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Kishk – a dried fermented milk/cereal mixture. 3. Nutritional composition

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Abstract — An investigation of the nutritional properties of 25 commercial samples of Lebanese Kishk was undertaken. Profiling of the carbohydrate-based nutrients (g·100 g^{-1} on dry matter basis [DMB]) in the samples gave the following ranges: fibre 7–12, phytic acid 0.7–1.6, and β-glucan 0.1–0.6. Some Kishk samples contained appreciable amounts of polyunsaturated fatty acids, while the contents of monounsaturated fatty acids of most of the samples were considerably lower than those present in milk and other dairy products. All the Kishk samples contained appreciable quantities (mg·100 g^{-1} [DMB]) of the major minerals (K 495, P 397, Ca 243 and Mg 123), and such product was a good source of Fe and Mn which originated from the Burghol. Sodium was present in high amounts (~1657 mg·100 g^{-1} [DMB]). The amino acids composition of the protein from Kishk was good. Vitamins C, pyridoxine and β-carotene were not detected in the Kishk samples, and approximately half of these samples did not contain α-tocopherol. The thiamin and riboflavin contents of Kishk were in the range of what has been reported in the literature. Kishk has a limiting vitamin factor and is not considered a good dietary source. The selenium content of the majority of the Kishk samples was good and such a product may represent a potentially good dietary source. © Inra/Elsevier, Paris.

Kishk / β-glucan / amino acid / mineral / vitamin / selenium

Résumé — Le kishk – un mélange lait/céréales fermenté et séché : 3. Composition nutritionnelle. Les propriétés nutritionnelles de 25 échantillons de kishk libanais du commerce ont été étudiées. Les profils de nutriments glucidiques (en g pour 100 g de matière sèche) étaient compris dans les gammes suivantes : fibre 7 à 12, acide phytique 0,7 à 1,6 et β-glucane 0,1 à 0,6. Certains échantillons de kishk contenaient une quantité appréciable d'acides gras polyinsaturés, tandis que les

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teneurs en acides gras mono-insaturés de la plupart des échantillons étaient nettement inférieures à celles présentes dans le lait et les produits laitiers. Tous les échantillons de kishk contenaient des quantités appréciables des principaux éléments minéraux (K 495, P 397, Ca 243 et Mg 123 $mg \cdot 100\ g^{-1}$ de matière sèche), et constituaient de bonnes sources de Fe et Mn apportées par le Burghol. Le sodium était présent en forte quantité (~1657 $mg \cdot 100\ g^{-1}$ de matière sèche). La composition en acides aminés des protéines du kishk était bonne. La vitamine C, la pyridoxine et le β-carotène n'étaient pas détectés dans les échantillons de kishk et environ la moitié des échantillons ne contenaient pas d'α-tocophérol. Les teneurs en thiamine et riboflavine du kishk étaient dans la gamme rapportée dans la littérature. Le kishk avait une teneur en vitamines limitée et de ce fait n'est pas considéré comme étant une bonne source en diététique. La teneur en sélénium de la majorité des échantillons de kishk était bonne ce qui en fait une source intéressante dans le régime alimentaire.

kishk / β-glucane / acide aminé / minéraux / vitamine / sélénium

1. INTRODUCTION

Fermented milk products have always been considered a highly nutritious food containing significant concentrations of protein, fat, minerals and micronutrients, and has been extensively investigated and reviewed by many research groups [2, 24–27, 36, 37]. Some data are available on the nutritional properties of Kishk, which has been recently reviewed by Tamime and O'Connor [45] and Tzanetakis [49]. Kishk is a dried yoghurt and cereal (Burghol) mixture which is a good source of protein [21–23, 30, 46, 47]. The yoghurt makes up for the amino acids limited in cereal (lysine and methionine). However, Burghol (parboiled cracked wheat) is a good source of certain minerals (Fe, Cu and Mn) that are deficient in milk [11, 33].

Certain cereals may contain components of interest to human nutritionists including: 1) dietary fibre, which is considered a good vehicle to control blood cholesterol levels and may also reduce the incidence of colon cancer; 2) β-glucan and other soluble fibres, which may reduce cholesterol absorption from the intestinal tract, and also reduce the formation of low density lipoprotein (LDL); 3) phytic acid, which has the potential to exert negative nutritional effect and binds divalent minerals (Ca, Zn and Fe) [12, 17, 29, 41, 42, 44, 50]; and 4) selenium, which has been demonstrated to exhibit an antioxidant role, is involved in thyroid metabolism and antimutagenic activity [8]. An association between cardiovascular death, myocardial infraction and serum selenium levels has been reported. The selenium content of 700 UK foods has been recently determined by Barclay and MacPherson [5] and Barclay et al. [6]. Limited data are available on these components and the vitamin content of commercial Kishk samples, and only niacin levels are appreciably high when compared with skimmed milk powder. However, this could be attributed to the metabolic activity of the starter culture, and Burghol is also a good source of niacin [45].

The objectives of this study were to investigate in detail the chemical composition, species of origin of milk protein, nutritional composition and microbiological qualities of 25 Lebanese Kishk samples obtained from different outlets. The results of the nutritional composition of Kishk are given in detail here.

2. MATERIALS AND METHODS

2.1. Kishk samples

Twenty-five samples of commercial Kishk (~1 kg each) were obtained from different retail outlets in Lebanon [48].

2.2. Analytical methods

2.2.1. Minerals

The Ca, P, Mg, K, Na, Zn, Fe and Mn contents in Kishk were determined using a nitric-perchloric acid digestion procedure according to the method described by MAFF [31] followed by induction coupled plasma-100 (ICP) emission spectroscopy (Thermo Electron Ltd., Birchwood, Warrington, UK).

The analysis was performed at the following flow rates: 1) main argon at 15 $L \cdot min^{-1}$, 2) nebulizer argon at 0.5 $L \cdot min^{-1}$, and 3) sample at 0.8 $mL \cdot min^{-1}$. The mineral eluates were monitored at wavelengths of 317.9 nm - Ca; 214.9 nm - P; 285.2 nm - Mg; 766.5 nm - K; 589.6 nm - Na; 213.9 nm - Zn; 238.2 nm - Fe; 324.8 nm - Cu and 257.6 nm - Mn.

2.2.2. Chemical analysis

Phytic acid, β-glucan and selenium contents in the Kishk samples were determined according to the methods described by AOAC [4], McCleary and Glennie-Holmes [32] and Hershey and Oostdyke [18], respectively.

2.2.3. Vitamin assays

Retinol (vitamin A), α-tocopherol (vitamin E) and β-carotene were analysed by the high performance liquid chromatography (HPLC) method based on the procedure described by Bieri et al. [7]. Kishk (1 g) was weighed out accurately into a test tube, and extracted by the method of Butriss and Diplock [10]. Following extractions, the residues were reconstituted with 200 µL of absolute alcohol.

An in-house reference sample consisting of infant baby food powder containing known amounts of retinol, α-tocopherol and β-carotene was also analysed with the Kishk samples. HPLC analysis was conducted using a Shimadzu LC-6A pump, a Rheodyne 7125 syringe loading injector, and a Machery-Nagel Nucleosil 5 C_{18} column under the following conditions:

Vitamin C (ascorbic acid + dehydroascorbic acid) was measured using a HPLC method based on a modification of that of Speek et al. [40]. After extraction, ascorbic acid (AA) was oxidised enzymatically by ascorbic acid oxidase to dehydroascorbic acid (DHAA). DHAA was condensed with *o*-phenylenediamine (OPDA) to its highly fluorescent quinoxaline derivatives. These derivatives are separated on a reverse-phase HPLC column and detected fluorometrically. DHAA can be determined separately by the same procedure with the omission of the enzymatic oxidation. The difference in DHAA measured in the presence or absence of the ascorbic acid oxidase is related to the ascorbic acid content of the sample.

HPLC analysis was carried out within 12 h using a Shimadzu LC-6A pump, a Rheodyne 7125 syringe-loading injector, a Machery-Nagel Nucleosil 5 C_{18} column and a pre-column of similar composition. A Waters Guard-Pak filter unit was fitted to protect the column from being clogged by particulates. The mobile phase was methanol (20 % v/v), 0.08 $mol \cdot L^{-1}$ KH_2PO_4 buffer, pH 6.6 (1:4; v/v) at a flow rate of 1 $mL \cdot min^{-1}$. DHAA was detected by measuring fluorescence of the eluate using a Shimadzu RF-535 fluorescence detector (excitation wavelength 365 nm and emission wavelength 418 nm).

Thiamin (vitamin B_1) and vitamin B_6 (pyridoxine, pyridoxal and pyridoxamine) were extracted and quantified as total vitamin B_6 from Kishk samples by the method of Brubacher et al. [9]. Thiamin was oxidised to thiochrome using a procedure based on AOAC [3]. The thiochrome was measured directly by HPLC. A Shimadzu LC-6A pump, a Rheodyne 7125 syringe-loading injector and a Shimadzu RF 535 fluorescence detector were used. A Machery-Nagel Nucleosil 5 C_{18} column and precolumn were also used. The mobile phase was methanol–water (95:5; v/v) at a flow-rate of 1 $mL \cdot min^{-1}$. Thiochrome was measured by fluorescence detection, using an excitation wavelength of 365 nm and an emission wavelength of 435 nm.

Riboflavin (vitamin B_2) was extracted from the Kishk samples as outlined earlier for thiamin

	Lamp	λ	Solvent	Flow rate ($mL \cdot min^{-1}$)
α-tocopherol	D	292 nm	$MeOH/H_2O$ 97:3	2
Retinol	D	325 nm	$MeOH/H_2O$ 95:5	2
β-carotene	W	450 nm	$MeOH/H_2O$/acetonitrile 47:6:47	2.2

(vitamin B_1); however, the oxidation step was omitted. After filtration, the filtrate was diluted 1:2 with a methanol–water solution (70:30;v/v), filtered through a 0.45-μm filter and injected onto the column. An in-house reference sample of infant baby food powder containing a known concentration of riboflavin was also analysed. A similar HPLC system and column was used as outlined earlier for thiamin. The mobile phase was methanol–water (70:30) at a flow rate of 1 $mL \cdot min^{-1}$. Detection was by fluorescence using excitation and emission wavelengths of 453 and 521 nm, respectively.

2.2.4. Amino acids

The concentrations of amino acids in 25 samples of Lebanese Kishk were determined by the method of Spakman et al. [39] using model 3A 29 automatic amino acid analyser (Carlo Erba Science, Milan, Italy).

A sample of Kishk (100 mg) was weighed in a universal bottle and dissolved in 3 mL of 6 $mol \cdot L^{-1}$ HCl solution. Later, nitrogen was bubbled through the sample to remove oxygen, then sealed and placed in an oven at 110 °C for 24 h. The sample was filtered into 100 mL volumetric flask, diluted with distilled water and made-up to 100 mL. Ten mL filtrate was dried and the residue resuspended in Na-citrate buffer at pH 2.2. Amino acids were quantified by measuring the peak area, and the elution gradient was controlled electronically to neutralise the amino acids in different pH buffers. The flow rate of the buffers was 30 $mL \cdot h^{-1}$ for 20 min at pH 3.3, 15 min at pH 4.13 and 40 min at pH 6.8. The results of amino acids contents were expressed as $mg \cdot g^{-1}$ N on a wet matter basis (WMB).

2.3. Statistical analysis

The data were analysed by univariate (analysis of variance), and multivariate (principal component analysis [PCA]) techniques using the Genstat computer program as described by Tamime et al. [48].

3. RESULTS AND DISCUSSION

3.1. Carbohydrate-based nutrients

The average concentration of carbohydrate content in 25 samples of Kishk were detailed by Tamime et al. [48]; the phytic acids, and β-glucan contents ($g \cdot 100\ g^{-1}$ [DMB]) ranged between 0.71 and 1.62, and 0.14 and 0.61, respectively (*table I*). An appreciable amount of fibre (~9.3 $g \cdot 100\ g^{-1}$ [DMB]) was found in the Kishk samples [48]. At present, there is widespread consensus on the benefits of dietary fibre [41]. The source of fibre in the Kishk samples is the Burghol, and the variation in the fibre content of these samples could be attributed to: 1) different varieties of wheat used during the production of Burghol; 2) the efficiency of de-husking stage; and 3) the different ratio of Burghol to yoghurt used during Kishk-making [45, 46]. High fibre diets increase the bulk of the faeces and reduce the transit time through the large intestine and may progressively lower the risk of large bowel cancer. Furthermore, dietary fibre is the most effective means of treating chronic constipation, diverticular disease, obesity and diabetes [13]. The fibre content ($g \cdot 100\ g^{-1}$ [DMB]) of 'all bran', brown flour, white flour and wholemeal flour averaged 25.3, 7.3, 3.6 and 10.5, respectively [20]. Thus, eight Kishk samples (numbers 4, 5, 11, 13, 15, 17→19) examined can provide a level of fibre ≥ than wholemeal flour.

Phytic acid (the hexaphosphoric ester of inositol) was found in the 25 samples of Kishk at an average level of 0.94 $g \cdot 100\ g^{-1}$ (DMB). The source of phytic acid is the Burghol rather than the yoghurt [46]. However, the Phosphoinositol molecule is 88.8 % phosphate, and the phosphorus bound as phytate phosphorous was calculated (*table I*, figures in parentheses). The results suggest that many Kishk samples have high levels of phytate phosphate which may prevent the absorption of divalent cations (Ca, Fe and Zn) in the body [34].

The β-glucan content of the 25 samples of Kishk averaged 0.33 $g \cdot 100\ g^{-1}$ (DMB) which originated primarily from the Burghol. This level is rather low because the β-glucan content in wheat Burghol is 0.24 $g \cdot 100\ g^{-1}$

Table I. The nutritional components of different commercial samples of Kishk.
Tableau I. Composition nutritionnelle de différents échantillons de kishk du commerce.

Components	Minimum	Maximum	Mean
Carbohydrates-based ($g \cdot 100\ g^{-1}$)[a]			
Dietary fibre	6.51	12.24	9.32
Phytic acid	0.71 (49)[b]	1.62 (> 100)	0.94
β-glucan	0.14	0.61	0.33
Main classes of fatty acids (% w/w)[c]			
Saturated	55.40	81.02	70.07
Monounsaturated	15.93	29.84	23.25
Polyunsaturated	4.42	22.40	7.15
Amino acids ($mg \cdot g^{-1}$ N)			
Serine	158	567	268
Proline	242	675	450
Aspartic acid	189	763	397
Glutamic acid	904	2769	1309
Alanine + glycine	92	381	219
Histidine	83	189	134
Arginine	226	704	347
Valine	48	234	143
Tyrosine	157	406	234
Phenylalanine	165	405	253
Lysine	100	322	204
Leucine	247	765	424
Iso-leucine	52	175	110
Threonine	162	472	243
Selenium ($\mu g \cdot 100\ g^{-1}$)[a]	2.5	26.0	10.2
Vitamins			
Retinol } ($\mu g \cdot g^{-1}$)[a]	0.001	1.027	0.165
α-tocopherol }	ND[d]	3.32	0.44
Thiamin } ($mg \cdot 100\ g^{-1}$)[a]	ND	0.292	0.151
Riboflavin }	0.034	0.193	0.079

[a] Results are the average of two determinations performed on each sample; data were computed on dry matter basis; [b] figures in parentheses represent phosphate as phytate phosphate; [c] data were calculated on weight of fat; [d] ND: not detected.

[a] Les résultats sont la moyenne de deux déterminations par échantillons ; les données étaient calculées par rapport à la teneur en matière sèche. [b] Les chiffres entre parenthèses représentent le phosphate en tant que phytate phosphate. [c] Données calculées par rapport au poids de la matière grasse. [d] ND : non détecté.

(DMB) when compared with barley Burghol ($3.51\ g \cdot 100\ g^{-1}$ [DMB]) and oat Burghol ($3.75\ g \cdot 100\ g^{-1}$ [DMB]) [46]. In view of the current nutritional value of β-glucan, Kishk has been manufactured in our laboratory where the wheat Burghol was replaced by either barley or oats Burghol in order to increase the β-glucan content in Kishk, and the results have been reported by Tamime et al. [47].

In order to visualise the similarities among the 25 samples of Kishk and the relationships between the carbohydrate-based nutrients (fibre data taken from [48], phytic acid and β-glucan components), a PCA was performed and principal component (PC) biplot was produced (*figure 1*). The main features of interest within a biplot are the layout of the variables (vectors), clusters of samples (points), samples with high loadings on particular variables and outliers from clusters of points. The percentage variance of a biplot is an indicator of how well the data are summarised in *figure 1*; 84.6 % of the correlation matrix of phytic acid, β-glucan and fibre is accounted for. The vectors for phytic acid and β-glucan are almost co-incident, indicating that such components are strongly correlated. Conversely, the vector for fibre is at right angles to the other two components, indicating that fibre is uncorrelated with both phytic acid and β-glucan. None of the samples exhibit any obvious clustering; however, samples 5, 15, 18, 25 and possibly 19 are outliers and thus of interest. These samples have relatively high loadings on fibre, and hence it is conjectured that these Kishk samples (5, 15, 18 and 19) were probably made with a higher proportion of Burghol than the others, or the Burghol used contained different amounts of fibre reflecting the efficiency of de-husking during the production of Burghol. The phytic acid and β-glucan contents of sample 25 are similar to sample 18, but the former sample has an average fibre content.

3.2. Nutritional value of fatty acids

Profiling of the fatty acid content of different commercial samples of Lebanese Kishk has been reported elsewhere [48]. *Table I* shows the total contents of saturated, mono- and polyunsaturated fatty acids present in the Kishk samples tested. In humans the most essential fatty acid is arachidonic ($C_{20:4}$, n-6) which is readily formed from linoleic acid ($C_{18:2}$, n-6), and hence it is the main dietary source [34]; however, milk and dairy products are usually low in such essential fatty acid while cereals are much higher [20].

Kishk samples 13, 17, 19 and 25 contain an appreciably higher amount of polyunsaturated fatty acids (22.4, 16.9, 13.9 and 15.9 %, respectively; for details refer to [48]) than the rest of the Kishk samples (~ 5.2 %). Such marked increase in the

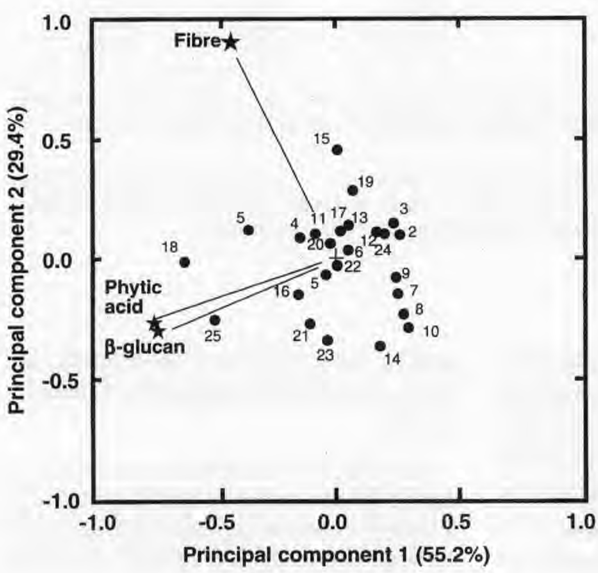

Figure 1. A principal component biplot of some carbohydrates-based nutrients in Kishk samples. (For sample identification, refer to [48]).

Figure 1. Analyse en composantes principales de quelques nutriments glucidiques dans les échantillons de kishk. Voir Tamime et al. [48] pour l'identification des échantillons.

polyunsaturated fatty acid contents may be attributed to: 1) using a higher level of Burghol during the preparation of the Kishk, and/or 2) possible conversion of saturated fatty acids into an unsaturated counterpart during the secondary fermentation stage (see [45]).

Monounsaturated fatty acids are the major constituent of human adipose tissue [34], and these fatty acids are the major component of olive oil which is used widely in the Mediterranean diet. Monounsaturated fatty acid contents of milk and other dairy products is considerably higher than those reported for Kishk (*table I*) and, in particular, Kishk samples 2, 3 and 6 (15.9, 17.1 and 17.9 %, respectively) are well below the average of most dairy products (for details refer to [48]).

Saturated fatty acids are more stable than unsaturated fatty acids to oxidation, but generally the nutritional advice is to decrease the daily intake. Kishk samples 13, 17 and 25 have the lowest levels (52, 58.8 and 53.4 %, respectively), and again this may only be a reflection of using higher cereal content in Kishk-making [48].

A PCA was performed on the correlation matrix of the saturated, mono- and polyunsaturated fatty acid data of the Kishk samples, and a PC biplot was plotted (*figure 2*). Since the three variables are constrained to add to 100 %, any one variable may be calculated from the other two, and hence a two-dimensional solution summarises *table II* in its entirety. PC 1 accounted for 82.1 % of the total variation and contrasted the main difference between samples of Kishk, which was due to the ratio of saturated to unsaturated fatty acids. PC 2 accounted for a further 17.4 % of the variation and separates the Kishk samples by the ratio of mono- to polyunsaturated fatty acids. Most of the data is contained in a single cluster; however, several samples form jet streams from the main cluster. Kishk samples 2, 3, 5 and 6 are notable for their high proportion of saturated fatty acid, and sample 18 is high in monounsaturates while samples 13, 17 and 19 are high in polyunsaturates. Sample 25 is well isolated (*figure 2*) because it has a high unsaturated fatty acids content (for sample identification, see [48]).

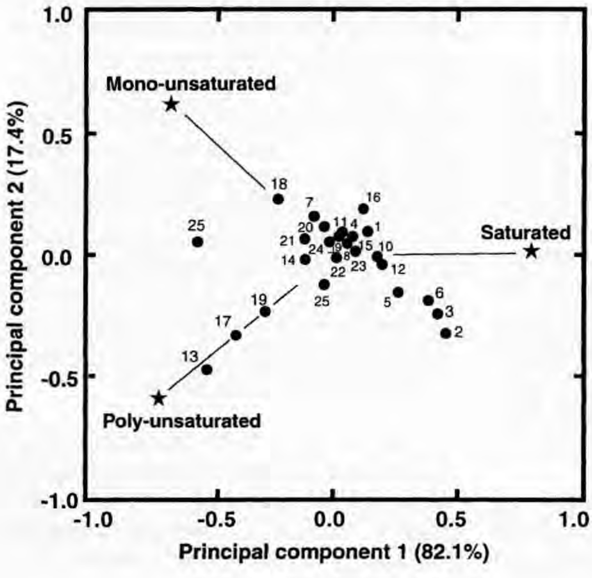

Figure 2. A principal component biplot of saturated, monounsaturated and polyunsaturated fatty acid contents in Kishk samples. (For sample identification, refer to [48]).

Figure 2. Analyse en composantes principales d'acides gras saturés, mono-insaturés et poly-insaturés des échantillons de kishk. Voir Tamime et al. [48] pour l'identification des échantillons.

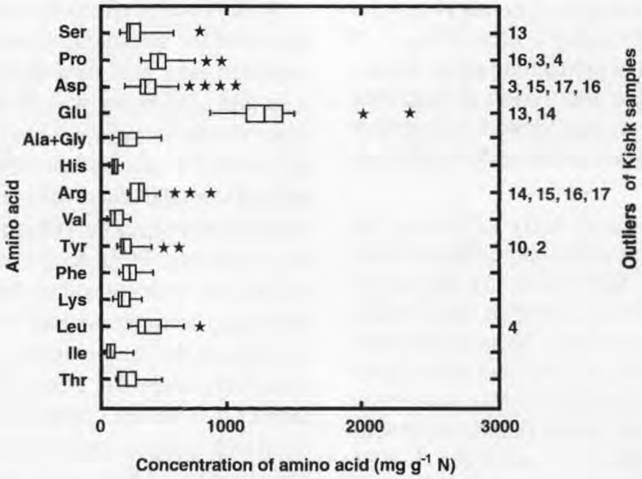

Figure 3. Box plot of concentration of amino acids of the Lebanese Kishk samples. (For sample identification, refer to [48].) The vertical line inside the box represents the median and the vertical ends of the box represent the 1st and 3rd quartiles. Asterisks represent outliers which are further out than 1.5 × inter-quartile range from the 1st and 3rd quartiles, respectively.

Figure 3. Concentrations en acides aminés des échantillons de kishk libanais, avec les intervalles d'incertitude. Voir Tamime et al. [48] pour l'identification des échantillons. Note : les lignes verticales à l'intérieur des boîtes représentent la valeur médiane et les extrémités verticales des boîtes, le 1er et le 3e quartile. Les astérisques représentent les échantillons extrêmes qui sont au-delà de 1,5 fois la variation inter-quartile entre le 1er et le 3e quartile.

3.3. Micronutrients in Kishk

3.3.1. Amino acids

The average protein content of 25 samples of Kishk was 17.8 $g \cdot 100\ g^{-1}$ (DMB) [48], which is considered very high, and the variations in the different amino acid concentrations ($mg \cdot g^{-1}$ N) is shown in *table I*; however, a box plot (*figure 3*) illustrates the distribution of the variable(s). It is evident that there was extensive variation of the amino acid contents, in particular when compared with the commercial sample reported by Jamalian and Pellett [28]. Some of the essential amino acids (Thr, Leu, Lys, Phe, Tyr and Val) were abundant in most of the Kishk samples studied.

Tryptophan and sulphur-containing amino acid contents are low in Kishk, which is not really a good source [33]; however, the analytical procedures are cumbersome and for this reason they were not determined. The loss or decomposition of these amino acids could be attributed to processing conditions such as the fermentation of milk followed by sun-drying. Nevertheless, the same authors reported that Kishk is a good source of amino acids when compared with the provisional pattern suggested by FAO/WHO [16], although Try was a limiting factor. The spectrum of amino acids in milk proteins is better than wheat flour [19, 34, 35], and the data shown in *table I* suggest that milk protein in Kishk supplements the amino acid deficiencies in the Burghol.

The PC biplots of the amino acids demonstrate that the distribution of amino acids is concentrated on the positive half plane of the first PC and uniformly distributed on the second PC. Hence, PC 1 relates to the abundance of the amino acids while the second PC differentiates the samples. The PC biplot of the amino acids of the Kishk samples is shown in *figure 4A*. The Kishk samples form two major groups plus a small group consisting of samples 3, 5 and 10. The first group is characterised by samples (13 $\rightarrow$ 17) having a higher-than-average content of Arg, Ser, Glu, Asp and Ala + Gly. Within the second group, samples with relatively high Pro and Leu contents are plotted towards the top, while the bottom of this group is characterised by samples with high Ile. The third group consists of samples 3, 5 and 10 which have relatively high levels of Thr and Tyr. Introducing the amino acid contents of Burghol and skimmed milk powder (SMP) into the data set reverses the direction of the Ile and Val axis in *figure 4B* with respect to *figure 4A*. SMP is clearly an outlier in the plot, but remarkably does not change the configuration of the rest of *figure 4A*.

Little published data are available on the amino acid contents of Kishk, and the data on a commercial Lebanese product [28] and two commercial Cypriot Trahana products [14, 45] have been used for comparative purposes. A PC biplot was produced (*figure 4C*) to highlight any differences between the two main groups of the 25 samples of Kishk shown in *figure 4A* and the three commercial products. Adding the commercial samples to the data set has a more profound effect on the configuration of samples.

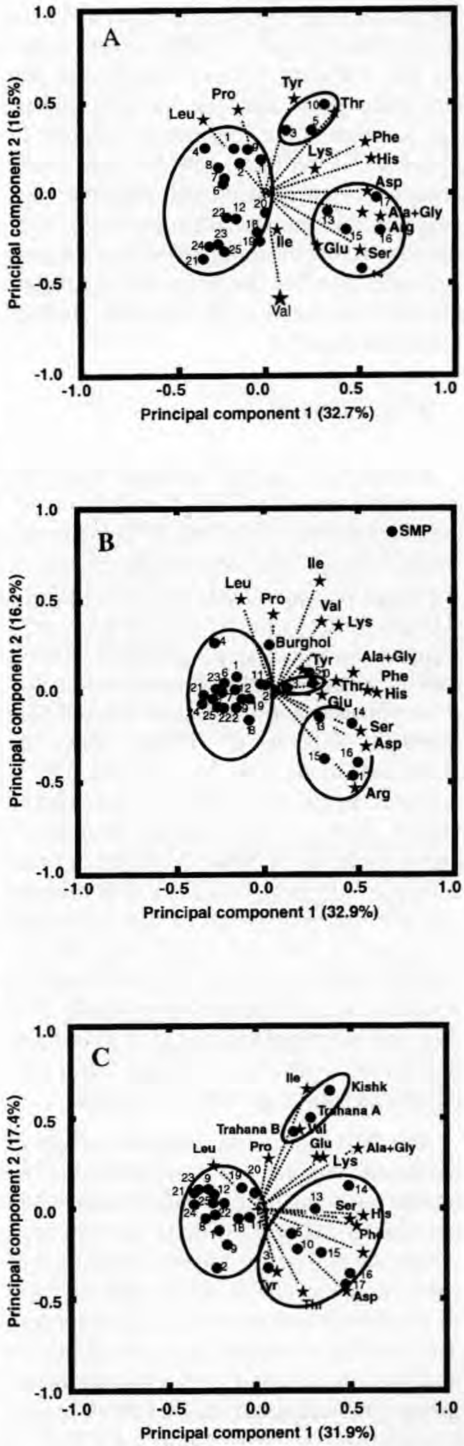

Figure 4. Principal component biplots of amino acids present in the Kishk samples (A), *vis-a-vis* in skimmed milk powder (SMP) and Burghol (B) and in two Trahana and one Lebanese Kishk products (C). (For sample identification, refer to [48]).

Figure 4. Analyses en composantes principales des acides aminés dans les échantillons de kishk (A) de poudre de lait écrémé et de burghol (B) et dans deux trahana et deux kishk libanais (C). Voir Tamime et al. [48] pour l'identification des échantillons.

Specifically the Tyr, Thr, and Ile, Val axes are reversed in *figure 4C* with respect to *figure 4A*, while the vectors representing the remaining amino acids remain fairly similar. The location of the commercial samples in *figure 4C* is distinct from the other three groups previously identified. This may suggest that the nutritional properties of present-day Kishk have improved over the past 2 decades possibly due to the use of a higher ratio of fermented milk: Burghol, such as 4:1 rather than 2:1.

3.3.2. Vitamins

Vitamins C and β-carotene were not detected in any of the Kishk samples; however, vitamins A, E, B_1 and B_2 contents are shown in *table I*. The concentration of vitamin A ranged between 0.001 and 0.324 $\mu g \cdot g^{-1}$ (DMB) in the majority of Kishks except sample 25 (1.027 $\mu g \cdot g^{-1}$ [DMB]). Nearly half the Kishk samples did not contain any α-tocopherol, and the rest of the samples averaged ~0.85 $\mu g \cdot g^{-1}$ (DMB). Since the Kishk was made from low fat milk, this is reflected in the low content of fat-soluble vitamins present. Incidentally, vitamins A and E contents of SMP averaged 3.5 and 2.7 $\mu g \cdot g^{-1}$, respectively [19]. The thiamin and riboflavin contents of these samples averaged 0.164 and 0.079 $mg \cdot 100\ g^{-1}$ (DMB), which appear to be in the range of what has been published previously [45, 49], and skimmed milk [19]. It is evident that Kishk might be a limiting factor as a beneficial source of certain vitamins.

The PC biplot of the vitamin content of the Kishk samples provided limited information regarding the correlation matrix (data not shown). However, there are two axes within the plot defined by the opposition of retinol to α-tocopherol, and at right angles to it, riboflavin and thiamin are juxtaposed. The majority of samples lie on the riboflavin and thiamin axis, and form a homogeneous group. Outliers occur on the retinol and α-tocopherol axis with sample 25 high in retinol, and samples 8 and 15 high in α-tocopherol.

3.3.3. Selenium

The selenium content ($\mu g \cdot 100\ g^{-1}$ [DMB]) of the Kishk samples ranged between 2.5 and 26.0 (*table I*) while the mean value was 10.3, which is similar to the value of yoghurt (9.4 $\mu g \cdot 100\ g^{-1}$ [DMB]) reported by Barclay et al. [6], and higher than skimmed or whole milk powder (7.2 or 8.3 $\mu g \cdot 100\ g^{-1}$ [DMB], respectively [19]). The distribution of selenium in the Lebanese samples of Kishk is shown in *figure 5*. The selenium content of Burghol was 8.8 $\mu g \cdot 100\ g^{-1}$ (DMB) which compares favourably with wheat flours available in the United Kingdom (range between 2.5 and 6.5 $\mu g \cdot 100\ g^{-1}$ [DMB]) [6].

Assuming that the Kishk samples are composed of 80 % yoghurt to 20 % Burghol, the Lebanese yoghurts or most likely the strained yoghurt used must represent a better source of selenium than the UK counterpart. However, the effect of selenium on the diet is skewed by the consideration of dry matter

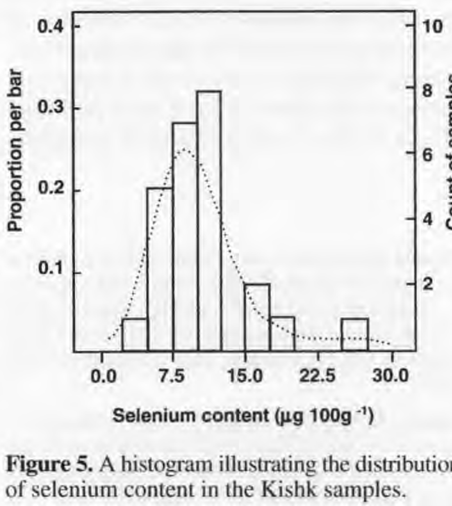

Figure 5. A histogram illustrating the distribution of selenium content in the Kishk samples.

Figure 5. Histogramme illustrant la distribution du sélénium dans les échantillons de kishk.

Table II. Mineral analysis (mg·100 g^{-1})[a] of different Lebanese Kishk samples, skimmed milk powder (SMP) and Burghol.

Tableau II. Analyse des minéraux (mg·100 g^{-1} de matière sèche) de différents échantillons de kishk libanais, de poudre de lait écrémé et de burghol.

Minerals	Kishk				
	Minimum	Maximum	Mean	SMP[b]	Burghol[c]
Sodium	836.3	2418.8	1661.9	550.0	4.5
Potassium	307.5	614.6	495.2	1590.0	476.5
Phosphorous	321.9	447.7	396.5	970.0	378.0
Calcium	138.6	340.0	242.5	1280.0	70.0
Magnesium	94.9	167.8	123.1	130.0	122.0
Iron	3.7	9.5	5.8	0.3	11.8
Zinc	2.5	4.0	3.1	4.0	3.3
Manganese	1.1	4.2	2.1	Tr[d]	2.8
Copper	0.33	0.57	0.42	Tr	0.57

[a] Results are the average of two determinations performed on each sample; data were computed on dry matter basis; [b] SMP: skimmed milk powder; data compiled from [19]; [c] data (for coarse Burghol) compiled from [46]; [d] Tr: trace.

[a] Les résultats sont la moyenne de deux déterminations par échantillon ; les données étaient calculées par rapport à la teneur en matière sèche. [b] SMP, poudre de lait écrémé : données issues de Holland et al. [19]. [c] données (pour le burghol broyé) issues de Tamime et al. [46]. [d] Tr, trace.

figures rather than the fresh weight. For example, a UK yoghurt of 16 g·100 g^{-1} total solids content may have a selenium content of 1.5 µg·100 g^{-1} (DMB). Kishk sample 25 (26 µg·100 g^{-1} [DMB]) represents a considerable dietary potential of selenium.

3.3.4. Minerals

The concentration of minerals in 25 samples of Kishk is shown in *table II*, and sample 25 had high concentrations (mg·100 g^{-1} [DMB]) of Mg 260, Fe 18.5 and Cu 0.6, whilst in sample 3 the concentration of Fe was 12.8. Such high concentrations of minerals, in comparison with the other Kishk samples, had dominated the PC biplot of the PCA, and they were therefore excluded from *table II* and statistical analysis. However, for comparative purposes, data of the concentration of minerals of SMP and Burghol (coarse type) are also included in *table II*. It is evident that the sodium content is very high due to added salt during the preparation of Kishk. According to Tamime et al. [48], the added salt in these Kishk samples, which was calculated from chloride by titration, averaged 2.8 g NaCl·100 g^{-1} (DMB). Although such a level of salt in Kishk may have possible dietary implications (such as a contributory factor to high blood pressure), the salt level will be reduced when the Kishk is prepared as a hot gruel 'dish'.

The Lebanese Kishk samples contain appreciable quantities of K, P and Ca (495, 397 and 243 mg·100 g^{-1} [DMB], respectively), but they are below the contents found in SMP. This is attributed to the Burghol where the concentration of these elements is ~30 % below that found in SMP (*table II*). However, concentration of Mg (123 g·100 g^{-1} [DMB]) is similar to that in the milk powder and Burghol (100 % retention) with the exception of Kishk samples

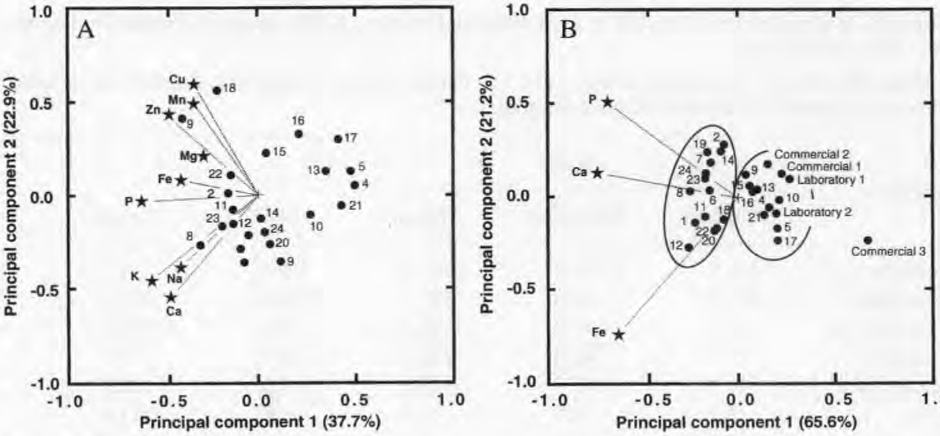

Figure 6. Principal component biplots of mineral contents in the Kishk samples (A), and of P, Ca and Fe of the same samples compared with three commercial and two laboratory-made Kishks (B). (For sample identification, refer to [48]).

Figure 6. Analyse en composantes principales des minéraux des échantillons de kishk (A) et de P, Ca et Fe des mêmes échantillons comparés avec trois kishks du commerce et deux kishks fabriqués en laboratoire (B). Voir Tamime et al. [48] pour l'identification des échantillons.

21 (low) and 2, 3, 10, 11 and 25 (high). The concentration of Zn, Mg and Cu (3.1, 2.1 and 0.42 mg·100 g^{-1} [DMB], respectively) is similar to Burghol, but much higher in Mg and Cu when compared with SMP (*table II*). An appreciable quantity of Fe (5.8 mg·100 g^{-1} [DMB]) is present in the Kishk samples.

A PCA was performed and a PC biplot was produced with Kishk samples 3 and 25 excluded. In this analysis, *figure 6A* summarises 60.6 % of the correlation matrix between the concentration of minerals in the Kishk samples. The variables did not show any obvious clustering between the samples of Kishk, but samples 18 and 19 are outliers. The two clusters of the Kishk samples are approximately at right angles denoting independence (*figure 6A*). There are three large positive (Cu, Mn, Zn) and three large negative loadings (Ca, K, Na). Of the remaining minerals, Mg and Fe do not fit into the pattern of distribution of other minerals while P is distinct in that it has a high loading on PC 1 and none on PC 2. It is surmised that PC 1 reflects the abundance of the minerals while PC 2 measures the electrochemical property of the soil.

Only the P, Ca and Fe contents of the three commercial and two laboratory-made Kishk samples have been reported [1, 15, 33, 38], and these have been compared with our 23 samples of Kishk. A further PCA was performed on the correlation matrix of the three available minerals. The first PC (*figure 6B*) accounted for 65.6 % of the total variation and simply represented the mean of the three minerals. The positions of samples along PC 1 are similar to the samples shown in *figure 6A*. PC 2 accounted for a further 21.2 % of the variation, and such mapping of the Kishk samples is more akin to PC 3 (not shown) for the data in *figure 6A* than its PC 2. Samples which were high in P are positioned towards the top of the plot, while those that were high in Fe are found at the bottom. Both the commercial and laboratory-made Kishk samples had low P, Ca and Fe contents when compared with Lebanese Kishk samples, and only one commercial sample was the only true outlier.

4. CONCLUSION

It is evident from the current results that Kishk has considerable dietary potential as a source of fibre, amino acids, minerals and selenium contents, but is deficient in certain vitamins.

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