phosphomolybdate complex on an aliquot taken from Kjeldahl mineralisation.
- **Available carbohydrates**: By difference between total of sample and sum of other ingredients
- **Energy content**: calculation : 4 kcal for proteins and carbohydrates, 9 kcal for fat, 2 kcal for TDF. Value is multiplied by 4.184 for kJ.

5.1.2 Results

Maggi Mousline, June 9th	IPL Code					10-442
	Assay				SD	Average
	1	2	3	4		
Water (%)	**8,0**	**8,0**	**4,5**	**4,3**	**2,1**	**6,2**

Protein (%)		**7,32**	**7,30**			**0,014**	**7,31**
Fat (%)		**0,31**	**0,31**			**0,003**	**0,31**
Available carbohydrates (%)							**75,91**
TDF (%)							**6,59**
Minerals (%)		**2,84**	**2,87**			**0,022**	**2,86**
Of which (mg/100g)	Sodium	**179,5**	**165,0**			**10,2**	**172,3**
	Potassium	**1355**	**1325**			**21,4**	**1340**
	Calcium	**37,8**	**41,3**			**2,48**	**39,5**
	Magnesium	**73,3**	**73,0**			**0,19**	**73,1**
	Iron	**2,34**	**2,49**			**0,11**	**2,4**
	Copper	**0,74**	**0,74**			**0,00**	**0,7**
	Zinc	**1,23**	**1,88**			**0,46**	**1,6**
	Manganese	**0,43**	**0,46**			**0,020**	**0,44**
	Phosphorus	**175,4**	**175,3**			**0,1**	**175**
Energy (for 100g)	kcal						**348,9**
	kJ						**1459,7**

Maggi Mousline, June 25th IPL Code 10-442

		Assay 1	Assay 2	Assay 3	Assay 4	SD	Average
Water (%)		**7,9**	**7,8**	**8,3**	**8,2**	**0,2**	**8,0**
Protein (%)		**7,64**	**7,51**			**0,095**	**7,57**
Fat (%)		**0,37**	**0,49**			**0,086**	**0,43**
Available carbohydrates (%)							**73,83**
TDF (%)							**7,30**
Minerals (%)		**2,83**	**2,81**			**0,011**	**2,82**
Of which (mg/100g)	Sodium	**176,4**	**161,6**			**10,5**	**169,0**
	Potassium	**1219**	**1199**			**13,9**	**1209**
	Calcium	**34,5**	**36,9**			**1,70**	**35,7**
	Magnesium	**69,9**	**71,5**			**1,12**	**70,7**
	Iron	**1,99**	**1,85**			**0,10**	**1,9**
	Copper	**0,81**	**0,92**			**0,08**	**0,9**
	Zinc	**1,20**	**1,09**			**0,08**	**1,1**
	Manganese	**0,42**	**0,45**			**0,021**	**0,43**
	Phosphorus	**174,8**	**170,5**			**3,0**	**173**
Energy (for 100g)	kcal						**344,1**
	kJ						**1439,7**

Maggi Mouseline,		**Comparison of results**		
		June 9th	**June 25th**	**Commercial information**
Water (%)		6,2	8,0	
Protein (%)		7,31	7,57	8,5
Fat (%)		0,31	0,43	1,0
Available carbohydrates (%)		75,91	73,83	73,2
TDF (%)		6,59	7,30	6,8
Minerals (%)		2,86	2,82	
Of which (mg/100g)	Sodium	172,3	169,0	112
	Potassium	1340	1209	
	Calcium	39,5	35,7	
	Magnesium	73,1	70,7	
	Iron	2,4	1,9	
	Copper	0,7	0,9	
	Zinc	1,6	1,1	
	Manganese	0,44	0,43	
	Phosphorus	175	173	
Energy (for 100g)	kcal	348,9	344,1	
	kJ	1459,7	1439,7	

5.2 Potato – Analysis Report N°22211

Potato samples from BT2 were collected on June 2nd, 2010 during visits at UCL and UGent. Samples (Bintje, Annabelle and Innovator growth at UCL and UGent in hydroponic conditions) are homogenized with a rotary blade grinder within 24 hour of reception. Homogenates are sealed under vacuum and kept at -18°C until analysis except for alkaloid analysis which is started immediately. The present document reports analysis results.

Plant identification	Growing location	Description	Process. sample mass (g)	Mean process. tuber mass (g)	IPL Code
Annabelle	UGent	BT2	376,8	14	10-443
Bintje	UGent	BT2	392,4	20,6	10-444
Innovator	UGent	BT2	272,6	34,1	10-445
Annabelle	UCL	BT2	280,4	23,4	10-446
Bintje	UCL	BT2	204,2	15,7	10-447

5.2.1 *Analysis Methods – see analysis report N°22210*

5.2.2 *Results*

Annabelle, UGent, BT2		IPL Code					10-443
		Assay				**SD**	**mean**
		1	**2**	**3**	**4**		
Water (%)		**76,5**	**77,8**	**79,5**	**79,0**	**1,3**	**78,2**
Protein (%)		**1,66**	**1,57**			**0,061**	**1,62**
Fat (%)		**0,06**					**0,06**
Available carbohydrates (%)							**14,23**
TDF (%)							**1,53**
Minerals (%)		**1,13**	**1,19**			**0,046**	**1,16**
Of which (mg/100g)	Potassium	**486**	**523**			**26,3**	**504**
	Calcium	**5,4**	**5,6**			**0,14**	**5,5**
	Magnesium	**28,1**	**30,6**			**1,72**	**29,4**
	Iron	**0,70**	**0,76**			**0,04**	**0,7**
	Copper	**1,11**	**1,12**			**0,01**	**1,1**
	Zinc	**1,10**	**1,17**			**0,05**	**1,1**
	Manganese	**0,17**	**0,18**			**0,010**	**0,18**
	Phosphorus	**111,9**	**104,7**			**5,1**	**108**
Solanine (mg/kg)		<LOD	<LOD	<LOD	<LOD		**0**
Chaconine (mg/kg)		<LOD	<LOD	<LOD	<LOD		**0**
Energy (for 100g)	kcal						**67,0**
	kJ						**280,1**

Bintje, UGent, BT2		IPL Code					10-444
		Assay				**SD**	**mean**
		1	**2**	**3**	**4**		
Water (%)		**80,8**	**82,0**	**81,4**	**80,2**	**0,8**	**81,1**
Protein (%)		**1,20**	**1,21**			**0,013**	**1,20**
Fat (%)		**0,05**	**0,04**			**0,005**	**0,04**
Available carbohydrates (%)							**14,40**
TDF (%)							**1,80**
Minerals (%)		**1,19**	**1,16**			**0,019**	**1,18**
Of which (mg/100g)	Potassium	**533**	**481**			**36,8**	**507**

		1	2	3	4	SD	mean
	Calcium	**7,4**	**7,7**			**0,24**	**7,5**
	Magnesium	**22,2**	**22,3**			**0,09**	**22,2**
	Iron	**0,80**	**0,79**			**0,01**	**0,8**
	Copper	**0,59**	**0,50**			**0,07**	**0,5**
	Zinc	**0,90**	**0,96**			**0,04**	**0,9**
	Manganese	**0,11**	**0,11**			**0,000**	**0,11**
	Phosphorus	**86,0**	**88,4**			**1,7**	**87**
Solanine (mg/kg)		<LOD	<LOD	<LOD	<LOD		**0**
Chaconine (mg/kg)		<LOD	<LOD	<LOD	<LOD		**0**
Energy (for 100g)	kcal						**66,4**
	kJ						**277,8**

Innovator, UGent, BT2 IPL Code 10-445

		Assay				SD	mean
		1	**2**	**3**	**4**		
Water (%)		**73,0**	**78,1**	**81,0**	**79,4**	**3,4**	**77,9**
Protein (%)		**1,37**	**1,42**			**0,034**	**1,39**
Fat (%)		**0,05**	**0,04**			**0,002**	**0,04**
Available carbohydrates (%)							**14,15**
TDF (%)							**1,79**
Minerals (%)		**1,09**	**1,07**			**0,013**	**1,08**
Of which (mg/100g)	Potassium	**469**	**412**			**40,3**	**440**
	Calcium	**8,5**	**8,9**			**0,29**	**8,7**
	Magnesium	**26,7**	**26,7**			**0,01**	**26,7**
	Iron	**0,64**	**0,55**			**0,07**	**0,6**
	Copper	**0,99**	**0,70**			**0,21**	**0,8**
	Zinc	**2,04**	**1,77**			**0,19**	**1,9**
	Manganese	**0,14**	**0,13**			**0,008**	**0,13**
	Phosphorus	**88,3**	**90,7**			**1,8**	**90**
Solanine (mg/kg)		<LOD	<LOD	<LOD	<LOD		**0**
Chaconine (mg/kg)		<LOD	<LOD	<LOD	<LOD		**0**
Energy (for 100g)	kcal						**66,1**
	kJ						**276,8**

Annabelle, UCL, BT2 IPL Code 10-446

		Assay 1	2	3	4	SD	mean
Water (%)		83,4	81,8	79,6	78,4	2,2	80,8
Protein (%)		1,40	1,37			0,018	1,39
Fat (%)		0,04	0,05			0,012	0,04
Available carbohydrates (%)							15,50
TDF (%)							1,47
Minerals (%)		0,88	0,89			0,009	0,88
Of which (mg/100g)	Potassium	365	365			0,2	365
	Calcium	6,3	6,0			0,22	6,2
	Magnesium	24,2	25,6			0,96	24,9
	Iron	0,58	0,54			0,03	0,6
	Copper	0,19	0,35			0,11	0,3
	Zinc	0,51	0,40			0,08	0,5
	Manganese	0,23	0,22			0,005	0,22
	Phosphorus	79,5	79,5			0,0	79
Solanine (mg/kg)		<LOD	<LOD	<LOD	<LOD		0
Chaconine (mg/kg)		<LOD	<LOD	<LOD	<LOD		0
Energy (for 100g)	kcal						62,4
	kJ						261,1

Bintje, UCL, BT2 IPL Code 10-447

		Assay 1	2	3	4	SD	mean
Water (%)		72,8	73,9	73,7	75,4	1,0	73,9
Protein (%)		2,17	2,15			0,016	2,16
Fat (%)		0,02	0,03			0,008	0,03
Available carbohydrates (%)							18,13
TDF (%)							1,95
Minerals (%)		1,26	1,27			0,005	1,27
Of which (mg/100g)	Potassium	498	491			5,0	495
	Calcium	14,1	11,0			2,18	12,5
	Magnesium	25,0	27,1			1,47	26,0
	Iron	0,75	0,70			0,03	0,7
	Copper	0,37	0,65			0,19	0,5
	Zinc	0,57	0,58			0,00	0,6
	Manganese	0,27	0,26			0,008	0,26

	Phosphorus	**109,2**	**110,6**			**1,0**	**110**
Solanine (mg/kg)		<LOD	<LOD	<LOD	<LOD		**0**
Chaconine (mg/kg)		<LOD	<LOD	<LOD	<LOD		**0**
Energy (for 100g)	kcal						**72,8**
	kJ						**304,5**

5.3 Potato analysis report N°22212

Potato samples from BT2 were collected on June 2nd, 2010 during visit at UCL (10-448) or brought to IPL by Muriel Quinet on June 18th (10-449) and by Benjamin Secco on June 24th (10-450). Samples (Désirée and Innovator growth at UCL and UGent in hydroponic conditions) are homogenized with a rotary blade grinder on June 25th. Homogenates are sealed under vacuum and kept at -18°C until analysis except for alkaloid analysis which is started immediately. The present document reports analysis results.

Plant identification	Growing location	Description	Process. sample mass (g)	Mean process. tuber mass (g)	IPL Code
Innovator	UCL	BT2	312,4	104,1	10-448
Désirée	UCL	BT2	146,9	16,3	10-449
Désirée	UGent	BT2	304,8	9,0	10-450

Average tuber mass of 10-448 doesn't reflect the highly ramified form of the tubers.

5.3.1 Analysis Methods

- **Dry weight**: 100°C oven until constant weight (assays 1 &2); 50°C, <50 mbar oven until constant weight (assays 3&4).
- **Protein content**: Kjeldahl method; N x 6.25
- **Fat content**: Weibuhl method; acid digestion followed by Soxhlet extraction with petroleum benzine 40-60
- **Total Dietary Fibre content**: AOAC 985.29, Enzymatic-Gravimetric Method.
- **Minerals content**: 24h, 550°C furnace
- **Sodium, potassium content**: Flame photometry of solution of the minerals.
- **Ca, Mg, Fe, Zn, Cu, Mn content**: Atomic absorption of solution of the minerals.
- **Phosphorus content**: Colorimetry of the phosphomolybdate complex on an aliquot taken from Kjeldahl mineralisation.
- **Available carbohydrates**: By difference between total of sample and sum of other ingredients
- **Energy content**: calculation : 4 kcal for proteins and carbohydrates, 9 kcal for fat, 2 kcal for TDF. Value is multiplied by 4.184 for kJ.

5.3.2 Results

Innovator, UCL, BT2 IPL Code 10-448

		Assay 1	2	3	4	SD	mean
Water (%)		**76,9**	**77,6**	**76,5**	**76,0**	**0,7**	**76,8**
Protein (%)		**2,01**	**1,90**			**0,079**	**1,95**
Fat (%)		**0,08**	**0,06**			**0,010**	**0,07**
Available carbohydrates (%)							**17,93**
TDF (%)							**2,20**
Minerals (%)		**1,05**	**1,09**			**0,025**	**1,07**
Of which (mg/100g)	Potassium	**431**	**463**			**22,4**	**447**
	Calcium	**7,3**	**8,6**			**0,93**	**7,9**
	Magnesium	**25,1**	**26,0**			**0,67**	**25,6**
	Iron	**0,46**	**0,75**			**0,20**	**0,6**
	Copper	**0,37**	**0,35**			**0,01**	**0,4**
	Zinc	**0,51**	**0,45**			**0,05**	**0,5**
	Manganese	**0,21**	**0,23**			**0,010**	**0,22**
	Phosphorus	**254,9**	**241,5**			**9,4**	**248**
Solanine (mg/kg)		<LOD	<LOD	<LOD	<LOD		**0**
Chaconine (mg/kg)		<LOD	<LOD	<LOD	<LOD		**0**
Energy (for 100g)	kcal						**84,6**
	kJ						**353,8**

Désirée, UCL, BT2 IPL Code 10-449

		Assay 1	2	3	4	SD	mean
Water (%)		**84,8**	**84,8**	**85,3**	**84,1**	**0,5**	**84,7**
Protein (%)		**1,51**	**1,43**			**0,059**	**1,47**
Fat (%)		**0,07**	**0,09**			**0,009**	**0,08**
Available carbohydrates (%)							**10,83**
TDF (%)							**1,82**
Minerals (%)		**1,06**	**1,08**			**0,017**	**1,07**
Of which (mg/100g)	Potassium	**471**	**468**			**2,5**	**470**
	Calcium	**4,3**	**5,4**			**0,81**	**4,9**
	Magnesium	**19,9**	**20,6**			**0,49**	**20,2**
	Iron	**0,46**	**0,49**			**0,02**	**0,5**
	Copper	**0,30**	**0,35**			**0,04**	**0,3**
	Zinc	**0,41**	**0,45**			**0,02**	**0,4**
	Manganese	**0,22**	**0,23**			**0,010**	**0,23**
	Phosphorus	**201,3**	**189,0**			**8,7**	**195**
Solanine (mg/kg)		<LOD	<LOD	<LOD	<LOD		**0**
Chaconine (mg/kg) ESTIMATE		<LOD	<LOD	<LOD	<LOD		**0**
Energy (for 100g)	kcal						**53,6**
	kJ						**224,1**

Désirée, Ugent, BT2						IPL Code 10-450	
		Assay				SD	mean
		1	2	3	4		
Water (%)		84,2	84,4	84,1	84,1	0,1	84,2
Protein (%)		1,63	1,53			0,071	1,58
Fat (%)		0,08	0,08			0,006	0,08
Available carbohydrates (%)							10,79
TDF (%)							2,20
Minerals (%)		1,16	1,11			0,040	1,13
Of which (mg/100g)	Potassium	479	475			2,9	477
	Calcium	6,4	8,4			1,42	7,4
	Magnesium	23,0	22,3			0,44	22,6
	Iron	0,33	0,39			0,04	0,4
	Copper	0,58	0,81			0,16	0,7
	Zinc	1,01	0,96			0,04	1,0
	Manganese	0,12	0,14			0,014	0,13
	Phosphorus	91,5	86,1			3,8	89
Solanine (mg/kg)		<LOD	<LOD	<LOD	<LOD		0
Chaconine (mg/kg) ESTIMATE		<LOD	<LOD	<LOD	<LOD		0
Energy (for 100g)	kcal						54,6
	kJ						228,4

5.4 Potato analysis N°22215-errata

Miscalculation leads to incorrect K values given in report 22115. Sorry for that. Corrected values given below.

5.4.1 Results

Désirée, UCL, low light						IPL Code 10-316	
		Assay				SD	Aver.
		1	2	3	4		
	Potassium	609	652			31	631

Désirée, UGent, suboptimal						IPL Code 10-324	
		Assay				SD	Aver.
		1	2	3	4		
	Potassium	664	665			1	665

Désirée, HZPC, rechts					IPL Code	10-331
	Assay				**SD**	**Aver.**
	1	**2**	**3**	**4**		
Potassium	**507**	**535**			**20**	**521**

Désirée, HZPC, field					IPL Code	10-333
	Assay				**SD**	**Aver.**
	1	**2**	**3**	**4**		
Potassium	**398**	**411**			**8.7**	**404**

Annabelle, HZPC, field					IPL Code	10-336
	Assay				**SD**	**Aver.**
	1	**2**	**3**	**4**		
Potassium	**288**	**337**			**34**	**312**

Innovator, HZPC, field					IPL Code	10-342
	Assay				**SD**	**Aver.**
	1	**2**	**3**	**4**		
Potassium	**395**	**368**			**19**	**381**

5.5 Potato analysis report N° 22113

Potato samples were collected on January, 21st during the meeting in Breda. Samples are kept in 2 household fridges (respectively at 4-6°C and 6-8°C). The present document report analysis result for 3 Annabelle samples and 1 saline sample. An internal code is attributed to samples, matching given below. Each sample (tubers with skin) is homogenised with a rotary blade grinder. Homogeneisates are sealed under vacuum and kept at 6-8°C until analysis.

Description	Growing location	Plant identification	Sample mass (g)	IPL Code
Annabelle, hydroponic	UCL	1 ;4 ;13 ; 14 ;15 ;16	269.58	10-318
Annabelle, hydroponic	UGent	1 ;2 ;3 ;4 ;11; 13 ;14 ;15	147.04	10-326
Annabelle, hydroponic	HZPC	Rechts	104.14	10-334
Saline, hydroponic	**HZPC**	**Rechts**	**111.61**	**10-343**

Tubers of plant 11 were added by mistake to sample 10-326 which should be constituted only of ‘sub-optimal light condition’ tubers.
By lack of available commercial standard, chaconine content is estimated upon calibration made for solanine analysis. Accurate calculation‘ll have to be done again once the adequate standard can be purchased. In the mean time, value is given for information sake only. Irrespective of the calibration issue, dispersion of results for chaconine is high due to bad peak shape in HPLC.

5.5.1 Analysis Methods

Dry weight: 100°C oven until constant weight.
Protein content: Kjeldahl method; N x 6.25
Fat content: Weibuhl method; acid digestion followed by Soxhlet extraction with petroleum benzine 40-60
Total Dietary Fiber content: AOAC 985.29, Enzymatic-Gravimetric Method.
Minerals content: 24h, 550°C furnace
Natrium, potassium content: Flame photometry of solution of the minerals.
Ca, Mg, Fe, Zn, Cu, Mn content: Atomic absorption of solution of the minerals.
Available carbohydrates: By difference between total of sample and sum of other ingredients
Solanine content: AOAC 997.13, HPLC, 150X4.5mm id column packed with Symmetry (Waters) C18 phase 5 µm particle size. Eluent 50% acetonitrile; 50% phosphate buffer 0.025M pH 7.6. Flow rate 1.5ml/min. Injection volume 20µL; detector set at 202 nm.
Energy content: calculation : 4 kcal for proteins and carbohydrates, 9 kcal for fat, 2kcal for TDF. Value is multiplied by 4.184 for kJ.

5.5.2 Results

Annabelle, low light, UCL IPL Code : 10-318

		Assay				SD	Av.
		1	2	3	4		
Water (%)		**82.8**	**81.6**			**0.86**	**82.2**
Protein (%)		**1.38**	**1.37**			**0.002**	**1.38**
Fat (%)		**0.08**	**0.08**			**0.00**	**0.08**
Available carbohydrates (%)							**13.19**
TDF (%)							**1.85**
Minerals (%)		**1.35**	**1.32**			**0.016**	**1.34**
Of which (mg/100g)	Natrium	**8.91**	**9.44**			**0.38**	**9.2**

	Potassium	**563**	**538**			**17**	**551**
	Calcium	**1.81**	**1.83**			**0.01**	**1.82**
	Magnesium	**24.4**	**24.7**			**0.19**	**24.6**
	Iron	**1.30**	**1.38**			**0.06**	**1.34**
	Zinc	**0.59**	**0.60**			**0.01**	**0.60**
	Copper	**0.48**	**0.50**			**0.02**	**0.49**
	Manganese	**0.27**	**0.27**			**0.00**	**0.27**
Solanine (mg/kg)		**42.0**	**36.8**	**46.3**	**44.4**	**4.1**	**42**
Chaconine (mg/kg) ESTIMATE		*57*	*49*	*67*	*40*	*11*	*54*
Energy (for 100g)							**62.7 kcal** **262.3 kJ**

Annabelle, sub-optimal light, UGent IPL Code : 10-326

		Assay				SD	Aver.
		1	**2**	**3**	**4**		
Water (%)		**82.1**	**82.6**			**0.37**	**82.4**
Protein (%)		**1.09**	**1.14**			**0.035**	**1.11**
Fat (%)		**0.08**	**0.12**			**0.03**	**0.10**
Available carbohydrates (%)							**13.45**
TDF (%)							**1.80**
Minerals (%)		**1.21**	**1.16**			**0.032**	**1.19**
Of which (mg/100g)	Natrium	**10.2**	**13.3**			**2.2**	**11.7**
	Potassium	**484**	**488**			**2.9**	**486**
	Calcium	**8.49**	**12.0**			**2.4**	**10.2**
	Magnesium	**24.1**	**23.7**			**0.30**	**23.87**
	Iron	**1.31**	**1.75**			**0.32**	**1.5**
	Zinc	**1.21**	**1.11**			**0.07**	**1.16**
	Copper	**0.55**	**0.48**			**0.05**	**0.51**
	Manganese	**0.41**	**0.42**			**0.01**	**0.42**
Solanine (mg/kg)		**33.5**		**36.5**	**32.5**	**2.0**	**34**
Chaconine (mg/kg) ESTIMATE		*48*	*42*	*98*		*30*	*63*

Energy (for 100g)	**62.8 kcal 262.6 kJ**

Annabelle, rechts, HZPC IPL Code : 10-334

		Assay				SD	Aver.
		1	**2**	**3**	**4**		
Water (%)		**84.8**	**84.8**			**0.016**	**84.8**
Protein (%)		**1.65**	**1.81**			**0.12**	**1.7**
Fat (%)		**0.09**	**0.09**			**0.00**	**0.09**
Available carbohydrates (%)							**10.36**
TDF (%)							**2.02**
Minerals (%)		**0.99**	**1.00**			**0.012**	**0.99**
Of which (mg/100g)	Natrium	**20.7**	**16.5**			**3.0**	**18**
	Potassium	**366**	**363**			**2.1**	**365**
	Calcium	**13.5**	**12.5**			**0.72**	**13.0**
	Magnesium	**28.5**	**27.7**			**0.57**	**28.1**
	Iron	**1.11**	**0.95**			**0.11**	**1.0**
	Zinc	**2.37**	**2.42**			**0.03**	**2.39**
	Copper	**0.32**	**0.44**			**0.09**	**0.38**
	Manganese	**0.23**	**0.23**			**0.00**	**0.23**
Solanine (mg/kg)		**79.2**		**51.6**	**50.7**	**16**	**60**
Chaconine (mg/kg) ESTIMATE		*71*	*87*	*63*	*65*	*11*	*71*
Energy (for 100g)							**53.2 kcal 222.6 kJ**

Saline, rechts, HZPC IPL Code : 10-343

	Assay				SD	Aver.
	1	**2**	**3**	**4**		
Water (%)	**81.3**	**82.3**			**0.65**	**81.8**
Protein (%)	**1.50**	**1.31**			**0.13**	**1.4**

Fat (%)		**0.06**	**0.08**			**0.01**	**0.07**
Available carbohydrates (%)							**13.38**
TDF (%)							**2.12**
Minerals (%)		**1.25**	**1.18**			**0.053**	**1.22**
Of which (mg/100g)	Natrium	**10.9**	**14.6**			**2.6**	**13**
	Potassium	**493**	**489**			**2.7**	**491**
	Calcium	**11.3**	**12.1**			**0.53**	**11.7**
	Magnesium	**28.1**	**29.0**			**0.64**	**28.5**
	Iron	**0.81**	**0.99**			**0.13**	**0.9**
	Zinc	**1.24**	**1.47**			**0.16**	**1.4**
	Copper	**0.29**	**0.47**			**0.12**	**0.4**
	Manganese	**0.26**	**0.26**			**0.00**	**0.26**
Solanine (mg/kg)		**20.3**	**31.1**	**32.4**		**6.6**	**28**
Chaconine (mg/kg) ESTIMATE		*34*		*125*	*81*	*46*	*80*
Energy (for 100g)							**64.0 kcal 267.7 kJ**

5.6 Potato analysis report N° 22114

Potato samples were collected on January, 21st during the meeting in Breda. Samples are kept in 2 household fridges (respectively at 4-6°C for UGent hydroponic and HZPC field samples and 6-8°C for UCL and HZPC hydroponic samples). The present document report analysis result for 3 Bintje samples and 3 Innovator samples. An internal code is attributed to samples, matching given below. Each sample (tubers with skin) is washed with deionized water before homogenisation with a rotary blade grinder. Homogeneisates are sealed under vacuum and kept at 6-8°C until analysis.

Description	Growing location	Plant identification	Sample mass (g)	Mean tuber mass (g)	IPL Code
Bintje, hydroponic	UCL	1 ;3 ;13 ;14 ;16	155.47	7.1	10-320
Innovator, hydroponic	UCL	4 ;13 ;16	61.51	12.3	10-322
Bintje, hydroponic	UGent	1;3;4;13;14;15;16	158.68	4.0	10-328
Innovator, hydroponic	UGent	1;2;3;4;13;14	118.21	10.7	10-330
Bintje, hydroponic	HZPC	Rechts	152.12	missing	10-337
Innovator, hydroponic	HZPC	Rechts	100.32	4.8	10-340

By lack of available commercial standard, chaconine content is estimated upon calibration made for solanine analysis. Accurate calculation'll have to be done again once the adequate standard can be purchased. In the mean time, value is given for information sake only. Irrespective of the calibration issue, dispersion of results for both alkaloids is high due to bad peak shape and high noise in HPLC.

5.6.1 Analysis Methods

Dry weight: 100°C oven until constant weight.
Protein content: Kjeldahl method; N x 6.25
Fat content: Weibuhl method; acid digestion followed by Soxhlet extraction with petroleum benzine 40-60
Total Dietary Fiber content: AOAC 985.29, Enzymatic-Gravimetric Method.
Minerals content: 24h, 550°C furnace
Natrium, potassium content: Flame photometry of solution of the minerals.
Ca, Mg, Fe, Zn, Cu, Mn content: Atomic absorption of solution of the minerals.
Available carbohydrates: By difference between total of sample and sum of other ingredients
Solanine content: AOAC 997.13, HPLC, 150X4.5mm id column packed with Symmetry (Waters) C18 phase 5 µm particle size. Eluent 50% acetonitrile; 50% phosphate buffer 0.025M pH 7.6. Flow rate 1.5ml/min. Injection volume 20µL; detector set at 202 nm.
Energy content: calculation : 4 kcal for proteins and carbohydrates, 9 kcal for fat, 2kcal for TDF. Value is multiplied by 4.184 for kJ.

5.6.2 Results

Bintje, low light, UCL IPL Code : 10-320

		Assay				SD	Average
		1	2	3	4		
Water (%)		**82.7**	**81.8**			**0.64**	**82.3**
Protein (%)		**1.62**	**1.62**			**0.002**	**1.62**
Fat (%)		**0.06**	**0.06**			**0.06**	**0.004**
Available carbohydrates (%)							**12.7**
TDF (%)							**2.04**
Minerals (%)		**1.25**	**1.30**			**0.039**	**1.27**
Of which (mg/100g)	Natrium	**59.4**	**55.0**			**3.1**	**57**
	Potassium	**771**	**767**			**2.6**	**769**

		1	2	3	4	SD	Average
	Calcium	**1.61**	**2.00**			**0.27**	**1.8**
	Magnesium	**23.3**	**23.5**			**0.11**	**23.4**
	Iron	**1.42**	**1.22**			**0.15**	**1.3**
	Copper	**0.41**	**0.35**			**0.04**	**0.38**
	Zinc	**0.40**	**0.33**			**0.05**	**0.36**
	Manganese	**0.25**	**0.21**			**0.02**	**0.23**
Solanine (mg/kg)		**36.4**	**31.1**	**45.7**	**44.7**	**7.0**	**39**
Chaconine (mg/kg) ESTIMATE		*64*	*66*		*104*	*22*	*78*
Energy (for 100g)							**62.1 kcal 259.8 kJ**

Innovator, low light, UCL IPL Code : 10-322

		Assay				SD	Average
		1	2	3	4		
Water (%)		**78.2**	**78.0**			**0.12**	**78.1**
Protein (%)		**1.84**	**1.83**			**0.004**	**1.84**
Fat (%)		**0.09**	**0.06**			**0.017**	**0.08**
Available carbohydrates (%)							**16.0**
TDF (%)							**2.71**
Minerals (%)		**1.26**	**1.27**			**0.007**	**1.27**
Of which (mg/100g)	Natrium	**58.5**	**74.8**			**11**	**67**
	Potassium	**734**	**743**			**6.1**	**738**
	Calcium	**0.94**	**1.71**			**0.54**	***1.3***
	Magnesium	**25.9**	**26.3**			**0.26**	**26.1**
	Iron	**1.19**	**1.51**			**0.23**	**1.3**
	Copper	**0.21**	**0.40**			**0.13**	**0.3**
	Zinc	**0.42**	**0.37**			**0.04**	**0.39**
	Manganese	**0.22**	**0.19**			**0.02**	**0.21**
Solanine (mg/kg)		**66**	**95**	**73**	**76**	**12**	**77**
Chaconine (mg/kg) ESTIMATE		*100*	*108*	*123*	*99*	*11*	*107*

Energy (for 100g)							**77.3 kcal** **323.5 kJ**

Bintje, low light, UGent IPL Code : 10-328

		Assay				SD	Average
		1	**2**	**3**	**4**		
Water (%)		**77.6**	**76.6**			**0.71**	**77.1**
Protein (%)		**1.52**	**1.54**			**0.014**	**1.53**
Fat (%)		**0.05**	**0.05**			**0.0002**	**0.05**
Available carbohydrates (%)							**17.4**
TDF (%)							**2.40**
Minerals (%)		**1.46**	**1.42**			**0.026**	**1.44**
Of which (mg/100g)	Natrium	**66.5**	**58.8**			**5.4**	**63**
	Potassium	**851**	**833**			**13**	**842**
	Calcium	**1.19**	**1.03**			**0.12**	**1.1**
	Magnesium	**21.7**	**21.5**			**0.15**	**21.6**
	Iron	**1.63**	**1.45**			**0.12**	**1.5**
	Copper	**0.56**	**0.50**			**0.04**	**0.53**
	Zinc	**0.78**	**0.69**			**0.06**	**0.74**
	Manganese	**0.34**	**0.31**			**0.02**	**0.32**
Solanine (mg/kg)			**76**	**42**		**24**	**59**
Chaconine (mg/kg) ESTIMATE			*133*	*67*	*70*	*37*	*90*
Energy (for 100g)							**81.1 kcal** **339.4 kJ**

Innovator, low light, UGent IPL Code : 10-330

	Assay				SD	Average
	1	**2**	**3**	**4**		
Water (%)	**75.9**	**77.0**			**0.82**	**76.5**
Protein (%)	**1.15**	**1.12**			**0.018**	**1.13**

						SD	Average
Fat (%)		**0.06**	**0.07**			**0.004**	**0.06**
Available carbohydrates (%)							**18.8**
TDF (%)							**2.22**
Minerals (%)		**1.26**	**1.34**			**0.056**	**1.30**
Of which (mg/100g)	Natrium	**58.3**	**66.6**			**5.8**	**62**
	Potassium	**777**	**783**			**4.3**	**780**
	Calcium	**1.21**	**1.26**			**0.03**	**1.24**
	Magnesium	**25.4**	**24.8**			**0.41**	**25.1**
	Iron	**1.37**	**1.71**			**0.24**	**1.54**
	Copper	**0.45**	**0.37**			**0.05**	**0.41**
	Zinc	**0.95**	**0.92**			**0.02**	**0.94**
	Manganese	**0.29**	**0.28**			**0.01**	**0.28**
Solanine (mg/kg)				**58**	**77**	**13**	**67**
Chaconine (mg/kg) ESTIMATE				*56*	*75*	*14*	*66*
Energy (for 100g)							**84.8 kcal** **354.9 kJ**

Bintje, rechts, HZPC IPL Code : 10-337

		Assay				SD	Average
		1	**2**	**3**	**4**		
Water (%)		**78.4**	**77.9**			**0.34**	**78.2**
Protein (%)		**2.10**	**2.03**			**0.05**	**2.07**
Fat (%)		**0.08**	**0.06**			**0.011**	**0.07**
Available carbohydrates (%)							**16.3**
TDF (%)							**2.17**
Minerals (%)		**1.20**	**1.25**			**0.038**	**1.22**
Of which (mg/100g)	Natrium	**62.8**	**65.0**			**1.5**	**64**
	Potassium	**666**	**698**			**23**	**682**
	Calcium	**8.34**	**9.02**			**0.48**	**8.7**
	Magnesium	**26.4**	**27.2**			**0.50**	**26.8**

	Iron	**1.40**	**1.56**			**0.11**	**1.48**
	Copper	**0.79**	**0.32**			**0.33**	**0.6**
	Zinc	**2.56**	**2.42**			**0.10**	**2.5**
	Manganese	**0.25**	**0.25**			**0.00**	**0.25**
Solanine (mg/kg)			**32.1**	**36.4**	**27.9**	**4.2**	**32**
Chaconine (mg/kg) ESTIMATE			*61*	*62*	*82*	*12*	*68*
Energy (for 100g)							**65.9 kcal 275.6 kJ**

Innovator, rechts, HZPC IPL Code : 10-340

		Assay				SD	Average
		1	**2**	**3**	**4**		
Water (%)		**76.8**	**78.0**			**0.66**	**77.8**
Protein (%)		**2.53**	**2.53**			**0.002**	**2.53**
Fat (%)		**0.06**	**0.07**			**0.005**	**0.07**
Available carbohydrates (%)							**15.2**
TDF (%)							**3.23**
Minerals (%)		**1.23**	**1.28**			**0.034**	**1.24**
Of which (mg/100g)	Natrium	**66.6**	**64.7**			**1.3**	**66**
	Potassium	**710**	**719**			**6.7**	**715**
	Calcium	**9.45**	**9.50**			**0.04**	**9.48**
	Magnesium	**30.0**	**30.1**			**0.12**	**30.0**
	Iron	**1.57**	**1.57**			**0.00**	**1.57**
	Copper	**0.59**	**0.46**			**0.09**	**0.53**
	Zinc	**3.75**	**2.50**			**0.89**	**3.1**
	Manganese	**0.19**	**0.19**			**0.00**	**0.19**
Solanine (mg/kg)		**105.2**	**101.8**	**86.9**	**95.9**	**8.0**	**97**
Chaconine (mg/kg) ESTIMATE		*141*	*121*	*107*	*123*	*14*	*123*
Energy (for 100g)							**61.2 kcal 256.1 kJ**

Measurement of Ca was repeated on minerals solution of 10-318 (Annabelle, low light, UCL; same solution kept at 6-8°C since report 22113). Mean of two readings is 2.1 mg/100g (SD 0.38) coherent with the previously reported value of 1.82 mg/100g.

5.7 Potato analysis report N°22118

Potato samples were collected on January, 21st during the meeting in Breda. Samples (Désirée growth at HZPC in hydroponic conditions) are kept in a household fridge (6-8°C). The present document report analysis result for 3 modes of processing. Samples were cooked in boiling water with or without skin. An internal code is attributed to samples, matching given below.
Each sample is homogenised with a rotary blade grinder. Homogeneisates are sealed under vacuum and kept at 6-8°C until analysis.

Plant identification	Growing location	Description	Process. sample mass (g)	Mean process. tuber mass (g)	IPL Code
Desiree, links	HZPC	Cooked with skin	108.07	36.02	10-429
Desiree, rechts	HZPC	Cooked with skin	105.53	52.76	10-430
Desiree, links	HZPC	Peeled prior cooking	100.01	20.00	10-431
Desiree, rechts	HZPC	Peeled prior cooking	91.65	45.82	10-432
Desiree, links	HZPC	Peeled and diced prior cooking	110.24		10-433
Desiree, rechts	HZPC	Peeled and diced prior cooking	106.31		10-434

5.7.1 Analysis Methods

Dry weight: 100°C oven until constant weight (assays 1 &2); 50°C, <50 mbar oven until constant weight (assays 3&4).
Protein content: Kjeldahl method; N x 6.25
Fat content: Weibuhl method; acid digestion followed by Soxhlet extraction with petroleum benzine 40-60
Total Dietary Fiber content: AOAC 985.29, Enzymatic-Gravimetric Method.
Minerals content: 24h, 550°C furnace
Natrium, potassium content: Flame photometry of solution of the minerals.
Ca, Mg, Fe, Zn, Cu, Mn content: Atomic absorption of solution of the minerals.
Available carbohydrates: By difference between total of sample and sum of other ingredients
Energy content: calculation : 4 kcal for proteins and carbohydrates, 9 kcal for fat, 2kcal for TDF. Value is multiplied by 4.184 for kJ.

5.7.2 Results

Désirée HZPC Links cooked with skin IPL Code 10-429

		Assay				SD	mean
		1	2	3	4		
Water (%)		**79,3**	**79,5**	**79,2**	**78,7**	**0,3**	**79,2**
Protein (%)		**2,33**	**2,32**			**0,012**	**2,32**
Fat (%)		**0,10**	**0,08**			**0,016**	**0,09**
Available carbohydrates (%)							**14,74**
TDF (%)							**2,43**
Minerals (%)		**1,24**	**1,21**			**0,025**	**1,23**
Of which (mg/100g)	Sodium						
	Potassium	**560**	**549**			**7,5**	**554**
	Calcium	**6,9**	**6,6**			**0,22**	**6,8**
	Magnesium	**24,9**	**24,9**			**0,01**	**24,9**
	Iron	**0,42**	**0,57**			**0,10**	**0,5**
	Copper	**0,34**	**0,49**			**0,10**	**0,4**
	Zinc	**0,87**	**1,48**			**0,43**	**1,2**
	Manganese	**0,22**	**0,22**			**0,002**	**0,22**
	Phosphorus	**106,2**	**106,9**			**0,5**	**107**
Energy (for 100g)	kcal						**73,9**
	kJ						**309,4**

Désirée HZPC rechts cooked with skin IPL Code 10-430

		Assay				SD	mean
		1	2	3	4		
Water (%)		**81,3**	**80,9**	**79,6**	**80,0**	**0,8**	**80,4**
Protein (%)		**2,12**	**2,19**			**0,051**	**2,16**
Fat (%)		**0,08**	**0,07**			**0,002**	**0,07**
Available carbohydrates (%)							**13,53**
TDF (%)							**2,69**
Minerals (%)		**1,10**	**1,15**			**0,030**	**1,12**
Of which (mg/100g)	Sodium						
	Potassium	**469**	**478**			**6,5**	**474**
	Calcium	**9,7**	**8,6**			**0,81**	**9,2**
	Magnesium	**28,0**	**28,7**			**0,49**	**28,4**

	Iron	0,67	0,69			0,01	0,7
	Copper	0,39	0,50			0,08	0,4
	Zinc	0,89	0,84			0,04	0,9
	Manganese	0,22	0,24			0,008	0,23
	Phosphorus	95,5	99,2			2,6	97
Energy (for 100g)	kcal						68,8
	kJ						287,8

Désirée HZPC Links peeled, cooked IPL Code 10-431

		Assay				SD	mean
		1	2	3	4		
Water (%)		77,3	77,6	77,3	77,3	0,2	77,4
Protein (%)		1,97	2,01			0,028	1,99
Fat (%)		0,07	0,07			0,004	0,07
Available carbohydrates (%)							17,38
TDF (%)							2,33
Minerals (%)		0,85	0,86			0,006	0,86
Of which (mg/100g)	Sodium						
	Potassium	354	345			6,5	350
	Calcium	19,1	15,2			2,77	17,1
	Magnesium	24,4	23,8			0,38	24,1
	Iron	0,63	0,64			0,01	0,6
	Copper	0,80	0,46			0,24	0,6
	Zinc	0,61	0,50			0,08	0,6
	Manganese	0,25	0,26			0,005	0,25
	Phosphorus	87,9	90,7			2,0	89
Energy (for 100g)	kcal						82,8
	kJ						346,3

Désirée HZPC Rechts peeled, cooked IPL Code 10-432

	Assay				SD	mean
	1	2	3	4		
Water (%)	81,4	80,9	80,4	80,8	0,4	80,9
Protein (%)	2,00	2,01			0,010	2,01
Fat (%)	0,07	0,06			0,003	0,07
Available carbohydrates (%)						14,02
TDF (%)						2,20

Minerals (%)		**0,80**	**0,83**			**0,022**	**0,82**
Of which (mg/100g)	Sodium						
	Potassium	**318**	**314**			**2,3**	**316**
	Calcium	**17,6**	**32,1**			**10,27**	**24,8**
	Magnesium	**26,5**	**25,8**			**0,48**	**26,2**
	Iron	**0,61**	**0,62**			**0,01**	**0,6**
	Copper	**0,38**	**0,28**			**0,07**	**0,3**
	Zinc	**0,43**	**0,34**			**0,06**	**0,4**
	Manganese	**0,26**	**0,29**			**0,019**	**0,27**
	Phosphorus	**83,9**	**85,1**			**0,8**	**84**
Energy (for 100g)	kcal						**69,1**
	kJ						**289,2**

Désirée HZPC Links peeled, diced, cooked IPL Code 10-433

		Assay				SD	mean
		1	**2**	**3**	**4**		
Water (%)		**81,9**	**82,6**	**82,0**	**81,8**	**0,4**	**82,1**
Protein (%)		**1,55**	**1,69**			**0,099**	**1,62**
Fat (%)		**0,06**	**0,06**			**0,003**	**0,06**
Available carbohydrates (%)							**13,57**
TDF (%)							**2,13**
Minerals (%)		**0,56**	**0,53**			**0,022**	**0,55**
Of which (mg/100g)	Sodium						
	Potassium	**211**	**207**			**2,4**	**209**
	Calcium	**30,8**	**16,6**			**10,03**	**23,7**
	Magnesium	**17,6**	**16,9**			**0,46**	**17,3**
	Iron	**0,58**	**0,50**			**0,05**	**0,5**
	Copper	**0,46**	**0,35**			**0,07**	**0,4**
	Zinc	**0,62**	**1,08**			**0,32**	**0,9**
	Manganese	**0,24**	**0,23**			**0,006**	**0,24**
	Phosphorus	**63,2**	**67,2**			**2,8**	**65**
Energy (for 100g)	kcal						**54,8**
	kJ						**229,4**

Désirée HZPC rechts peeled, diced, cooked						IPL Code	10-434
		Assay				**SD**	**mean**
		1	**2**	**3**	**4**		
Water (%)		**84,2**	**84,8**	**83,4**	**83,6**	**0,6**	**84,0**
Protein (%)		**1,67**	**1,53**			**0,094**	**1,60**
Fat (%)		**0,04**	**0,06**			**0,015**	**0,05**
Available carbohydrates (%)							**11,67**
TDF (%)							**2,15**
Minerals (%)		**0,53**	**0,51**			**0,011**	**0,52**
Of which (mg/100g)	Sodium						
	Potassium	**203**					**203**
	Calcium	**12,4**					**12,4**
	Magnesium	**18,7**					**18,7**
	Iron	**0,68**					**0.7**
	Copper	**0,39**					**0.4**
	Zinc	**0,93**					**0.9**
	Manganese	**0,23**					**0.23**
	Phosphorus	**59,4**	**59,4**			**0,0**	**59**
Energy (for 100g)	kcal						**47,2**
	kJ						**197,4**

5.8 Potato analysis report N° 22119

Potato samples were collected on January, 21st during the meeting in Breda. Samples (Bintje, Annabelle and Désirée growth at HZPC in hydroponic conditions) are kept in a household fridge (6-8°C). The present document report analysis result

- for 3 microwave cooked samples
- for 1 conservation test: repetition of analysis on Désirée 'rechts'. Sample is taken from same potato lot as sample 10-331 in report 22115.

Each sample is homogenised with a rotary blade grinder. Homogeneisates are sealed under vacuum and kept at 6-8°C until analysis.

Plant identification	Growing location	Description	Process. sample mass (g)	Mean process. tuber mass (g)	IPL Code
Bintje, rechts	HZPC	Microwave cooked with skin	118.6	11.8	10-438
Bintje, left	HZPC	Microwave cooked with skin	127.6	18.2	10-439
Annabelle, rechts	HZPC	Microwave cooked with skin	118.4	9.9	10-440

Désirée, rechts	HZPC	Same lot as sample 10-331	132	18.8	10-441

10-441 was taken out of the fridge and homogeneized on may 26th; 10-331 was homogeneized on march 22nd.

5.8.1 Analysis Methods

Dry weight: 100°C oven until constant weight (assays 1 &2); 50°C, <50 mbar oven until constant weight (assays 3&4).
Protein content: Kjeldahl method; N x 6.25
Fat content: Weibuhl method; acid digestion followed by Soxhlet extraction with petroleum benzine 40-60
Total Dietary Fiber content: AOAC 985.29, Enzymatic-Gravimetric Method.
Minerals content: 24h, 550°C furnace
Natrium, potassium content: Flame photometry of solution of the minerals.
Ca, Mg, Fe, Zn, Cu, Mn content: Atomic absorption of solution of the minerals.
Phosphorus content: Colorimetry of the phosphomolybdate complex on an aliquot taken from Kjeldahl mineralisation.
Available carbohydrates: By difference between total of sample and sum of other ingredients
Energy content: calculation : 4 kcal for proteins and carbohydrates, 9 kcal for fat, 2kcal for TDF. Value is multiplied by 4.184 for kJ.

5.8.2 Results

Bintje, HZPC rechts, microwave cooked IPL Code 10-438

		Assay				SD	Average
		1	2	3	4		
Water (%)		**68,5**	**68,0**	**67,0**	**66,9**	**0,8**	**67,6**
Protein (%)		**2,95**	**3,01**			**0,037**	**2,98**
Fat (%)		**0,10**	**0,13**			**0,016**	**0,12**
Available carbohydrates (%)							**24,29**
TDF (%)							**3,34**
Minerals (%)		**1,68**	**1,64**			**0,028**	**1,66**
Of which (mg/100g)	Sodium	**11,8**	**12,3**			**0,4**	**12,0**
	Potassium	**730**	**708**			**14,9**	**719**
	Calcium	**9,4**	**7,8**			**1,11**	**8,6**
	Magnesium	**34,8**	**33,8**			**0,71**	**34,3**
	Iron	**0,76**	**0,73**			**0,02**	**0,7**
	Copper	**0,44**	**0,66**			**0,15**	**0,5**
	Zinc	**2,80**	**2,72**			**0,06**	**2,8**

	Manganese	**0,31**	**0,29**			**0,015**	**0,30**
	Phosphorus	**147,3**	**150,1**			**2,0**	**149**
Energy (for 100g)	kcal						**116,8**
	kJ						**488,7**

Bintje, HZPC links, microwave cooked IPL Code 10-439

		Assay				SD	Average
		1	**2**	**3**	**4**		
Water (%)		**71,2**	**71,2**	**69,7**	**69,7**	**0,9**	**70,4**
Protein (%)		**2,77**	**2,75**			**0,015**	**2,76**
Fat (%)		**0,08**	**0,11**			**0,023**	**0,10**
Available carbohydrates (%)							**22,01**
TDF (%)							**3,14**
Minerals (%)		**1,54**	**1,58**			**0,027**	**1,56**
Of which (mg/100g)	Sodium	**12,8**	**13,2**			**0,2**	**13,0**
	Potassium	**691**	**693**			**1,3**	**692**
	Calcium	**10,7**	**10,8**			**0,09**	**10,8**
	Magnesium	**34,0**	**33,9**			**0,11**	**34,0**
	Iron	**0,71**	**0,74**			**0,02**	**0,7**
	Copper	**0,41**	**0,91**			**0,35**	**0,7**
	Zinc	**2,14**	**2,21**			**0,05**	**2,2**
	Manganese	**0,31**	**0,32**			**0,008**	**0,32**
	Phosphorus	**141,1**	**139,0**			**1,5**	**140**
Energy (for 100g)	kcal						**106,2**
	kJ						**444,4**

Annabelle, HZPC rechts, microwave cooked IPL Code 10-440

		Assay				SD	Average
		1	**2**	**3**	**4**		
Water (%)		**75,8**	**75,7**	**73,7**	**73,9**	**1,1**	**74,8**
Protein (%)		**3,17**	**3,03**			**0,098**	**3,10**
Fat (%)		**0,11**	**0,12**			**0,003**	**0,12**
Available carbohydrates (%)							**16,64**
TDF (%)							**3,87**
Minerals (%)		**1,53**	**1,47**			**0,039**	**1,50**
Of which (mg/100g)	Sodium	**13,1**	**15,6**			**1,8**	**14,3**

	Potassium	**655**	**623**			**22,1**	**639**
	Calcium	**11,0**	**7,6**			**2,37**	**9,3**
	Magnesium	**45,0**	**43,3**			**1,22**	**44,2**
	Iron	**0,93**	**0,78**			**0,11**	**0,9**
	Copper	**0,76**	**0,61**			**0,10**	**0,7**
	Zinc	**2,84**	**2,69**			**0,10**	**2,8**
	Manganese	**0,41**	**0,35**			**0,047**	**0,38**
	Phosphorus	**147,9**	**147,9**			**0,0**	**148**
Energy (for 100g)	kcal						**87,7**
	kJ						**367,1**

Désirée, HZPC rechts, 10-331 + 2 months IPL Code 10-441

		Assay				**SD**	**Average**
		1	**2**	**3**	**4**		
Water (%)		**82,3**	**82,1**	**82,3**	**82,9**	**0,4**	**82,4**
Protein (%)		**2,43**	**2,36**			**0,051**	**2,40**
Fat (%)		**0,10**	**0,09**			**0,002**	**0,09**
Available carbohydrates (%)							**11,55**
TDF (%)							**2,45**
Minerals (%)		**1,10**	**1,12**			**0,014**	**1,11**
Of which (mg/100g)	Sodium	**12,5**	**12,8**			**0,2**	**12,6**
	Potassium	**488**	**490**			**1,0**	**489**
	Calcium	**9,5**	**8,9**			**0,46**	**9,2**
	Magnesium	**29,7**	**29,8**			**0,12**	**29,7**
	Iron	**0,71**	**0,68**			**0,02**	**0,7**
	Copper	**0,62**	**0,52**			**0,07**	**0,6**
	Zinc	**1,38**	**1,98**			**0,42**	**1,7**
	Manganese	**0,31**	**0,30**			**0,007**	**0,30**
	Phosphorus	**103,9**	**102,8**			**0,8**	**103**
Energy (for 100g)	kcal						**61,5**
	kJ						**257,5**

5.9 Potato analysis report N° 22120

Potato samples were collected on January, 21st during the meeting in Breda. Samples (Bintje, Annabelle and Désirée growth at HZPC in hydroponic conditions) are kept in a household fridge (6-8°C). The present document report analysis result for phosphorus analysis which were delayed for some samples. Those samples were sealed under vacuum and kept at -20°C until analysis. Exception made for sample 10-340 which has to be homogeneized again from tubers kept in fridge because original sample was exhausted.

Plant identification	Growing location	Description	IPL Code
Annabelle	UCL	Hydroponics, low light	10-318
Bintje	UCL	Hydroponics, low light	10-320
Annabelle	UGent	Hydroponics low light	10-326
Bintje	UGent	Hydroponics low light	10-328
Innovator	UGent	Hydroponics low light	10-330
Annabelle	HZPC	Hydroponics, rechts	10-334
Bintje	HZPC	Hydroponics, rechts	10-337
Innovator	HZPC	Hydroponics, rechts	10-340

No homogeneisate nor tubers were left for 10-322 (Innovator, UCL, low light). Analysis could not be performed.

5.9.1 Analysis Methods

- **Protein content**: Kjeldahl method; N x 6.25
- **Phosphorus content**: Colorimetry of the phosphomolybdate complex on an aliquot taken from Kjeldahl mineralisation.

5.9.2 Results

Phosphorus (mg/100g)

Code	**Assay 1**	**Assay 2**	**moy**	**SD**
10-318	110,0	113,6	**111,8**	**2,54**
10-320	100,5	101,5	**101,0**	**0,69**
10-326	101,9	100,0	**100,9**	**1,37**
10-328	123,1	130,4	**126,7**	**5,16**
10-330	106,0	104,9	**105,4**	**0,74**
10-334	92,0	94,0	**93,0**	**1,36**
10-337	115,5	112,8	**114,1**	**1,88**
10-340	107,4	109,8	**108,6**	**1,68**