AFTER

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Contents

Executive summary

The physical and organoleptic properties of traditional products have been characterized for several samples collected from the traditional processors for every version of the processes. From 6 to 28 samples collected for each of the 2 to 4 versions of the processes were analyzed in general, but a more limited number of samples (2 to 4 per version of the process) were analyzed for aroma of Akpan and Gowé.

Particle size revealed significant differences in the process types of Akpan and Kenkey. This will have a great impact in the acceptability of the products as consumers generally look for a "smooth" (not rough) product. Texture was also significantly affected by the process.

Gelatinization level appeared very diverse for Akpan, pointing out that cooking level is a critical point for this process for which gelatinization must not be completed. Gowé and Keneky are however completely cooked.

Colour differences were also noticed between Keneky process types. Colour parameters could not be measured on Akpan and Gowé due to the failure of the equipment.

Aroma compounds were identified for the first time on Gowé and Akpan.

Some data are missing, in particular on Kishk Sa'eedi, due to the Egyptian revolution that delayed the collection of samples on field.

All these measurements will serve as basic knowledge for controlling and targeting re-enginering toward products of better quality. These data will be compared to sensorial and consumer data to best quantify the target of quality for each product.

Results

For each product, the summary and detailed reports are given in annexes for, Akpan, Gowe, Kenkey, and Kishk Sa'eedi, respectively. The table and figure numbers refer to each annex respectively.

Annex 1 – detailed report for Akpan

Concerning particles size analysis (Table 1), the major fraction was less than 45 µm for all Akpan. Akpan from ogi was however finer with 73.4 to 84.7% (db) of particles less than 45 µm against 43.4 and 64.6 % (db) for dough akpan.

According to producers akpan must be slightly cooked, particularly akpan from maize ogi. The degree of gelatinization indeed varied between 64.5 and 88 % in the collected traditional akpan.

The apparent viscosity of sorghum akpan appeared higher (235-247 u RVA) than that of maize or mixed akpan (158-172 uRVA)

Concerning aroma, Gas Chromatography coupled with Mass Spectrometry was performed after Solid Phase Micro-Extraction. The total number of compounds detected with quality index > 80 (degree of agreement between mass spectrum of sample and mass spectrum in database on scale of 0 to 100) was respectively 81, 60, 50 and 28 compounds for Akpan from maize ogi (MO), Akpan from sorghum ogi (SO), Akpan from mixture'' maize + sorghum'' dough (SMD) and Akpan from sorghum dough (SD). Taking into account the odor detection threshold, according to the literature, 25 compounds have been considered. These compounds comprised one ester, one acid, 10 carbonyls, 8 alcohols and 5 phenolics compounds (Table 2). Alcohols were the dominant compounds in numbers for all types of Akpan, but carbonyls should have the most important aromatic impact with 4 of them having higher pseudo-odour active values (OAV, peak area over threshold of detection) over 1. The number of significant peaks and pseudo-OAV were lower than for gowé; this was surely due to the shorter fermentation duration in the case of akpan. Limonène and D-limonène were however specific of akpan; they indeed originated from the citronella which is often added in the diluting water of akpan. There was significant difference ($P < 0.05$) between akpan processes. Some compounds (1-Butanol, Nonanal, 1-Octen-3-ol and 1-Octanol) were detected in every types of Akpan, but several ones were only identified in one type. Akpans made from ogi (MO and SO) appeared richer in carbonyls, particularly in aldehydes whereas akpans made from maize (MO and SMD) appeared richer in Limonène, ethyl-actetate and eugenol.

Table 1. Results for sensory, physical and textural analysis of akpan

Parameter and unit of measurement		SOP number	Responsible partner and lab	Variety/Treatment/Process/Raw material used							
				Sorghum ogi		Sorghum dough		Maize ogi		Maize and sorghum mixed dough	
				Number of samples	Mean +/-SD	Number of samples	Mean +/-SD	Number of samples	Mean +/-SD	Number of samples	Mean +/-SD
Physical:											
Particle size (wet material) (**%** db)	X < 45 µm	Phys-cere-001-en	UAC@ UAC	6	84.7±0.9	6	43.4±3.7	6	73.4±0.7	6	64.6±3.5
	X < 150 µm				89.4±0.6		53.7±0.6		76.7±7.6		73.9±1.4
	X < 180 µm				91.4±2.1		64.2±8.7		76.9±1.6		75.7±1.2
	X < 300 µm				94.7±0.9		74.5±3.2		92.9±0.1		83.1±1.1
Degree of gelatinization (%)		Phys-cere-003-fr/en	UAC @ CIRAD	2	88±16.9	2	76±29.7	4	64.5±24.7	2	85±21.2
Organoleptic:											
Aroma compounds		Phys-Cere-007-en	UAC @CIRAD	2	See table 2	2	See table 2	4	See table 2	2	See table 2
Texture of liquid Product (u RVA)		Phys-Cere-008-fr	UAC @ UAC	6	246.7 ± 78	6	235.2± 68.8	6	157.5± 30	6	171.5± 29.9

Table 2. Volatile compounds in various types of Akpan. The amounts of volatiles are expressed as relative peak area / (10^7x threshold)

Compounds	Akpan from maize ogi	Akpan from sorghum ogi	Akpan from maize and sorghum mixed dough	Akpan from sorghum dough
Alcohols				
Ethanol	7,12E-06[a]	1,05E-05[b]	8,10E-05[c]	nd
1-Butanol	2,03E-03[a]	1,99E-03[a]	1,83E-03[a]	1,73E-03[a]
1-Butanol, 3-methyl-	2,52E-03[a]	nd	5,84E-03[b]	nd
1-Hexanol	3,92E-04[a]	2,28E-04[a]	2,42E-04[a]	nd
1-heptanol	**4,20E-01[a]**	**nd**	**2,23E-01[b]**	**nd**
1-Octen-3-ol	**6,08E-01[a]**	**5,60E-01[a]**	**1,59E+00[b]**	**nd**
1-Octanol	1,05E-02[a]	7,82E-03[b]	1,33E-02[a]	6,26E-03[b]
Phenylethyl Alcohol	1,99E-03	nd	nd	nd
Carbonyls				
2-Butanone	2,54E-05	nd	nd	nd
Hexanal	4,26E-02[a]	8,95E-02[b]	nd	nd
Octanal	**1,18E+00[a]**	**3,72E+00[b]**	**1,01E+00[a]**	**1,36E+00[a]**
Nonanal	**8,23E-01[a]**	**2,60E+00[b]**	**7,04E-01[a]**	**9,50E-01[a]**
2-Octenal, (E)-	5,47E-02	nd	nd	nd
2-Nonenal, (E)-	**4,59E+00[a]**	**5,75E+00[a]**	**nd**	**nd**
Heptane, 2,2,4,6,6-pentamethyl	**nd**	**2,87E-01**	**nd**	**nd**
Benzaldehyde	nd	nd	nd	1,62E-02
Limonène	**8,16E-01[a]**	**nd**	**3,92E+00[b]**	**nd**
D-Limonène	nd	6,85E-02	nd	nd
Acid				
Octanoïc acid	1,12E-04[a]	nd	3,66E-04[b]	nd
Esters				
Ethyl Acetate	**3,58E-01[a]**	**nd**	**8,58E-01[b]**	**nd**
Phenols				
Phenol, 2-methoxy-4-methyl-	1,64E-01[a]	1,69E-02[a]	1,84E-02[a]	nd
Phenol	nd	3,61E-04	nd	nd
Eugenol	**5,96E+00[a]**	**nd**	**2,10E+00[b]**	**8,14E-01[c]**
Phenol, 4-ethyl-	nd	4,57E-02[a]	3,82E-02[a]	1,48E-02[b]
2-Methoxy-4-vinylphenol	**nd**	**8,06E-01**	**nd**	**nd**

nd : not detected
Mean with same letter on the line was not significantly different.

Annex 2 – detailed report for Gowe

Gowe has a medium texture (neither fine nor coarse), with a median particle size around 150 µm and about 67% and 63% of particles under 300 µm for sorghum Gowe and maize Gowe, respectively (Table 1).

The viscosity varies between 156 and 339 uRVA (Table 1); it was significantly lower for steam cooked gowé.

Concerning aroma, Gas Chormatography coupled with Mass Spectrometry was performed after Solid Phase Micro-Extraction. The total number of compounds detected with high match quality (good correlation with library spectra) was 107 and according to literature, only 31 of these were found to have a significant odour impact. Gowe contained compounds typically reported in the literature (Narvhus *et al.*, 1998; Hartvgsen, 2000; Nana *et al.*, 2003). These compounds were produced in varying amounts among the samples and may greatly influence Gowe acceptability. The different Gowe types were significantly different ($P < 0.05$) and identified compounds were seven (7) alcohols, fifteen (15) carbonyls (aldehydes and acetones), two (2) acids, one (1) ester and six (6) phenolic compounds. Among them, one alcohol (1-Octen-3-ol), three carbonyls (1-Octen-3-one, Nonanal and 2-Nonenal, (E)) and one phenolic compound (2-Methoxy-4-vinylphenol) had pseudo odour active values (peak area/threshold of detection) over one and should give the most significant aroma impact. Regarding aldehydes, nonanal was found in same amount in all Gowe types while butanal-3 methyl, pentanal, hexanal, heptanal, octanal, 2-Octenal (E), 2-Nonenal (E), were formed in highest amounts in steam cooked maize Gowe. For butanal-2-methyl, it was formed in highest amounts in 'sorghum and maize' Gowe than others Gowe types. Among acetones, 1-octen-3-one, which was the acetone produced in highest amounts, was higher in steam cooked maize Gowe than sorghum Gowe. 3-octanone was detected in all Gowe types whereas 2-Butanone was identified in sorghum Gowe and maize Gowe and 2-octanone only in steam cooked maize Gowe. Ethyl acetate was identified only in sorghum Gowe and maize Gowe. Regarding alcohols, ethanol, 1-hexanol, 3-Hexen-1-ol, Phenylethyl alcohol and 1-octen-3-ol were formed in all Gowe types. 1-octen-3-ol, the most abundant alcohol formed was found in lowest amounts in steam cooked maize Gowe than others Gowe types.

Table 1. Particle size and texture

Parameter and unit of measurement	SOP number	Respon-sible partner and lab	Variety/Treatment/Process/Raw material used							
			Malted and non-malted sorghum		Malted and non-malted Maize		Malted and non-malted maize and steam cooking		Sorghum malted and non-malted maize mixed	
			Number of samples	Mean +/-SD	Number of samples	Mean +/-SD	Number of samples	Mean +/-SD	Number of samples	Mean +/-SD
Physical:										
Particle size (% wet material)	Phys-cere-001-en	UAC @ UAC	9		6		6		6	
X < 45 µm				52.3±2.5		47.8±3 1		48.3±1.7		43.4±2.0
X < 150 µm				54.6±1.9		50.6±2.1		49.8±1.0		44.7±1.5
X < 180 µm				56.4±2.0		54.7±1.4		53.3±2.3		47.0±1.8
X < 300 µm				66.9±2.7		63.3±2.2		63.7±3.7		52.8±2.4
Organoleptic:										
Aroma compound	Phys-Cere-007-en	UAC @ CIRAD	3	See table 2	2	See table 2	3	See table 2-	2	See table 2-
Texture of liquid Product (uRVA)	Phys-Cere-008-fr	UAC @ UAC	9	320 ±122	6	339 ±108	6	156 ±51	6	280 ±80

Table 2. Aromatic compounds (Amount of volatile compounds is expressed as relative peak area / (10^7 × Threshold)

Compound	Sorghum Gowe (N=3)	Maize Gowe (N=2)	Maize Steam cooked Gowe (N=3)	'Sorghum and maize' Gowe (N=2)
Alcohols				
Ethanol	3,64E-05	5,31E-05	1,2E-05	2,43E-05
1-Butanol, 3-methyl-	6,79E-03	7,24E-03	2,55E-04	3,89E-03
1-Hexanol	5,72E-04	5,47E-04	7,74E-04	4,06E-04
3-Hexen-1-ol, (Z)-	1,07E-02	9,45E-03	6,29E-04	2,04E-03
1-Octen-3-ol	**3,88**	**4,13**	**1,68**	**12,05**
1-Octanol	1,79E-03	1,03E-03	Nd	Nd
Phenylethyl Alcohol	2,65E-03	3,74E-03	2,47E-04	1,04E-03
Carbonyls				
2-Butanone	2,12E-05	1,14E-05	Nd	Nd
Butanal, 3-methyl-	**Nd**	**Nd**	**2,25E-01**	**Nd**
Butanal, 2-methyl	**1,43E-02**	**Nd**	**1,27E-01**	**1,51E-01**
Pentanal	Nd	Nd	8,35E-03	Nd
Hexanal	2,05E-02	1,66E-02	2,1E-01	7,14E-02
Heptanal	**Nd**	**Nd**	**4,53E-01**	**1,52E-01**[c]
2-Hexenal	2,82E-02	Nd	Nd	Nd
3-Octanone	**1,10E-01**	**1,25E-01**	**7,31E-03**	**1,00E-01**
2-Octanone	Nd	Nd	2,75E-03	Nd
Octanal	**1,27E-01**	**Nd**	**6,94E-01**[c]	**3,34E-01**
1-Octen-3-one	**22,36**	**Nd**	**114,27**	**Nd**
Nonanal	**1,23**	**1,02**	**1,13**	**1,19**
2-Octenal, (E)-	2,48E-02	Nd	3,50E-01	1,27E-01
Benzaldehyde	6,38E-04	Nd	2,75E-03	1,16E-03
2-Nonenal, (E)-	**3,99**	**Nd**	**19,1**	**11,9**
Acids				
Hexanoic acid	2,33E-03	2,31E-04	Nd	Nd
Octanoic Acid	Nd	Nd	9,17E-05	Nd
Ester				
Ethyl Acetate	**7,31E-01**	**5,04E-01**	**Nd**	**Nd**
Phenols				
Phenol, 2-methoxy-4-methyl-	6,64E-03	1,25E-02	7,25E-04	5,55E-03
Phenol	Nd	Nd	Nd	6,71E-04
Phenol, 4-methyl-	6,65E-04	2,04E-02	Nd	Nd
Eugenol	5,38E-02	Nd	1,44E-01	Nd
Phenol, 4-ethyl-	1,74E-04	4,11E-04	4,02E-04	3,95E-04
2-Methoxy-4-vinylphenol	**1,06E-02**	**1,55E-01**	**7,18E-01**	**1,06**

Nd : Not detected

Annex 3 – detailed report for Kenkey

Particle size of dough

Results showed (Table 1, Figure 1) that Fanti dough had the finest particle size (with a median lower than 0.1 mm) hence giving a smoother Kenkey. Ga dough was the coarsest (median by 0.3 mm) and white dough intermediate (median by 0.15 mm). The maize grains for all three types of kenkey are steeped for 2 days before milling, therefore steeping cannot be responsible for the differences in particle size. White kenkey, however, is dehulled before steeping hence loss of the fibrous pericarp will give it finer particle sizes after milling. In all three cases the milled meal is kneaded into dough. With white kenkey this dough may be processed immediately into kenkey without any further fermentation, though some processors will allow the dough to ferment for up to 12 h before further processing. With Ga-kenkey, however, the dough is fermented for at least 2 days and Fanti kenkey for at least 3 days. The more extended fermentation of the Fanti dough will account for its particle size being finer than Ga dough as observed in Figure 1 since fermentation will result in further structural breakdown. Figure 1 shows that the extended fermentation of the Fanti dough eventually results in it having finer particle sizes than in the dehulled white dough. In Ga kenkey, however, the dough fermentation is not extensive enough to achieve this.

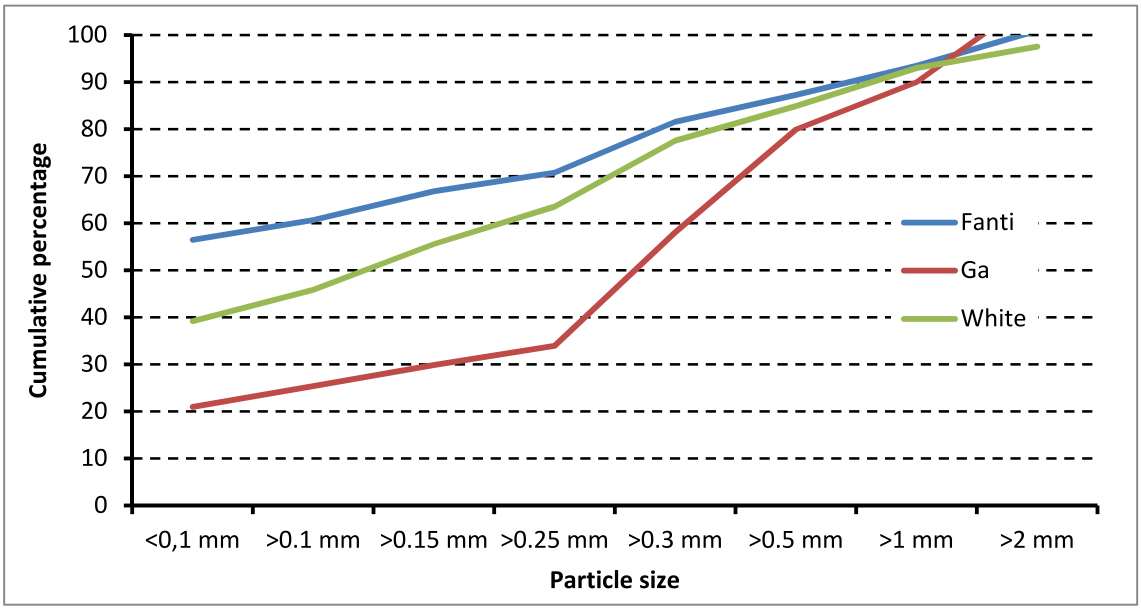

Figure 1. Distribution of particle size for traditional dough

Gelatinization level

There was 100% gelatinization of starch in all three types of kenkey. White kenkey is indeed steamed for 30 minutes, Ga kenkey cooked/boiled for 3 hours and Fanti kenkey cooked/boiled for 6 hours. These cooking regimes/times are sufficient to achieve complete gelatinization of starch in each case.

Colour parameters of the different types of Kenkey

L value measures the whiteness or lightness of a sample. The closer the L value is to 100, the more white the sample. White Kenkey recorded the highest L value of 81. This is because the

Kenkey is produced from dehulled maize grains which make the product whiter. Ga Kenkey and Fanti kenkey are produced using whole grain maize. Ga Kenkey had an L value of 72 and -Fanti Kenkey - 70 (Table 1). They were therefore less white but quite similar in their tinge of whiteness. This slight difference can be attributed to the two types of kenkey being wrapped and boild in different leaves i.e. plantain leaves for Fanti kenkey and dried maize husks for Ga kenkey. The leaves impart both colour and aroma to the products.

Table 1 Results for sensory, physical and textural analysis of kenkey (Group 1)

Property	Parameter and unit of measurement	SOP number	Respon-sible partner and lab	Variety/Treatment/Process/Raw material used								
				Fanti kenkey			Ga kenkey			White kenkey		
				Number of Samples	Mean	SD	Number of Samples	Mean	SD	Number of Samples	Mean	SD
Physical	Particle size (wet material)- Dough	Phys-cere-001-en	FRI @ FRI	9			9			18		
	> 2 mm				100,95	4.64		108,4	8.06		97,55	2.80.4
	> 1 mm				93,51	1.97		90,02	4.46		93,03	0.60
	> 0.5 mm				87,32	0.24		79,95	2.63		84,93	1.26
	> 0.3 mm				81,62	3.65		58,13	3.64		77,55	11.17
	> 0.25 mm				70,81	1.55		33,99	1.21		63,59	4.30
	> 0.15 mm				66,82	2.81		29,87	0.02		55,6	1.36
	> 0.1 mm				60,74	0.29		25,43	0.31		45,85	1.72
	< 0.1 mm				56.52.	12.49		20,96	5.75		39,21	16.84
	Median particle size (mm)				<0.1			0.3			0.15	
	Degree of gelatinization	Phys-cere-003-fr/en	FRI @ CIRAD	3	100		1	100		1	100	
Organo-leptic	Texture of solid product	Phys-Cere-005-en	FRI @ FRI		See table 2							
	Colour parameters L A b	Phys-Cere-006-en	FRI@ FRI	10	69.67 4.55 9.48	0.84 0.06 0.29	10	71.74 4.79 9.23	0.65 0.08 0.76	20	81.01 -0.90 7.59	1.90 0.44 1.53

Texture of different types of Kenkey

Table 2 illustrates maximum force, minimum force and stickiness of the three types of Kenkey. Maximum Force indicates hardness of samples. 50 g of kenkey was compressed using a 6 mm penetrometer till a deformation of 20 % of the sample occurred. The maximum force measured in this state of compression corresponded to the hardness of the kenkey sample. As the penetrometer retracted the minimum force was measured corresponding to the force of adhesion. The negative area under the curve measured the stickiness of the sample.

Table 2: Texture of the different types of kenkey

	Number of samples		Maximum Force (g)	Minimum force (g)	Stickiness(g.s)
Fanti kenkey	49	Mean	168	-45.	-64
		SD	91	12	28
Ga kenkey	72	Mean	225	-37	-44
		SD	107	18	35
White kenkey	56	Mean	204	-26	-28
		SD	57	10	18

Hardness values ranged from 168-225 g (Table 2) with Ga Kenkey having the hardest texture (225 g) and Fanti Kenkey the least hard (168 g). The results are in agreement with the results of obtained for particle size of the doughs and shown in table 1. Fanti Kenkey recorded a minimum force of 45 g and white Kenkey 26 g. Fanti kenkey has the most sticky texture of the three types of kenkey, and white kenkey the least sticky texture.

Annex 4 – detailed report for Kishk Sa'eedi

Beity (home quality) and Sooky (commercial quality) KS showed similar particle size; 20% of material has particle size more than 710 µm (Table 1). They, in addition showed similar whiteness; E value was close to 65 for both types of KS.

Degree of gelatinization, aroma and texture analysis will be performed at CIRAD from 15/06 to 14/07 during the stay of a PhD student from NRC. Concerning aroma, we will use Chromatography/Mass Spectrometry coupled with Gas Chromatography/Olfactometry to identify the main aromatic compounds. Concerning texture, we will develop specific instrumental methods for evaluating fracturability and grittiness. These methods will then be used as control tools in the re-engineering studies.

In the mean time, seven different KS samples representing the wide spectrum of sensorial quality were tasted using an unstructured line scale (D 5.3.2.1). The sensory evaluation test showed that traditional KS has good organoleptic properties. Substantial differences in sensory character were noted between the KS in particular, differences in color, fresh odor, KS taste and mouth coating. In general, high ratings for creamy colour, fresh odour, *KS* taste and fracturability are considered as positive effects that would be favoured by panellists while increase in caramel colour, sour taste, denseness and mouth coating are regarded as undesirable. This work showed that the application of QFD and PCA techniques could provide the useful information to KS and helped to identify the importance of product attributes.

Descriptive Sensory evaluations between of the KS eating panellists and non-KS eating panellists revealed that assessors perceive the sensory descriptors differently. The KS samples were acceptable to the non-KS eating panelists, but the typical KS aroma was not popular to them. Tastes i.e. sour, salty, spicy and KS taste; denseness, and grittiness were discriminating attributes. Fermented odour, color i.e. creamy and caramel; presence of fissure and presence of bran were least discriminating. KS non-eaters scored tastes attributes i.e. sour, salty, spicy, and KS taste lower than KS eaters whereas, creamy colour, denseness and grittiness were scored higher by KS non-eaters.

In addition consumer acceptance test for KS samples were conducted for both traditional KS eaters (n=225) and European consumer (n=85). Analysis is ongoing.

Table 1. Results for sensory, physical and textural analysis of kishk Sa'eedi (Group 1)

<table>
<tr><th rowspan="3">Property</th><th rowspan="3">Parameter and unit of measurement</th><th rowspan="3">SOP number</th><th rowspan="3">Respon-sible partner and lab</th><th colspan="6">Variety/Treatment/Process/Raw material used</th></tr>
<tr><th colspan="3">BEITY KS*</th><th colspan="3">SOOKY KS**</th></tr>
<tr><th>Number of Samples</th><th>Mean</th><th>SD</th><th>Number of Samples</th><th>Mean</th><th>SD</th></tr>
<tr><td rowspan="2">Physical</td><td>Particle size (dry material) (% over 710 µm)</td><td>Phys-cere-004-en</td><td>NRC@ NRC</td><td>28</td><td>19%</td><td>1.39</td><td>7</td><td>20.17%</td><td>1.41</td></tr>
<tr><td>Degree of gelatinization</td><td>Phys-cere-003-fr/en</td><td>NRC @NRC and CIRAD</td><td colspan="6">Will be performed in July 2013</td></tr>
<tr><td rowspan="4">Organo-leptic</td><td>Aroma compound</td><td>Phys-Cere-007-en</td><td>NRC @ CIRAD</td><td colspan="6">Sensory tests performed: 11 samples by 35 pannelists
Consumers: 5 samples by 225 consumers) (D 5.3.2.1)
The analysis of aromatic compounds will be performed during the stay of Egyptian PhD student in CIRAD (15/06 to 14/07/2013)</td></tr>
<tr><td rowspan="2">Texture of solid product</td><td rowspan="2">Phys-Cere-005-en</td><td rowspan="2">NRC @ CIRAD and NRC</td><td>5</td><td></td><td></td><td>2</td><td></td><td></td></tr>
<tr><td colspan="6">Sensory tests performed: 11 samples by 35 pannelists
Consumers: 5 samples by 225 consumers) (D 5.3.2.1)
Instrumental tests will be performed during the stay of Egyptian PhD student in CIRAD (15/06 to 14/07/2013)</td></tr>
<tr><td>Colour index (E)</td><td>Phys-Cere-006-en</td><td>NRC @ FAAU</td><td>28</td><td>65.41</td><td>3.09</td><td>7</td><td>64.56</td><td>3.46</td></tr>
</table>

* KS homemade, home quality
** KS homemade, commercial quality