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Nutritional Evaluation of Amino Acids as Influenced by cooking of Some Saudi Traditional Diets

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Abstract: The main objective of the current work was to evaluate the nutritional quality of amino acids of traditional diets that consumed regularly in Saudi Arabia and to establish a useful knowledge for the evaluation of the nutritional status of Saudi traditional foods. In the present study, five Saudi traditional diets (kabsa, gursan, garish, saleeg and hunaini) were investigated for their amino acids contents and scores. Among the essential amino acids content of garish, the highest value (12.97 g/100 g protein) was found for phenylalanine plus tyrosine in cooked garish with score of 2.00, whereas uncooked garish recorded lowest value of tryptophan (1.74 g/100 g protein) with score of 1.51. Cooking significantly ($P \leq 0.05$) increased the amino acids values for all amino acids, except threonine which was significantly ($P \leq 0.05$) decreased after cooking. Moreover, the score of most amino acids increased after cooking with few exceptions. In gursan, cooking significantly ($P \leq 0.05$) decreased both the amino acids contents and score except tryptophan, which is slightly increased from 1.93 to 2.05 g/100g protein with score slightly increased from 1.75 to 1.80. For all diets lysine was found to be the most limiting amino acid, and thus supplementation of such diets with legume proteins may significantly improve the lysine content of the diets. The calculated protein efficiency ratio of the traditional diets and their ingredients showed a range of 1.35- 2.04 compared to casein value of 2.68.

Key words: Amino acids, kabsa, gursan, garish, saleeg, hunaini

INTRODUCTION

The importance of food composition data has long been recognized by the Food and Agriculture Organization (FAO), and has received more attention in recent years. Accurate food composition data are needed to show association between food and nutritional status, to design interventions, to meet regulatory standards, to properly label food and to assist in product formulation (Lewis and Lupien, 1996: Dashati *et al.*, 2001). Windham *et al.* (1983) have emphasized the importance of food composition and food consumption data in the analysis of human dietaries and understanding of the nutritional status of the population. Traditional foods are those foods, which are locally available and consumed by a large sector of the community. They are highly accepted and included in the meal (Musaiger *et al.*, 1990). A great emphasis has been made on the role of traditional foods in improving the nutritional status of the people (Kuhnlein and Receveur, 1996). Many of these foods are nutritionally important in the diet and can make a significant contribution in meeting the nutritional requirements of a population, particularly those of low income and those living in remote areas such as in deserts or mountains (FAO, 1987). The Gulf countries have been making substantial efforts to increase their food production and promote health and the nutritional well being of the community (Musaiger, 1987). Nevertheless, traditional foods are neglected in their constitution to nutrition on the dietary aspects of traditional foods. Promoting the consumption of such foods, therefore, would not be possible without understanding their nutrient composition (Musaiger *et al.*, 1990: Dashati *et al.*, 2001). Traditional diets in Saudi Arabia are those diets related to food habits and culture of Saudi people and which prepared locally and

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consumed in different regions of the country (Khan and Al-Kanhal, 1998). The ingredients and way of preparation of these diets may differ from one region to the other, and the knowledge of traditional diet preparation is passed from one generation to another. Kabsa is considered to be the most known traditional dish in Saudi Arabia, since 89% of Saudi families consumed it as a main dish (Al-Kanhal, 1991). Other traditional foods include for example: Mataziz jcrish, qursan, garrish, hunaini and almuhala. Al-Jassir *et al*. (1998) stated that there are few studies regarding the chemical composition, ratios of ingredients and way of preparation of traditional foods. Although some work on the chemical composition of food diets based on cereals (Al-Kanhal *et al*., 1994), cereal and legumes (Al-Jebrin *et al*., 1985) and meat (Sawaya *et al*., 1986) consumed in Saudi Arabia, and mixed diets used in Kuwait (Kamel and Allam, 1979; Dashati *et al*., 2001) and in Bahrain (Musaiger and Al-Dallal, 1985) has been reported, yet adequate data on the nutritional quality of Saudi diets is scares. It is important for dietitians and doctors to know the nutrients composition and nutritional quality of Saudi diets to enable them to set a menu for healthy people and patients that suit them nutritionally and socially. The studies concerning food composition of Saudi national diets are limited, for lack of knowledge in their quantity of ingredients or the way of preparing or cooking (Al-Jassir *et al*. 1998). This has led to the necessity of assembling more complete food composition tables, yielding information not only about the traditional nutrients but also on micronutrients, amino acids, fiber content and digestibility. Thus, the aim of the current work is to evaluate the amino acids of traditional foods in Saudi Arabia. This evaluation may be of interest to those who are involved in nutrition and public health, since traditional foods are consumed by many sectors in Saudi community and little information is available concerning amino acids value.

MATERIALS AND METHODS

Samples Collection and Preparation:

Five ingredients namely: date, rice, brown flour, chicken and lamb meat for the diets preparation were purchased from markets in Riyadh. The fresh samples of such ingredients were freeze-dried and all samples were ground to fine powder and kept at -20ºC. Three samples of each food were prepared as follows: (a) Uncooked samples of kabsa, gursan, garish, saleeg and hunaini were prepared at the laboratory. The ingredients (Table 1) and method of preparation was followed as described by Al-Jassir *et al*. (1998). (b) Portions of uncooked samples were prepared as cooked samples according to the appropriate temperature for each food (Al-Jassir *et al*., 1998). (c) Commercial samples of each diet were collected from local markets in Riyadh. Ten samples of each diet were collected from different places and pooled. The samples were freeze dried, ground to powder and kept at -20ºC for further analysis.

Amino Acid Composition:

For the determination of all amino acids, three hydrolysates were prepared according to AOAC (1995) official methods. The three hydrolysis steps were (i) acid hydrolysis (6N HCl) of un oxidized protein for determination of all amino acid except tryptophan, methionine and cystine; (ii) acid hydrolysis of oxidized protein (performic acid oxidation) for determination of methionine and cystine; (iii) alkaline hydrolysis (4.2 N NaOH) of un oxidized protein for the determination of tryptophan. About 100 mg of the sample was taken in a hydrolysis tube. Then 5 mL of hydrolyzing reagent was added to the sample and the tube tightly closed and incubated at 110°C for 24 h. After incubation, the solution was filtered and 200 mL of the filtrate was evaporated to dryness at 140°C for 1 h. The hydrolysates after dryness were diluted with 1.0 mL of 0.12 N citrate buffer (pH 2.2). Aliquot of 150 µL of the sample hydrolysates was injected in an action separation column at 130 C. Amino acid analysis was performed on reverse phase-high pressure liquid chromatography (Shimadzu LC-10 AD, Shimadzu Corporation, Kyoto, Japan). Samples were analyzed on Shimpack amino-Na type column (10 cm x 6.0 mm) obtained from Shimadzu Corporation. The post column samples were derivatized with O-phthaldialdehyde (OPA) and data were integrated using an integrator model C-R7A (Shimadzu chromatopac data processor). Tryptophan was determined spectrophotometrically according to the method of Davaries *et al*. (1980).

Amino Acids Scores Calculation:

The following formula as proposed by Pellet and Young (1980) was used:

$$\text{Amino acids score} = \frac{\text{mg of amino acid per g N in test protein}}{\text{mg of amino acid per g N in reference pattern}}$$

The amino acid scoring pattern proposed by FAO/WHO/UNU (1985) for children of preschool age was used as the reference pattern. This pattern is recommended to be used to evaluate dietary protein quality for all age groups, except infants (FAO/WHO, 1991).

Calculated protein efficiency ratio (C. PER):

The calculated protein efficiency ratio was estimated following the procedure of Satterlee *et al*. (1982).

Statistical Analysis:

Each determination was carried out on three separate samples on dry weight basis and was analyzed in triplicate and the tables were then averaged. Data were assessed using analyses of variance (ANOVA) (Snedecor and Cochran, 1987). Mean comparisons for the treatments were made using the Duncan multiple range tests with a probability $p \leq 0.05$.

RESULT AND DISCUSSION

Amino Acids Content of Diets Ingredients:

Amino acids content and scores of the main ingredients used in the preparation of the traditional diets are shown in Tables 2 & 3. Date is the main ingredient of hunaini contained adequate amount of the essential amino acids; isoleucine, methionine + cystine, tyrosine + phenylalanine, threonine, tryptophan, histidine and valine (Table 2) compared to the protein reference pattern recommended for preschool children (FAO/WHO, 1991). Whereas, lysine and leucine were first and second limiting amino acids in date with scores of 60% and 83%, respectively. The highest value of nonessential amino acid in date was found to be for glutamic acid (19.06 g/100 g protein) whereas the lowest was for alanine (2.23 g/100g protein). The level of most of the essential amino acids in rice (the main ingredient of saleeg, kabsa and garish) was found to be adequate compared to those of protein reference (FAO/WHO, 1991). The first, second and third limiting amino acids in rice were lysine, threonine and leucine, respectively. For nonessential amino acids glutamic acid showed the highest level (21.42 g/100g protein). In brown flour (the main ingredient of garish, saleeg and hunaini) also first, second and third limiting amino acids were lysine, threonine and leucine, respectively. For nonessential amino acids glutamic acid showed the highest level (23.38 g/100g protein). Results of the amino acids contents in lamb and chicken meat (main ingredients in kabsa, gursan and saleeg) are presented in Table 3. The essential amino acids in lamb and chicken meats are sufficient compared to those of reference protein (FAO/WHO, 1991). The most limiting amino acids in both lamb and chicken meat were lysine, leucine and threonine. Although all ingredients used in the investigated Saudi traditional diets were deficient in threonine, likely in all traditional diets adequate amounts of such amino acid was observed.

Table 1: Ingredients of traditional diets investigated in this study.

Food	Ingredients
Kabsa	Rice (480g), chicken meat (500g), tomato (250g), oil (40g), onion (180g), hot pepper (15g), spices (5g)
Garish	Low fat milk (1200g), ground wheat (480g), rice (240g), hot pepper (10.2g), butter (10g), ground kamon (5g), salt (3g), animal fat (15g)
Gursan	Gursan (500g), bone less met (500g), green bean (12g), kosa (12g), carrot (12g), yellow pumkin (12g), tomato (500g), oil (30g), tomato paste (160g), onion (250g), hot pepper (15g), spices (5g)
Saleeg	Sliced met (1100g), rice (470g), powdered milk (80g), butter (5g), salt (3g), water (3840g), wheat flour (500g)
Hunaini	Date (1000g) wheat flour (500g), butter (120g)

Table 2: Amino acids content and scores of date, rice and brown flour as constituents of the investigated diets.

		Reference protein (FAO/WHO,1991) (g/100 g protein)			Amino acids content (g/100 g protein)			Amino acids scores		
		Infants	Pre-school	Adults	Date	Rice	Brown flour	Date	Rice	Brown flour
Essential Amino acids	Isoleucine	4.6	2.8	1.3	4.25±0.12	6.35±0.10	5.86±0.09	1.51	2.026	2.09
	Leucine	9.6	6.6	1.9	5.50±0.09	5.45±0.06	4.97±0.16	0.76	0.82	0.75
	Lysine	6.6	5.8	1.6	3.50±017	3.75±0.02	2.93±0.03	0.52	0.52	0.50
	Cysetine+ Methionine	4.2	2.5	1.7	5.70±0.20	4.38±0.09	4.85±0.12	2.31	1.75	1.94
	Phenylalanine + Tyrosine	7.2	6.3	1.9	5.60±0.09	10.85±0.11	10.23±0.14	0.92	1.72	1.62
	Threonine	4.3	3.4	0.9	3.32±0.10	2.70±0.10	2.46±0.03	0.94	0.79	0.72
	Tryptophan	1	1.1	0.5	2.68±0.08	2.17±0.03	2.01±0.04	2.43	1.79	1.84
	Histidine	2.6	1.9	1.6	4.59±0.13	2.68±0.07	2.48±0.02	2.14	1.41	1.30
	Valine	5.5	3.5	1.3	3.65±0.10	3.93±0.06	3.63±0.05	1.04	1.12	1.03
Non-essential amino acids	Alanine	-----	-----	-----	2.23±0.06	3.56±0.06	3.28±0.05	-----	-----	-----
	Arginine	-----	-----	-----	2.67±0.07	6.23±0.09	5.76±0.08	-----	-----	-----
	Asprtic asid				6.30±0.18	7.84±0.12	7.69±0.11			
	Glutamic acid	-----	-----	-----	19.06±0.26	21.42±0.58	23.38±0.12	-----	-----	-----
	Glycine	-----	-----	-----	3.21±0.01	5.67±0.08	5.26±0.07	-----	-----	-----
	Proline	-----	-----	-----	2.41±0.01	5.60±0.07	5.18±0.08	-----	-----	-----
	Serine	-----	-----	-----	4.68±0.10	7.58±0.11	7.00±0.13	-----	-----	-----

Values are mean ± standard deviation (N = 3).

Table 3: Amino acids ratios and scores of meat and chicken as constituents of the investigated diets.

		Reference protein (FAO/WHO,1991) (g/100 g protein)			Amino acids content (g/100g protein)		Amino acids scores	
		Infants	Pre-school	Adults	Meat	Chicken	Meat	Chicken
Essential amino acids	Isoleucine	4.6	2.8	1.3	6.20±0.05	6.07±*0.01**	2.2	2.19
	Leucine	9.6	6.6	1.9	4.97±0.02	5.50±0.001	0.75	0.83
	Lysine	6.6	5.8	1.6	4.05±0.02	3.57±0.01	0.69	0.62
	Cysetine+ Methionine	4.2	2.5	1.7	4.74 ±0.03	4.15±0.05	1.87	1.66
	Phenylalanine + Tyrosine	7.2	6.3	1.9	9.46±0.09	10.60±0.01	1.49	1.68
	Threonine	4.3	3.4	0.9	2.41±0.02	2.82±0.00	0.70	0.82
	Tryptophan	1	1.1	0.5	2.05±0.02	2.70±0.00	1.86	1.88
	Histidine	2.6	1.9	1.6	3.34±0.03	2.55±0.01	1.75	1.34
	Valine	5.5	3.5	1.3	3.50±0.04	3.76±0.00	1.00	1.04
Non-essential amino acids	Alanine	-----	-----	-----	3.25±0.03	3.20±0.02	-----	-----
	Arginine	-----	-----	-----	3.90±0.04	5.96±0.00	-----	-----
	Asprtic asid				5.80±0.05	7.86±0.09		
	Glutamic acid	-----	-----	-----	23.05±0.20	21.46±0.03	-----	-----
	Glycine	-----	-----	-----	4.68±0.08	5.45±0.01	-----	-----
	Proline	-----	-----	-----	3.51±0.03	5.37±0.01	-----	-----
	Serine	-----	-----	-----	4.63±0.10	7.26±0.13		-----

Values are mean ± standard deviation (N = 3).

Amino Acid Conent of Traditional Diets:

Adequate amounts of amino acids of a suitable pattern must be provided in the diet, either in a preformed state, or as appropriate precursors that can be used to generate a suitable mix of amino acids following endogenous transformations, in order to match the demand for protein synthesis and other metabolic pathways (FAO/WHO, 2002). In this study attempt was made to investigate the amino acids content and scores with reference to FAO/WHO (1991) recommendation for dietary requirement for human at different ages. The results of amino acid content and scores of Saudi traditional diet "garish" are presented in Table 4. Among the essential amino acids content of garish, the highest value (12.97 g/100 g protein) was found for tyrosine + phenylalanine in cooked garish, whereas the lowest value (1.74 g/100 g protein) was found for tryptophan in uncooked garish. Cooking significantly ($P \leq 0.05$) increased the amino acids values of the essential amino acids, except threonine which was significantly ($P \leq 0.05$) decreased after cooking. Similar observation was reported by Alajaji and El-Adawy (2006) who stated that microwave cooking of chickpea seeds caused a slight increase in the essential amino acids. Moreover, it has also been reported that cooking of pearl millet flour increased the values of valine, isoleucine, methionine plus cystine and leucine (Ali *et al*., 2010). Contrary to our results, cooking of *Canavalia cathartica* seeds decreased all amino acids (Seena *et al*., 2005). Onyango *et al*. (2005) reported that cooking after fermentation was also decreasing all amino acids of fermented uji (maize-finger millet blend). The values of isoleucine, methionine+cystine and tyrosine + phenylalanine in cooked garish were 7.17, 4.96, 12.97 g/100 g protein, respectively. Such levels are adequate compared to FAO reference pattern (FAO/WHO, 1991). Whereas, levels of lucine, lysine and threonine were lower compared to FAO reference pattern (FAO/ WHO, 1991). In garish lysine was found to be the first limiting amino acid with value of 50%. The second limiting amino acid was leucine with value of 65%. Similarly, Osman *et al*. (2010) reported that lysine is the first limiting amino acid in fermented and cooked Kawal (*Cassia obtusifolia*). It worth to note that sulfur containing amino acids (methionine and cystine), although they reported as most limiting amino acids in many studies (McLaren and Pellet, 1970; Al-Jebrin *et al*., 1985; Osman *et al*., 2010), were found in excess amount in garish. For nonessential amino acids the highest value was found for glutamic acids (21.69 g/100g protein), while the lowest value was 3.02 g/100 g protein for alanine in cooked garish. Cooking significantly ($P \leq 0.05$) increased the values of nonessential amino acids in garish, except for alanine which was slightly decreased from 3.12 to 3.02 g/100 g protein. The results obtained for amino acid content and scores of the diet "gursan" are presented in Table 5. Cooking significantly ($P \leq 0.05$) decreased the amino acids (essential and nonessential) content in gursan except for tryptophan which is slightly increased from 1.93 to 2.05 g/100g protein. The reduction in amino acids values of various meals and/or meals ingredients after cooking has been reported by many investigators (Onyango *et al*., 2005; Khalid and Mansor, 1995; Seena *et al*., 2005; Osman *et al*., 2010). The decrease in amino acids of gursan after cooking might be due to non-enzymatic browning reactions as explained by Onyango *et al*. (2005) or it may likely due to conversion of L-amino acid to D-amino acid during cooking (Liardon and Hurrel, 1983) which makes them unavailable for enzyme attack (Hayashi and Kameda, 1980). The level of the essential amino acids isoleucine, methionine plus cysetine, tyrosine plus tryptophan, threonine and valine in cooked gursan are 5.42, 3.75, 6.5, 4.45, and 4.9 g/100 g protein, respectively. Although cooking significantly ($P \leq 0.05$) decreased the values of such amino acids, they are still considered to be equal or in excess of FAO/WHO reference pattern (FAO/WHO, 1991).

In gursan lysine and leucine were found to be the first and second limiting amino acids with scores of 50% and 72%, respectively. Lysine as a limiting amino acid has been reported in many studies (Al-Jebrin *et al*., 1985; Sawaya *et al.,* 1986; Osman *et al*., 2010). For nonessential amino acids the highest value was found for glutamic acids (18.40 g/100g protein), while the lowest value was 2.67 g/100 g protein for alanine in cooked gursan. Cooking significantly ($P \leq 0.05$) decreased the values of nonessential amino acids in gursan. The amino acids values and scores of the diet "kabsa" are shown in Table 6. The essential amino acids content of kabsa varied from 1.66 g/100g protein for tryptophan in commercial kabsa to 10.21 g/100g protein for tyrosine + phenylalanine in un-cooked kabsa. Cooking significantly ($P \leq 0.05$) decreased the values of the essential amino acids except methionine + cystine which was slightly increased from 3.65 to 3.75 g/100 g protein. The reduction in amino acids values after cooking may be due to the racemization of L-amino acids to D-amino acids. Amino acids racemization occurs most readily during severe heat treatment and roasting of proteins (Liardon and Hurrel, 1983). Racemization of amino acids is assumed to be a prelude to the formation of isopeptide bonds in proteins (Friedman *et al*., 1981). These isopeptide cross-links may decrease the digestibility and bioavailability of proteins; however, it considered unlikely that conventional processing or cooking methods will cause extensive racemization of protein amino acids in foods (Bunjapmai *et al*., 1982). Most of the essential amino acids in kabsa were found to be adequate compared to reference protein pattern recommended by FAO/WHO, (1991). Similar to the amino acids scores in garish and gursan, the first and second limiting amino acids in cooked kabsa were lysine and leucine with scores of 52% and 72%, respectively. It is well known that sorghum and other cereals are nutritionally poor and deficient of some essential amino acids such as lysine (Eggum *et al*., 1983). Furthermore, some Saudi Arabian diets were reported to be deficient in tryptophan, lysine, sulphur amino acids (cystine plus methionine) and threonine (Al-Jabrin *et al*., 1985). In reviewing nutrition in Middle East, McLaren and Pellet (1970) have demonstrated that most countries in the region showed protein quality limited by sulphur amino acids (methionine + cystine), lysine and tryptophan. In contrast to the previous studies, our study interestingly demonstrated the presence of adequate amounts of tryptophan and sulphur amino acids in garish, gursan and kabsa. For nonessential amino acids, the highest content was found for glutamic acid (21.7 g/100g protein) in un-cooked kabsa, while the lowest content was found for alanine (3.02 g/100g protein) in commercial kabsa. Cooking significantly ($P \leq 0.05$) decreased nonessential amino acids contents. Generally, the amounts of nonessential amino acids in kabsa are sufficient and relatively high. The results of amino acids content of saleeg are shown in Table 7. Cooking significantly ($P \leq 0.05$) increased the essential amino acids content such as isoleucine, lucine, methionine + cystine, threonine, histidine and valine from 2.72, 4.85, 4.55, 4.83, 3.23 and 3.54 to 5.83, 4.92, 4.83, 4.93, 3.29 and 3.61 g/100 g protein, respectively. Whereas, it significantly ($P \leq 0.05$) decreased the content of lysine, tyrosine + phenylalanine and tryptophan from 3.05, 9.85 and 1.84 to 2.97, 9.38 and 1.37 g/100 g protein, respectively. Similar to others diets the investigated diets were deficiet in lysine and leucine which were found to be the first and second limiting amino acids. This could be attributed to low lysine content in the ingredients used for the preparation of the diets. Cooking also significantly ($P \leq 0.05$) increased the level of all nonessential amino acids. Glutamic acid had higher concentration (20.7 g/100g protein) in cooked saleeg. The results of the essential amino acids content and scores of hunaini are presented in Table 8. The results obtained demonstrated that cooking significantly ($P \leq 0.05$) reduced the values of lucine, lysine, tyrosine + phenylalanine, threonine, tryptophan and valine, while it significantly ($p \leq 0.05$) increased values of isoleucine, methionine + cystine and histidine. Cooking was found to decrease the content of the essential amino acid leucine from 9.64 to 3.36 g/100g protein in hunaini. The reduction in amino acids after cooking might be due to non enzymatic browning (Onyango *et al*., 2005), because date is the main ingredient in hunaini. Moreover, lysine and leucine (after cooking) were the most limiting amino acids in hunaini with scores of 52% and 72%, respectively. Cooking also decreased values of non essential amino acids arginine, aspartic acid and glutamic acid, while it increased values of glycine, proline and serine. No significant effect of cooking on the level of alanine was observed. Overall, the investigated traditional diets contained adequate and even excess levels of essential and nonessential amino acids, and they are unlikely lacking lysine and leucine. Supplementation of such diets with legumes such as soybean will overcome the shortages of lysine and leucine, because soybean was reported to contain high level of leucine (7.6 g/100g protein) and lysine (5.7 g/100g prtein) (Ali *et al*., 2010).

Calculated Protein Efficiency Ratio of Saudi Traditional Diets:

The calculated protein efficiency ratio (C-PER) of the Saudi traditional diets and their ingredients are presented in Table 9. The C-PER of the traditional diets and their ingredients showed the range of 1.35- 2.04 compared to casein value of 2.68. The values of the diets are comparable to the data of FAO (1970) for similar foods. The results obtained suggest that Saudi traditional diets have reasonably good nutritional quality.

Table 4: Amino acids content and scores before and after cooking of garish as a traditional diet.

		Reference protein (FAO/WHO,1991) (g/100 g protein)			Amino acids content (g/100 g protein)			Amino acids scores		
		Infants	Pre-school	Adults	Before cooking	After cooking	Commercial	Before cooking	After cooking	Commercial
Essential Amino acids	Isoleucine	4.6	2.8	1.3	4.99±0.02^{c}	7.17±0.11^{a}	5.93±*0.05^{b**}	1.87	2.60	2.13
	Leucine	9.6	6.6	1.9	3.07±0.06^{b}	3.11±0.02^{b}	3.68±0.02^{a}	0.68	0.65	0.65
	Lysine	6.6	5.8	1.6	1.95±0.03^{c}	2.58±0.05^{a}	2.16±0.02^{b}	0.53	0.50	0.51
	Cysetine+ Methionine	4.2	2.5	1.7	4.44±0.05^{b}	4.96±0.06^{a}	4.95±0.05^{a}	1.75	2.10	1.65
	Phenylalanine + Tyrosine	7.2	6.3	1.9	9.30±0.14^{c}	12.97±0.19^{a}	10.34±0.08^{b}	1.45	2.00	1.65
	Threonine	4.3	3.4	0.9	4.51±0.06^{a}	3.04±0.04^{b}	2.50±0.02^{c}	1.31	0.91	0.74
	Tryptophan	1	1.1	0.5	1.74±0.08^{c}	2.43±0.02^{a}	2,02±0.04^{b}	1.51	2.23	1.85
	Histidine	2.6	1.9	1.6	2.86±0.04^{b}	3.10±0.12^{a}	2.50±0.09^{c}	1.50	1.60	1.31
	Valine	5.5	3.5	1.3	3.30±0.04^{c}	4.44±0.07^{a}	3.69±0.03^{b}	0.93	1.28	1.06
Non-essential amino acids	Alanine	-----	-----	-----	3.12±0.18^{ab}	3.02±0.10^{b}	3.18±0.08^{a}	-----	-----	-----
	Arginine	-----	-----	-----	5.23±0.07^{c}	7.03±0.11^{a}	5.79±0.08^{b}	-----	-----	-----
	Asprtic asid				6.98±0.10^{c}	7.45±0.11^{b}	7.70±0.05^{a}			
	Glutamic acid	-----	-----	-----	19.34±0.26^{c}	21.69±0.03^{a}	21.66±0.37^{ab}	-----	-----	-----
	Glycine	-----	-----	-----	4.48±0.18^{c}	6.48±0.10^{a}	5.32±0.04^{b}	-----	-----	-----
	Proline	-----	-----	-----	4.71±0.01^{c}	6.33±0.10^{a}	5.24±0.04^{b}	-----	-----	-----
	Serine	-----	-----	-----	5.88±0.08^{c}	8.56±0.06^{a}	7.14±0.08^{b}	-----	-----	-----

* Mean ± standard deviation (N = 3). ** a, b, c, Duncan´s groupings referring to significant differences among means in a raw.

Table 5: Amino acids content and scores before and after cooking of qursan as a traditional diet.

		Reference protein (FAO/WHO,1991) (g/100 g protein)			Amino acids content (g/100 g protein)			Amino acids scores		
		Infants	Pre-school	Adults	Before cooking	After cooking	Commercial	Before cooking	After cooking	Commercial
Essential Amino acids	Isoleucine	4.6	2.8	1.3	5.99±0.03^{a}	5.42±0.12^{b}	5.92±*0.12^{a**}	2.13	1.98	2.11
	Leucine	9.6	6.6	1.9	4.95±0.04^{a}	4.80±0.09^{b}	4.90±0.08^{a}	0.75	0.72	0.73
	Lysine	6.6	5.8	1.6	3.50±0.02^{a}	2.93±0.12^{b}	2.95±0.02^{b}	0.52	0.50	0.51
	Cysetine+ Methionine	4.2	2.5	1.7	4.64±0.06^{a}	3.75±0.19^{b}	3.55±0.02^{c}	1.84	1.43	1.42
	Phenylalanine + Tyrosine	7.2	6.3	1.9	9.10±0.09^{a}	6.50±0.11^{c}	7.61±0.06^{b}	1.44	0.96	1.20
	Threonine	4.3	3.4	0.9	4.76±0.04^{a}	4.45±0.09^{c}	4.62±0.01^{b}	1.40	1.35	1.37
	Tryptophan	1	1.1	0.5	1.93±0.05^{b}	2.05±0.09^{a}	1.94±0.01^{b}	1.75	1.80	1.77
	Histidine	2.6	1.9	1.6	3.27±0.02^{a}	2.72±0.02^{b}	3.19±0.05^{ab}	1.70	1.40	1.67
	Valine	5.5	3.5	1.3	5.24±0.06^{a}	4.90±0.08^{b}	5.11±0.08^{ab}	1.49	1.42	1.46
Non-essential amino acids	Alanine	-----	-----	-----	3.59±0.05^{a}	2.67±0.05^{c}	3.11±0.02^{b}	-----	-----	-----
	Arginine	-----	-----	-----	3.54±0.01^{b}	3.29±0.01^{c}	3.72±0.12^{a}	-----	-----	-----
	Asprtic asid				5.61±0.07^{a}	4.40±0.07^{c}	5.54±0.05^{ab}			
	Glutamic acid	-----	-----	-----	18.40±0.26^{a}	18.08±0.26^{b}	17.60±0.12^{c}	-----	-----	-----
	Glycine	-----	-----	-----	4.60±0.18^{a}	3.95±0.18^{c}	4.47±0.10^{b}	-----	-----	-----
	Proline	-----	-----	-----	3.41±0.04^{a}	3.20±0.04^{b}	3.35±0.02^{ab}	-----	-----	-----
	Serine	-----	-----	-----	6.63±0.08^{a}	5.18±0.08^{c}	6.50±0.08^{ab}	-----	-----	-----

* Mean ± standard deviation (N = 3). ** a, b, c, Duncan´s groupings referring to significant differences among means in a raw.

Table 6: Amino acids content and scores before and after cooking of kabasa as a traditional diet.

		Reference protein (FAO/WHO,1991) (g/100 g protein)			Amino acids content (g/100 g protein)			Amino acids scores		
		Infants	Pre-school	Adults	Before cooking	After Cooking	Commercial	Before cooking	After cooking	Commercial
Essential Amino acids	Isoleucine	4.6	2.8	1.3	5.86±0.02^{a}	5.62±0.03^{c}	5.40±*0.12^{b**}	2.09	2.00	1.93
	Leucine	9.6	6.6	1.9	5.10±0.10^{a}	4.88±0.01^{b}	4.80±0.08^{c}	0.77	0.72	0.73
	Lysine	6.6	5.8	1.6	3.05±0.01^{a}	3.02±0.02^{b}	3.30±0.06^{c}	0.51	0.52	0.51
	Cysetine+ Methionine	4.2	2.5	1.7	3.65±0.01^{a}	3.75±0.04^{b}	3.39±0.05^{c}	1.45	1.47	1.35
	Phenylalanine + Tyrosine	7.2	6.3	1.9	10.21±0.09^{a}	9.77±0.08^{b}	9.40±0.05^{c}	1.60	1.56	1.49
	Threonine	4.3	3.4	0.9	4.95±0.04^{a}	4.74±0.04^{b}	4.65±0.01^{c}	1.45	1.40	1.37
	Tryptophan	1	1.1	0.5	1.85±0.01^{a}	1.74±0.03^{b}	1.66±0.07^{c}	1.67	1.58	1.50
	Histidine	2.6	1.9	1.6	2.47±0.02^{b}	2.25±0.04^{c}	2.52±0.05^{a}	1.30	1.18	1.32
	Valine	5.5	3.5	1.3	3.63±0.01^{a}	3.47±0.03^{b}	3.34±0.08^{c}	1.03	0.99	0.95
Non-essential amino acids	Alanine	-----	-----	-----	3.28±0.01^{a}	3.14±0.03^{b}	3.02±0.07^{c}	-----	-----	-----
	Arginine	-----	-----	-----	5.75±0.01^{a}	5.50±0.05^{b}	5.30±0.12^{c}	-----	-----	-----
	Asprtic asid				7.67±0.02^{a}	7.34±0.07^{b}	7.11±0.05^{c}			
	Glutamic acid	-----	-----	-----	21.70±0.79^{a}	20.67±0.03^{c}	20.85±0.11^{b}	-----	-----	-----
	Glycine	-----	-----	-----	5.26±0.05^{a}	5.03±0.01^{b}	4.84±0.10^{c}	-----	-----	-----
	Proline	-----	-----	-----	5.17±0.01^{a}	4.95±0.05^{b}	4.76±0.10^{c}	-----	-----	-----
	Serine	-----	-----	-----	6.47±0.02^{a}	6.18±0.06^{b}	6.46±0.08^{a}	-----	-----	-----

* Mean ± standard deviation (N = 3). ** a, b, c, Duncan´s groupings referring to significant differences among means in a raw.

Table 7. Amino acids content and scores before and after cooking of saleeg as a traditional diet.

		Reference protein (FAO/WHO,1991) (g/100 g protein)			Amino acids content (g/100 g protein)			Amino acids scores		
		Infants	Pre-school	Adults	Before cooking	After cooking	Commercial	Before cooking	After cooking	Commercial
Essential Amino acids	Isoleucine	4.6	2.8	1.3	5.72±0.01^{b}	5.83±0.06^{a}	5.60±*0.09^{c**}	2.04	2.08	2.00
	Leucine	9.6	6.6	1.9	4.85±0.01^{c}	4.92±0.02^{b}	5.10±0.06^{a}	0.73	0.74	0.77
	Lysine	6.6	5.8	1.6	3.05±0.02^{a}	2.97±0.12^{ab}	2.90±0.02^{b}	0.52	0.52	0.50
	Cysetine + Methionine	4.2	2.5	1.7	4.55±0.08^{c}	4.83±0.06^{b}	5,35±0.07^{a}	1.82	1.93	2.14
	Phenylalanine + Tyrosine	7.2	6.3	1.9	9.85±0.09^{a}	9.38±0.11^{b}	9.30±0.06^{b}	1.56	1.46	1.1.42
	Threonine	4.3	3.4	0.9	4.83±0.02^{b}	4.93±0.05^{a}	3.55±0.06^{c}	1.42	1.45	1.04
	Tryptophan	1	1.1	0.5	1.84±0.05^{b}	1.37±0.09^{c}	2.49±0.01^{a}	1.67	1.20	2.26
	Histidine	2.6	1.9	1.6	3.23±0.04^{b}	3.29±0.01^{b}	3.42±0.05^{a}	1.68	1.73	1.80
	Valine	5.5	3.5	1.3	3.54±0.01^{ab}	3.61±0.04^{a}	3.45±0.07^{b}	1.01	1.03	0.98
Non-essential amino acids	Alanine	-----	-----	-----	3.18±0.04^{c}	3.32±0.02^{b}	3.95±0.08^{a}	-----	-----	-----
	Arginine	-----	-----	-----	5.61±0.02^{a}	5.72±0.06^{a}	4.53±0.12^{c}	-----	-----	-----
	Asprtic asid				7.49±0.02^{b}	7.63±008^{b}	7.92±0.10^{a}			
	Glutamic acid	-----	-----	-----	20.23±0.07^{c}	20.70±0.12^{b}	20.95±0.12^{a}	-----	-----	-----
	Glycine	-----	-----	-----	5.18±0.03^{c}	5.23±0.05^{b}	5.54±0.09^{a}	-----	-----	-----
	Proline	-----	-----	-----	5.05±0.01^{b}	5.15±0.07^{a}	4.28±0.03^{c}	-----	-----	-----
	Serine	-----	-----	-----	6.30±0.02^{c}	6.44±0.06^{b}	6.74±0.08^{a}	-----	-----	-----

* Mean ± standard deviation (N = 3). ** a, b, c, Duncan´s groupings referring to significant differences among means in a raw.

Table 8: Amino acids ratios and scores before and after cooking of hunaini as a traditional diet.

		Reference protein (FAO/WHO,1991) (g/100 g protein)				Amino acids content (g/100 g protein)			Amino acids scores	
		Infants	Pre-school	Adults	Before cooking	After cooking	Commercial	Before cooking	After cooking	Commercial
Essential Amino acids	Isoleucine	4.6	2.8	1.3	3.21±0.03^{c}	5.86±0.02^{a}	5.40±*0.12^{b**}	2.85	2.02	1.97
	Leucine	9.6	6.6	1.9	9.64±0.10^{a}	3.36±0.01^{b}	3.10±0.08^{c}	0.76	0.72	0.75
	Lysine	6.6	5.8	1.6	2.12±0.01^{a}	2.02±0.02^{b}	1.92±0.06^{c}	0.51	0.52	0.51
	Cysetine+ Methionine	4.2	2.5	1.7	6.01±0.30^{b}	7.01±0.35^{a}	4.54±0.05^{c}	1.45	1.40	1.37
	Phenylalanine + Tyrosine	7.2	6.3	1.9	9.12±0.49^{a}	7.07±0.28^{b}	9.08±0.16^{a}	1.60	1.56	1.52
	Threonine	4.3	3.4	0.9	4.95±0.04^{a}	4.74±0.04^{b}	4.65±0.01^{c}	1.45	1.40	1.37
	Tryptophan	1	1.1	0.5	2.47±0.11^{b}	1.45±0.03^{c}	3.62±0.05^{a}	1.67	1.62	1.60
	Histidine	2.6	1.9	1.6	4.40±0.02^{ab}	4.46±0.04^{a}	3.14±0.05^{b}	2.31	2.34	1.65
	Valine	5.5	3.5	1.3	3.63±0.01^{a}	3.47±0.03^{b}	3.34±0.08^{c}	1.03	1.00	0.97
Non-essential amino acids	Alanine	-----	-----	-----	2.14±0.01^{b}	2.14±0.03^{b}	3.34±0.07^{a}	-----	-----	-----
	Arginine	-----	-----	-----	2.65±0.01^{b}	2.46±0.05^{c}	3.72±0.12^{a}	-----	-----	-----
	Asprtic asid				9.04±0.02^{a}	6.34±0.07^{b}	5.55±0.05^{c}			
	Glutamic acid	-----	-----	-----	16.90±0.19^{a}	16.88±0.16^{a}	17.64±0.28^{b}	-----	-----	-----
	Glycine	-----	-----	-----	3.08±0.08^{b}	3.09±0.11^{b}	4.48±0.07^{a}	-----	-----	-----
	Proline	-----	-----	-----	2.23±0.01^{c}	2.35±0.05^{b}	3.36±0.10^{a}	-----	-----	-----
	Serine	-----	-----	-----	4.49±0.02^{ab}	4.55±0.06^{b}	6.53±0.08^{a}	-----	-----	-----

* Mean ± standard deviation (N = 3). ** a, b, c, Duncan´s groupings referring to significant differences among means in a raw.

Table 9: Calculated protein efficiency ratio (C-PER) before and after cooking of traditional diets

Samples	C-PER
Kabsa before cooking	1.35±*0.02^{ef} **
Kabsa after cooking	1.58±0.012^{ed}
Kabsa-commercial	1.62±0.017^{d}
Qursan before cooking	1.54±0.021^{ef}
Qursan after cooking	1.56±0.003^{e}
Qursan-commercial	1.57±0.023^{e}
Garish before cooking	1.40±0.004^{h}
Garish after cooking	1.41±0.001^{h}
Garish-commercial	1.50±0.035^{gf}
Saleeg before cooking	1.47±0.013^{g}
Saleeg after cooking	1.41±0.005^{h}
Saleeg-commercial	1.48±0.029^{g}
Hunaini before cooking	-------
Hunaini after cooking	-------
Hunaini-commercial	-------
Date	-------
Rice	-------
Chicken	1.99±0.052^{c}
Brown flour	1.49±0.042^{gf}
Meat (lamb)	2.04±0.084^{b}
Casein	2.68±0.015^{a}

*Mean ± standard deviation (N = 3). a, b, c, d, e Duncan´s groupings referring to significant differences among means of the diets in a column.

Conclusions:

The need to establish food composition tables in Saudi Arabia has been emphasized by many scientists and specialists. Such data could be used in planning adequate diets, food consumption pattern, nutritional assessment of food and clinical nutrition research, where the relationships between degenerative diseases and diet are being studied. Saudi traditional diets (kabsa, gursan, garish, saleeg and hunaini) investigated contain high values of the essential amino acids except lysine and leucine. Cooking significantly affect the amino acids contents of such diets. The investigated diets had reasonably good nutritional quality since they showed a good calculated protein efficiency ratio.

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