African food tradition revisited by research

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Contents

Executive summary

The chemical, biochemical, nutritional and anti-nutritional qualities 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 for chemical and biochemical qualities. A more limited number of samples were analyzed for the nutritional and anti-nutritional qualities due to the cost of these analyses and the quantity of material needed.

Proximate analysis of the different traditional products is now well known, and the effect of the type of technology is characterized; for example, Akpan from maize ogi and White Kenkey that are prepared from degermed and dehulled maize, were poorer in fiber, ash, and crude fat that mainly originate from pericarp and germ, respectively. This also implies that these products (the preferred ones in urban areas in Africa and/or the most promising one for export) have lower nutritional qualities, i.e. for example dramatically lower vitamin and essential minerals such as Zn and Fe. For Kishk Sa'eedi, on the contrary, the commercialized product is richer in Zn and Fe than the self-consumed one.

The acidity and pH of the different versions of the products is known; for each product, lactic acid is the dominant, and almost the unique, organic acid. Sugar content is also known; it is low for akpan (less than 1%, dry basis), quite low for Kenkey (~ 2 %) and high for Gowé (> 10%). Glucose is the main sugar for every product but maltose is also important in the case of gowé, due to the action of malt alpha and beta-amylase. It should also be noticed that our analyses revealed some deviation in the traditional process; some sucrose was detected in Gowé, that was added by processors that surely do not succeed in the malting process.

As the whole, anti-nutritional compounds (cyanide, tannins and phytate) levels were quite low in the products. In particular, cyanide level was reasonably low in Gowé (which was important to check as cyanogenic compounds are synthesized during germination of sorghum), but close to the recommended limit of the WHO,

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

Six samples were collected from different producers for each of the four main technologies used for preparing akpan. They were analyzed for the main chemical and biochemical constituents and for nutritional and anti-nutritional compounds.

Concerning chemical and biochemical constituents (Table 1), it appears that akpan was a product with high water content (80.4 to 84.9 %). Titratable acidities of akpan from ogi, either from sorghum or maize were similar (2.8-2.9 % lactic acid) and lower than that of akpan from mixed dough and akpan from sorghum dough (3.1-4.1 % lactic acid). Lactic acid was the predominant (13.3-20.4 %) organic acid in all types of akpan and represented half of titratable acidity. Akpan from mixed “maize + sorghum “dough had a highest value of protein (12.0 %) and fibre (1.5%) contents at the opposite to Akpan from maize ogi which had the lowest protein (6.3 % db) and fibre (0.7 %) contents. As expected akpan from sorghum dough had higher fibre content (1.3 %) than akpan from ogi (0.7%), since fibre was lost during the sieving step of ogi process. Sucrose (0.1-0.6 %) was the main sugar in all of type of akpan; it was higher for akpan made from sorghum. It should however be noticed that sugar content remained quite low (less than 1%) in all akpan products.

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Concerning anti-nutritional compounds, we assessed the content of tannins and phytates that can interact with proteins, vitamins and minerals, thus restricting their bio-availability (Bhise et al., 1988). Tannin content was very low for any technology (Table 2); low tannin sorghum grains were thus used for preparing akpan. Phytate content appeared lower for akpan prepared with the ogi technology with a mean value was 0.58-0.59 g IP6/100 for Akpan from sorghum ogi and Akpan from maize ogi, against 0.78-0.79 g IP6/100 g for Akpan from sorghum dough and Akpan from mixed’’ sorghum and maize’’ dough. The procedure of processing ogi indeed includes a wet dehulling and degerming step that can reduce phytate content (El Hag et al., 2001, Lestienne et al., 2003; Ejigui et al ., 2005).

Mineral and vitamin determinations will be performed later due to equipment problems. This will be performed on a restricted sample number due to the high cost of analysis and the difficulty of freeze-drying a sufficient amount of sample for the analyses.

Table 1. Results for chemical and biochemical analysis of akpan

Parameter and unit of measurement		SOP number	Respon-sible partner and lab	Variety/Treatment/Process/Raw material used							
				Sorghum ogi		Sorghum dough		Maize ogi		Maize and sorghum mixed dough	
				Sample Number	Mean +/-SD	Sample Number	Mean +/-SD	Sample Number	Mean +/-SD	Sample Number	Mean +/-SD
Moisture (% wb)		Chem-cere-025/024-fr	UAC@ UAC	6	83.4 ± 3.4	6	83.8 ± 3.5	6	84.9 ± 3.7	6	80.4 ± 2.6
Organic acid (%)	Citric acid Lactic Acid Formic acid Propionic acid	Chem-cere-002-fr	UAC @ UAC	6	- 1.4±0.21. - 0.2±0.2	6	- 2.0±0.3 - 0.8±0.8	6	0.4±0.6 1.2±0.6 0.3±0.5 -	6	0.1±0.1 1.3±0.7 0.1±0.1 0.5±0.8
Acidity (% lactic acid)		Chem-cere-009-fr	UAC @ CIRAD	6	2.8 ± 0.7	6	4.1 ± 0.9	6	2.9 ± 0.9	6	3.1 ± 0.9
Crude ash		Chem-cere-017-en	UAC@ UAC	6	1.4±0.2	6	2.9±0.5	6	0.5±0.1	6	0.9±0.3
Crude protein in cereal products		Chem-cere-022-en	UAC @UAC	6	9.5± 1.5	6	9.2±0.6	6	6.3±0.9	6	12.0±1.1
Total fibre (% db)		Chem-cere-028-en	UAC@ UAC	4	0.7±0.3	2	1.3±0.2	6	0.7±0.4	2	1.5±0.4
Crude fat (% db)		Chem-cere-13-fr	UAC @ CIRAD	4	1.1±0.5	2	1.2±0.3	6	2.2±0.1	2	1.5±0.5
Sugars (%)	Raffinose Sucrose	Chem-cere-002-fr	UAC @ UAC	6	0.4±0.4 0.6±0.9	6	0.4±0.1 0.5±0.2	6	0.1±0.1 0.1±0.2	6	0.3±0.2 0.4±0.4

Table 2. Results for nutritional and anti-nutritional quality of akpan (Group 1)

Property	Parameter and unit of measurement	SOP number	Respon-sible 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
Nutritional factors	Mg, Fe etc	Chem-cere-19-en	UAC @ UAC	0 (see text)							
	Vitamins	Sub-contracted	UAC @ CIRAD	0 (see text)							
	Total amino acids	Nutri-cere-003-fr	UAC @CIRAD	2	See table 3	1	See table 3	2	See table 3	2	See table 3
Antinutri-tional factors	Phytate (IP6) (g/100g)	Anti-Nutri-cere-001-fr	UAC @ UAC	6	0.58 ±0.15	5	0.78 ±0.21	6	0.59 ±0.09	6	0.79 ±0.11
	Tannins (% db)	Anti-Nutri-cere-004-fr	UAC @ UAC	6	0.02 ±0.01	6	0.05±0.00	6	0.02±0.01	6	0.05±0.02

Table 3 shows the amino-acid profiles of traditional akpan. They are all very similar whatever the technology but sorghum akpan displayed double value of some amino-acids (glutamic acid etc). In any case, methionine and lysine are the most limiting amino-acids; 20 g of dried akpan (that is more or less the ration for an ordinary akpan consumer), represents less than 5% of the Recommended Daily Intake (RDI) for methionine and lysine.

Table 3. Amino-acid profiles of traditional Akpan

Process	**Sorghum ogi**	**Maize ogi**	**Sorghum dough**	**Maize and sorghum mixed dough**	**RDI**	**% RDI**
	Content (%, g/g dry basis)				**(mg/ 70 kg)**	**(/20 g akpan)**
Number of samples	2	2	1	2		
Leucine	1,14	0,75	1,30	1,15	980	22
Phenylalanine	0,42	0,26	0,50	0,43	980	8
Methionine	0,15	0,12	0,17	0,18	910	3
Lysine	0,19	0,18	0,25	0,26	840	5
Valine	0,43	0,31	0,48	0,45	700	12
Isoleucine	0,33	0,20	0,37	0,32	700	9
Aspartic acid	0,51	0,36	0,63	0,58		
Threonine	0,25	0,20	0,32	0,29		
Serine	0,32	0,26	0,41	0,38		
Glutamic acid	1,82	1,19	2,09	1,85		
Glycine	0,26	0,22	0,33	0,32		
Alanine	0,83	0,53	0,96	0,83		
Cystine	0,12	0,06	0,16	0,17		
Tyrosine	0,37	0,25	0,52	0,39		
Gaba	0,01	0,00	0,02	0,01		
Histidine	0,22	0,21	0,26	0,27		
Arginine	0,29	0,27	0,38	0,38		
Proline	1,39	0,92	1,64	1,40		

Annex 2 – detailed report for Gowe

Six to nine samples were collected from different producers for each of the four main technologies used for preparing gowé. They were analyzed for the main chemical and biochemical constituents and for nutritional and anti-nutritional compounds.

Concerning chemical and biochemical constituents (Table 1), the acidity of the Gowe samples collected at the market ranged between 2.4 and 3.8% (lactic acid equivalent, dry basis) with significant difference between technologies. Maize Gowe has the highest acidity (3.8% of lactic acid) followed by sorghum Gowe (3.3% of lactic acid), mixed ‘sorghum and maize’ Gowe (3.1% of lactic acid) and maize steam cooked Gowe (2.4% of lactic acid). Moisture content of steam cooked Gowe (63.4% wb) was significantly lower than Gowe obtained without steam cooking (76.5 to 78.6 % wb). Protein content of the Gowe samples were found to be 11.1% for sorghum Gowe, 10% for maize Gowe, 9.9% for maize with steam cooked Gowe and 9.5% for mixed ‘sorghum and maize’ Gowe. Ash (total minerals) content varied from 0.7-0.8% (db) for maize gowé to 2.0% for sorghum one. Total fibre content in sorghum Gowe and maize Gowe was 1.3 and 1.9 (% db), respectively. Crude fat content was higher in maize Gowe (1.5 % db) than in sorghum Gowe (1.1% db). Sugars identified in the Gowe samples included maltose, glucose, sucrose and fructose. In the Gowe types obtained without steam cooking, sucrose (6.6-7.1%) was the dominant sugar, followed by glucose (1.9-5.8%), maltose (0.4-4.0) and fructose (0.8-1.7%). In maize steam cooked Gowe, sucrose was not identified and the glucose (9.2%) was the dominant sugar. The presence of sucrose is probably due to added commercial sugar (sucrose is indeed normally very low in fermented cereal products) to increase the sweet taste of final product, which should be presumably low because malting failure. This pointed out the poor skill of Gowe processors on malting and/or a modification of the traditional process by decreasing malting duration that is indeed time consuming. Lactic acid (1-2.3%, db) was the dominant organic acid. Acetic acid was also detected in most commercial Gowe samples, but at very low level. Not other organic acid was evidenced. Lactic and acetic acids represented half to two third of total acidity.

Concerning anti-nutritional compounds, we assessed (Table 2) the content of tannins and phytates that can interact with proteins, vitamins and minerals, thus restricting their bio-availability (Bhise et al., 1988). We also determined cyanids level as cyanogenic glucides may be synthesized during germination, particularly in the case of sorghum. Phytate content of Gowe collected at the market ranged between 0.29 and 0.53 g IP6/100g, with significant difference between technologies. Mix ‘sorghum and maize’ Gowe (0.53 g IP6/100g) had the highest phytate content while maize Gowe, the lowest (0.29 g IP6/100g). These values are higher than those reported by Kayode *et al.* (2006) who observed 0.1 g IP6/100g in Tchoukoutou, a Beninese sorghum beer. In both cases, germination activates endogenous grains phytase which can degrade phytate (Syanberg and Lorri, 1997). In addition, the LAB and yeasts involved in Gowe or Tchoukoutou fermentation can also produce phytase and degrade phytate into its lower forms, i.e. IP5 (inositol-pentakisphosphate), IP4, etc., and inorganic ortho-phosphate (Pi) that is used by these microorganisms for their growth (Kerovuo and Tynkkynen, 2000).Thus, the difference in values observed could be related to the specificity of each technology. Concerning tannin content, there was no significant difference between the different types of commercial Gowe samples, and it was very low (0.05 %, db) in any sample. This should mean that tannin free cultivar was used for preparing gowé. Regarding the cyanide content of Gowe, varied between 11.6 and 13.1 mg/kg (dry basis) without any technology difference. It was low, but not so far from the safe limit recommended for cassava flour, for example (10 mg/kg) (FAO/WHO, 1991). The cyanide content of Gowe in our study is similar with value observed on sorghum malt by Adinsi (2010) and lower than that obtained by Traoré *et al*. (2004) on red sorghum malt.

Mineral and vitamin determinations will be performed later due to equipment problems. This will be performed on a restricted sample number due to the high cost of analysis and the difficulty of freeze-drying a sufficient amount of sample for the analyses.

Table 1. Results for chemical and biochemical analysis of gowé (Group 1)

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
Moisture (% wet basis)	Chem-cere-025/024	UAC @ UAC	9	76.5 ±2.6	6	78.6 ±2.7	6	63.4 ±1.9	6	77.2 ±1.7
Organic acid (% dry basis) Lactic acid Acetic acid	Chem-cere-002-fr	@ UAC UAC	9	2.0±0.5 0.05±0.08	6	2.3 ±2.1 0.2±0.2	6	1.0 ±0.6 0.1±0.1	6	2.0±0.8
Acidity (% lactic acid)	Chem-cere-009-?	UAC @ CIRAD	9	3.3 ±0.7	6	3.8 ±0.8	6	2.4 ±0.5	6	3.1 ±0.7
Crude ash (% dry basis)	Chem-cere-017-en	UAC @ UAC	9	2.0 ±0.3	6	0.7 ±0.1	6	0.8 ±0.1	6	1.3 ±0.2
Crude protein in cereal products (% dry basis)	Chem-cere-022-en	UAC @ UAC	9	11.1± 0.7	6	10.0 ±0.9	6	9.9±0.8	6	9.5±0.4
Total fibre (% dry basis)	Chem-cere-028-en	UAC @ UAC	7	1.3 ±0.2	3	1.9±0.09				
Crude fat (% dry basis)	Chem-cere-13/23-?	UAC @ UAC	7	1.1 ±0.1	3	1.5 ±0.2				
Sugar (% dry basis) Maltose Sucrose Glucose Fructose	Chem-cere-002-fr	UAC @ UAC	9	0.9±1.6 7.1±4.6 3.8±2.3 1.7±1.3	6	0.4±0.5 6.7±6.4 1.9 ±1.3 1.7±1.4	6	5.8±1.8 - 9.2 ±1.7 0.8±0.2	6	4.0±5.6 6.6±9.3 5.8 ±5.1 1.3±1.1

Table 2. Results for nutritional and anti-nutritional quality of gowé (Group 1)

Property	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
Nutritional factors	Mg, Ca, Fe, Na, Cu, Zn	Chem-cere-19-en	UAC @ UAC	0 (see text)							
	Total amino acids	Nutri-cere-003-fr	UAC @CIRAD	(see table 3)							
	Vitamins	Sub-contracted	UAC @ CIRAD	0 (see text)							
Antinutritional factors	Phytate (IP6) (g/100g)	Anti-Nutri-cere-001-fr	UAC @ UAC	9	0.46 ±0.08	6	0.29 ±0.14	6	0.34 ±0.1	6	0.53 ±0.07
	Tannins (% dry basis)	Anti-Nutri-cere-004-fr	UAC @ UAC	9	0.05 ±0.02	6	0.06 ±0.02	6	0.05 ±0.01	6	0.05 ±0.009
	Cyanids (mg/kg dyr basis)	Anti-Nutri-cere-005-fr	UAC @ UAC	9	12.5 ±2.2	6	12.5±0.9	6	11.6±1.7	6	13.1±1.1

Table 3 shows amino-acid profiles of traditional gowé samples. They are all very similar whatever the technology and the raw material (sorghum or maize). In any case, methionine and lysine are the most limiting amino-acid in the diet of 100 g of gowé, representing less than Recommended Daily Intake (RDI).

Table 3. Amino-acid profile of traditional Gowé

Process	Malted and non malted sorghum	Malted and non malted maize	Malted and non-malted maize and steam cooking	RDI (mg/ 70 kg)	% RDI (/20 g)
		Content (%, g/g)			
Number of samples	3	3	2		
Leucine	1,19	1,02	1,20	980	23
Phenylalanine	0,43	0,36	0,42	980	8
Methionine	0,15	0,12	0,19	910	3
Lysine	0,24	0,28	0,27	840	6
Valine	0,47	0,42	0,49	700	13
Isoleucine	0,33	0,27	0,32	700	9
Aspartic acid	0,58	0,50	0,58		
Threonine	0,30	0,28	0,31		
Serine	0,39	0,36	0,39		
Glutamic acid	1,93	1,66	1,86		
Glycine	0,33	0,32	0,37		
Alanine	1,06	0,83	0,94		
Cystine	0,00	0,00	0,00		
Tyrosine	0,36	0,31	0,40		
Gaba	0,00	0,01	0,03		
Histidine	0,25	0,28	0,31		
Arginine	0,35	0,35	0,40		
Proline	1,52	1,30	1,52		

Annex 3 – detailed report for Kenkey

Results of chemical and biochemical analysis of Kenkey are illustrated in Table 1. Moisture content of Kenkey types was from 67- 76g/100g with quite low SD; traditional products were thus not very variable on this point. Crude ash mean value for Ga Kenkey was 0.92g/100g, that for Fanti Kenkey was 0.71g/100g and that for White Kenkey 0.87 (Table 1). White kenkey had the least protein, fibre and crude fat contents: 2.4, 0.13 and 0.16 g/100g compared to 5.1, 1.22 and 1.02 g/100g for Fanti Kenkey. Fanti and Ga Kenkey are produced from whole grain maize whilst White Kenkey is produced from dehulled maize grain (pericarp and germ are discarded); white kenkey thus contains mainly endosperm which reduces protein, fibre and crude fat contents. According to studies by Obiri-Danso *et al*., (1997) and Annan-Prah and Agyeman, (1997), moisture of Ga Kenkey is 64.5%, ash content ranged from 0.5-1.9g/100g, fat content 1.3-3.2g/100g, protein content is 8.9-9.8g/100g. All parameter were in the literature range except protein content which was very low compared to literature value. However the protein content will depend on the maize variety used to prepare the kenkey.

Glucose was the main sugar in traditional Kenkey. Ga and White Kenkey recorded highest glucose value of 2.4-2.5 % (dry basis) and Fanti Kenkey the least value of 0.7 %. pH values were low for Ga and Fanti Kenkey, (3.40 and 3.78 mean values, respectively), but relatively high (4.39 mean value) for white Kenkey. Low pH values recorded by Ga and Fanti Kenkey were a result of the 48 hours fermentation time for whole maize dough used in their production. The general reduction in pH during fermentation is indicative of acid production by microorganisms present during fermentation and Ga and Fanti Kenkey had indeed a much higher titratable acidity (2.6 to 3.0 % lactic acid equivalent dry basis) than white kenkey (0.4%)..There was however a very large dispersion in titratable acidity between processors with standard deviation representing between 30 to 50% of the mean value for each kenkey type. This indicates large variability in the processing conditions between processors. Lactic acid was the main organic acid, in any Kenkey type; only very minor amounts of acetic acid could be detected. Lactic acid represented more than 50% of total acidity.

Mineral content of Kenkey types is shown in Table 2. White kenkey appeared poorer in mineral contents than Ga and Fanti kenkey; Zn content was in particular 4 times lower. This was surely due to the dehulling and degerming step during white Kenkey processing. The consumption of two balls of Fanti and Ga Kenkey (700 g with 68% water content) can cover 12% of Zn needs (15 mg), but not more than 3% for White kenkey. Watson (1987) indicated that iron content of maize was 30 mg/kg, which is in the range of the values measured on Kenkey samples. Similarly, Kenkey consumption could cover between 30 and 50% of iron needs (18 mg), if it were completely available.

Table 3 shows amino-acid profiles of traditional Kenkey samples. They are all quite similar whatever the type, except that White Kenkey has lower lysine content. Methionine and lysine are the most limiting amino-acid in the diet of 700 g of White Kenkey (250 g dry matter), representing more or less 50% of Recommended Daily Intake (RDI).

The level of the most important (in term of RDI coverage) vitamin was assessed for traditional Kenkey (Table 4). White Kenkey appears very poor in vitamins compared to the other Kenkey types; the value is for example ten folds lower for vitamin B1. This was due to degmering and dehulling during processing white Kenkey that thus eliminated a large part of the vitamins which are mainly located in the germ and aleurone layer. The consumption of two balls of Fanti and Ga Kenkey (700 g with about 68 % water content) can cover 11 to 37% of vitamin Recommended Daily Intakes (RDI). The consumption of two balls of White Kenkey could however cover less than 10% of vitamin RDI; except for vitamin B8, for which White Kenkey will cover 25% of RDI.

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Table 1. Results for chemical and biochemical analysis of kenkey (Group 1)

Parameter and unit of measurement	SOP number	Responsible 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
Moisture (%)or g/100g	Chem-cere-025/024	FRI @ FRI	12	68.16	1.67	12	67.40	3.30	12	73.25	3.01
Organic acids (%, dry basis): Lactic acid	Chem-cere-002-en	FRI @ UAC	1	1.6		1	2.0		1	0.2	
Acidity (% lactic acid dry basis)	Chem-cere-009-?	FRI @ FRI	9	2.59	0.77	9	2.95	1.14	18	0.43	0.22
pH	Chem-cere-009-?	FRI @ FRI	14	3.78	0.17	14	3.40	0.15	8	4.40	0.36
Crude ash (g/100g)	Chem-cere-017-en	FRI @ FRI	12	0.71	0.05	12	0.92	0.08	12	0.87	0.12
Crude protein in cereal products (g/100g)	Chem-cere-022-en	FRI @ FRI	10	5.06	0.68	10	5.36	1.13	16	2.39	0.62
Total fibre (g/100g)	Chem-cere-028-en	FRI @ FRI	1	1.22					1	0.13	
Fat acidity (in grain and flour)	Chem-cere-016-?	FRI @ FRI							7 (maize grains)	4.81	2.24
Crude fat (mg of KOH/100g)	Chem-cere-13/23-?	FRI @ FRI	10	1.02	0.32	11	0.95	0.18	15	0.16	0.05
Sugar (%, dry basis) Glucose	Chem-cere-002/fr	FRI @ CIRAD	1	0.7		1	2.5		1	2.4	

Table 2. Results for nutritional and anti-nutritional quality of Kenkey (Group 1)

Property	Parameter and unit of measurement	SOP number	Responsible 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
Nutritional factors	Fe (mg/kg) dry basis	Chem-cere-19-en	FRI @ FRI	2	25	2	2	37	4	2	22	3
	Cu(mg/kg) dry basis	Chem-cere-19-en	FRI @ FRI	2	1.3	0.	2	1.5	0.3	2	0.77	0.19
	Zn (mg/kg) dry basis	Chem-cere-19-en	FRI @ FRI	2	7.8	0.1	2	6.8	0.4	2	1.8	0.4
	Total amino acids	Nutri-cere-003-fr	FRI @ CIRAD	See table 3								
	Vitamins	Sub-contracted	FRI @ CIRAD	See table 4								
	Total phosphorus	Chem-cere-018-en	FRI @ FRI							5	5.3	1.0

Table3. Amino-acid profile of traditional Kenkey

Amino-acid	Fanti	Ga	White (g/100 g, db)	Sweet	Anum	RDI (mg/ 70 kg)	% RDI (/250 g Fanti or Ga)	% RDI (/250 g White)
Leucine	1,17	1,17	1,37	0,81	1,02	980	298	349
Phenylalanine	0,40	0,41	0,43	0,26	0,31	980	104	111
Methionine	0,19	0,22	0,19	0,10	0,19	910	56	**51**
Lysine	0,27	0,27	0,16	0,15	0,19	840	80	**48**
Valine	0,49	0,47	0,44	0,27	0,37	700	171	156
Isoleucine	0,34	0,34	0,33	0,19	0,26	700	121	119
Aspartic acid	0,54	0,51	0,45	0,30	0,36			
Threonine	0,31	0,29	0,26	0,17	0,23			
Serine	0,22	0,22	0,21	0,13	0,18			
Glutamique acid	1,85	1,83	2,03	1,30	1,70			
Glycine	0,38	0,34	0,24	0,16	0,25			
Alanine	0,91	0,91	0,91	0,56	0,73			
Tyrosine	0,35	0,47	0,37	0,41	0,33			
Gaba	0,08	0,04	0,00	0,01	0,01			
Histidine	0,30	0,30	0,30	0,21	0,28			
ornitine	0,07	0,08	0,02	0,00	0,00			
Arginine	0,25	0,22	0,22	0,14	0,21			
Proline	1,27	1,33	1,46	0,94	1,16			
Sum	10,39	10,32	9,40	6,95	8,69			

Table 4. Vitamin levels (µg/100 g, dry basis) of traditional Kenkey and RDI for vitamins

	Fanti kenkey	Ga kenkey	White kenkey	Sweet kenkey	Anum Kenkey	RDI (µg/70 kg)	% RDI (/700 g white kenkey)	% RDI (/700 g Fanti or Ga kenkey)
Vitamin B1	113	200	17	36	47	1300	3,3	30,1
Vitamin B3	807	643	138			17000	2,0	10,7
Vitamin B6	241	235	30	123		1600	4,7	37,2
Vitamin B8	5	10	6			60	25,0	31,3
Vitamin E	1193	694	405	404		15000	6,8	15,7

Annex 4 – detailed report for Kishk Sa'eedi

Samples were directly collected from processors for analysis; twenty eight samples of KS distained for home consumption (Beity KS) and seven KS distained for commercialization (Sooky KS).

With respect to proximate analysis (Table1), KS distained for home consumption (Beity KS) showed higher final moisture content as well as higher fibre and ash content. On contrary, KS distained for commercialization (Sooky KS) showed lower protein content. Same trend were reported for fat where KS for home consumption (Beity KS) were higher in fat content compared with KS for commercialization.

A number of analyses will indeed be performed during re-engineering as they concern intermediate products; for example protein in milk, or fat acidity of wheat grain (see D2.2.1 where some results are reported).

Table 1. Results for chemical and biochemical analysis of kishk Sa'eedi (Group 1)

Parameter and unit of measurement	SOP number	Respon-sible partner and lab	Variety/Treatment/Process/Raw material used					
			BEITY KS*			SOOKY KS**		
			Number of Samples	Mean	SD	Number of Samples	Mean	SD
Moisture (%)	Chem-cere-025/024	NRC @ NRC	28	9.91	1.67	7	9.6	1.99
Organic acid	Chem-cere-002-en	NRC @ NRC	Standards ordered (on going): 2-3 months					
Titrable Acidity	Chem-cere-009-?	NRC @ NRC	28	1.36	0.55	7	1.74	0.76
Total starch	Chem-cere-010/11-?	NRC @ NRC	14	66.97	0.21	3	65.62	0.24
Crude ash (%) on dry basis	Chem-cere-017-en	NRC @ NRC	28	6.59	1.59	7	7.19	2.30
Crude protein in milky products	Chem-cere-021-en	FAAU @ FAAU	This will be analyzed during re-engineering, not in the end product					
Crude protein in cereal products (%) on dry basis	Chem-cere-022-en	NRC @ NRC	28	15.21	2.18	7	13.86	1.78
Protein in milk	Chem-cere-027-en	FAAU @ FAAU	This will be analyzed during re-engineering, not in the end product					
Non protein nitrogen (in whole milk)	Chem-cere-026-en	FAAU @ FAAU	This will be analyzed during re-engineering, not in the end product					
Total fibre (%) on dry basis	Chem-cere-028-en	NRC @ NRC	28	0.93	0.36	7	1.67	0.34
Fat acidity (in grain and flour)	Chem-cere-016-?	FAAU @ FAAU	This will be analyzed during re-engineering, not in the end product					
Crude fat (%) on dry basis	Chem-cere-13/23-?	NRC @ NRC	28	5.97	2.83	7	3.77	1.32
Total fatty acids	Chem-cere-029-en	FAAU @ FAAU	10	See table 2			See table 2	

* KS homemade and destined for home consumption
** KS homemade and destined for commercialization

Concerning fatty acids profiles, table 2 shows that Kishk Sa'eedi fat contains palmitic acid (C16:0) with mean 28.17±2.87, 28.23±2.73 for Beity KS and Sooky KS respectively , oleic acids (C18:1) with mean 22.19±2.13, 19.84±2.84 for Beity KS and Sooky KS respectively and Linoleic acid (C18:2) with mean 23.33±10.19, 19.53±4.88 for Beity KS and Sooky KS respectively. These data showed that the KS samples contain similar level of palmitic acid in milk and low level of oleic acids with milk and significantly higher level of Linoleic acid with milk.

Table 2. Fatty acid profile of KS

	Beity KS*		Sooky KS**	
Fatty acids	**Mean**	**SD**	**Mean**	**SD**
C6:0	0.16	0.12	0.85	0.55
C8:0	0.49	0.12	0.46	0.13
C10:0	0.82	0.24	0.99	0.43
C12:0	1.14	0.10	1.31	0.51
C13:1	0.00	0.00	0.17	0.18
C14:0	4.77	1.65	6.64	1.71
Unknown	0.10	0.20	0.40	0.26
C14:1n9t	0.21	0.27	0.44	0.26
C14:1n9c	0.51	0.35	0.96	0.27
C15:0	0.98	0.74	1.40	0.32
C15:1	0.23	0.20	0.60	0.38
C16:0	28.17	2.87	28.23	2.73
C16:1n9t	0.76	0.62	0.62	0.17
C16:1n9c	1.56	0.78	1.68	0.59
Unknown	0.13	0.25	0.85	0.22
C17:0	0.82	0.69	1.11	0.31
C17:1	0.41	0.32	0.50	0.06
C18:0	6.66	2.45	7.52	0.94
C18:1n9t	1.61	0.98	2.46	1.08
C18:1n9c	22.19	2.13	19.84	2.84
Unknown	0.32	0.39	0.50	0.86
Unknown	0.26	0.30	0.22	0.21
C18:2n6t	0.17	0.33	0.39	0.39
C18:2n6c	23.33	10.19	19.53	4.88
C20:1	0.21	0.24	0.17	0.16
C18:3n3	1.94	0.98	1.73	0.38
C20:0	0.86	0.36	0.40	0.30
C21:0	0.54	0.63	0.68	0.39
C22:0	0.09	0.18	0.17	0.16
C22:1n9	0.10	0.21	0.10	0.15

* KS homemade and destined for home production
** KS homemade and destined for commercialization

Nutritional evaluation of 7 KS samples in terms of minerals content showed (Table 3) that KS is good source of essential nutrient like iron, calcium as well as zinc.

According to the average iron content, 100 g KS will provide the body with about 0.4 mg iron. Based on the field survey we can conclude that 200 g ks per day, which is an acceptable average consumption for ordinary consumer, will provide 0.8 mg iron/ day. This value represents about one tenth of the recommended daily requirement (8.0 mg/day for adult); by comparison one table spoon molasses will provide 0.9 mg iron (National institute of Health (NIH), http://ods.od.nih.gov/factsheets/Iron-HealthProfessional/)

Comparison of KS for home consumption (Beity KS) and for commercialization (Sooky KS) showed that KS for home consumption were richer in nutrients, i.e. contain more Fe, Zn, and calcium. In general KS contained very high content of sodium where KS for home consumption were lower in sodium content compared to KS for commercialization. Noteworthy, the KS is usually soaked before eaten where excess salt is discarded.

Phytate were analysed and results showed that KS for home consumption contained less phytate which is good from nutritional point of view.

Table 3. Results for nutritional and anti-nutritional quality of kishk Sa'eedi (Group 1)

Property	Parameter and unit of measurement	SOP number	Respon-sible partner and lab	Variety/Treatment/Process/Raw material used					
				BEITY KS*			SOOKY KS**		
				Number of Samples	Mean	SD	Number of Samples	Mean	SD
Nutritional factors	Mg (ppm)	Chem-cere-19-en	NRC @NRC	5	1.53	0.25	2	1.82	0.26
	Ca (ppm)	Chem-cere-19-en	NRC @NRC	5	612.0	29.54	2	197.0	29.70
	Na (ppm)	Chem-cere-19-en	NRC @NRC	5	1431.1	4.11.8	2	2120.0	896.61
	Cu (ppm)	Chem-cere-19-en	NRC @NRC	5	0.21	0.12	2	0.12	0.01
	Zn (ppm)	Chem-cere-19-en	NRC @NRC	5	2.22	0.47	2	2.14	0.10
	Fe (ppm)	Chem-cere-15-en	NRC @ NRC	5	3.97	0.66	2	3.79	1.25
	Total phosphorus (ppm)	Chem-cere-018-en	NRC @ NRC	5	201.24	21.54	2	166.90	45.11
	Total amino acids	Nutri-cere-003-fr	NRC @ NRC	Analysis is ongoing					
	Vitamins	Sub-contracted	NRC @ CIRAD	Will be analyzed in July					
Anti-nutri-tional factors	Phytate (IP6)	Anti-Nutri-cere-001-?	NRC @ NRC	5	0.48	0.34	2	0.67	0.17
	Total Phenolic compounds (mg/g)	Anti-Nutri-cere-002-fr	NRC@ NRC	5	1.59	0.65	2	2.39	0.15

* KS homemade and destined for home production
** KS homemade and destined for commercialization