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Nutritional Evaluation as Influenced by Cooking of Some Saudi Traditional Dishes

By
Abdulatif Saleh Hamd Al Jasser

B,Sc, (Food Technology) - 1982
M.Sc. (Human Nutrition) - 2003
King Saud University

Late supervisor
Profesor Abdullahi Hamid El Tinay

Current supervisor
Profesor Elfadil Elfadl Babiker

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Department of Food Science and Technology
University of Khartoum
Faculty of Agriculture

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DEDICATION

To my father

To my sons and daughters

To my wife (Um Abdallah)

WITH LOVE

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Thanks in beginning and at last for Allah the Gracious, the great for helping me going through and finishing this work.

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(Ph.D. Thesis)

Abdulatif Saleh Hamd Al Jasser

ABSTRACT

The main objective of the current work was to evaluate the nutritional value of traditional dishes that are regularly consumed in Saudi Arabia, and to provide adequate data on food composition to establish a data base for the evaluation of the nutritional status of the Saudi population. Five traditional dishes namely kabsa, gursan, garish, saleeg and hunaini were investigated for their nutritional quality as influenced by cooking.

The moisture, protein, fat, fiber, ash, carbohydrate contents and total energy of cooked kabsa, gursan, garish, saleeg and hunaini were significantly ($P \leq 0.05$) higher than those of commercial and uncooked samples. Low value of protein content was found in saleeg and high one was found in gursan. High ash content was observed in cooked saleeg compared to other dishes. Cooking significantly ($P \leq 0.05$) increased ash, fiber and carbohydrate content of all dishes.

Total energy of hunaini (300-309 kcal) was higher compared to that of kabsa (126-140Kcal), gursan (100-125Kcal), garish (88.2-149Kcal) and saleeg (73.3-138Kcal). The dishes of kabsa, gursan, garish, saleeg and hunaini contained variable amounts of macro-elements (K, Ca, Na, Mg and Mn) and trace elements (Fe, Cu and Zn) before and after cooking. Tannin content of the dishes varied from

0.009 for cooked garish to 0.36% for cooked gursan. Tannin content was fluctuated after cooking for all samples. Phytate content of the dishes was varied from 0.019 for commercial kabsa to 1.132% for hunaini.

Cooking slightly decreased phytate content of kabsa, gursan, saleeg and hunaini but it does not affect that of garish. Cooking significantly ($P \leq 0.05$) decreased trypsin inhibitor activity for all dishes except saleeg which showed slight increase (11.4%). The rate of reduction in trypsin inhibitor activity was 79.1%, 64.0%, 26.3% and 15.1% for gursan, hunaini, kabsa and garish, respectively. Cooking significantly ($P \leq 0.05$) increased the protein and starch digestibility of kabsa, gursan, garish, saleeg and hunaini.

Among the essential amino acids contents 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 obtained for tryptophan in uncooked garish. Cooking in general significantly ($P \leq 0.05$) increased the amino acids contents for all essential amino acids, except threonine which was significantly ($P \leq 0.05$) decreased. Cooking significantly ($P \leq 0.05$) decreased the amino acids contents and score in gursan except tryptophan which is slightly increased from 1.93 to 2.05 g/100g protein. The calculated protein efficiency ratio (C-PER) was ranged from 1.35 to 2.04 for the dishes and it was found to be low compared to that of casein.

ARABIC ABSTRACT

التقييم التغذوي المتأثر بعملية الطبخ لبعض الأكلات الشعبية
بالمملكة العربية السعودية
رسالة دكتوراه
عبد اللطيف بن صالح بن حمد الجاسر

المستخلص: الهدف الرئيسي من هذه الدراسة كان إجراء تقييم للحالة التغذوية في بعض الأكلات الشعبية في السعودية، والحصول على بيانات عن مكونات هذه الأكلات، وتأسيس قاعدة معلومات للإستفادة منها عند تقييم الحالة التغذوية بالمملكة العربية السعودية. تم دراسة خمس أكلات شعبية سعودية (الكبسة، القرصان، الجريش، السليق، الحنيني) وذلك لمعرفة مكوناتها الغذائية وتقدير تأثير الطبخ على هذه المكونات. دلت النتائج على أن محتوى الأكلات المطبوخة من الرطوبة، البروتين، الدهون، الألياف، الرماد، الكربوهيدرات والطاقة أعلى معنوياً ($P\leq0.05$) من العينات التجارية وغير المطبوخة. وجد أدنى قيمة للبروتين في السليق، بينما أعلى قيمة كانت في القرصان. أيضاً نلاحظ محتوى الرماد العالي في السليق المطبوخ بينما وجدت أقل نسبة في الجريش التجاري. وجد أن الطبخ له تأثيرا معنوياً ($P\leq0.05$) على محتوى الرماد، الألياف والكربوهيدرات في كل الأكلات الشعبية. يحتوى الحنيني على طاقة (300-309 كيلوكالوري) عالية مقارنة مع الكبسة (126-140 كيلوكالوري)، القرصان (100-125 كيلوكالوري)، الجريش (88-149 كيلوكالوري) والسليق (73.3-138 كيلوكالوري). تحتوي الكبسة، القرصان، الجريش، السليق والحنيني على كميات متفاوتة من العناصر المعدنية الكبرى (البوتاسيوم، الكالسيوم، الصوديوم، الماغنسيوم والمانجنيز) والعناصر الصغرى (الحديد، النحاس والزنك) قبل وبعد الطبخ. محتوى التانين لهذه الأكلات يتفاوت من 0.009 الى 0.363% للجريش والقرصان المطبوخين على التوالي. وجد أن الطبخ يؤثر معنوياً ($P\leq0.05$) على محتوى التانين من حيث الزيادة والنقصان لجميع الأكلات موضوع البحث . كما يتفاوت محتوي الفايتيت بالأكلات من 0.019 إلى 1.132% بالنسبة للكبسة والحنيني التجاريتين على التوالي. يقلل الطبخ محتوى الفايتيت في الكبسة،

القرصان، السليق والحنيني، بينما لا يؤثر على محتوى الفايتيت في الجريش. الطبخ يخفض نشاط مثبط التربسين معنوياً ($P\leq0.05$) في كل الأكلات عدا السليق الذي يظهر ارتفاعاً طفيفاً (11.04%) .معدل الإنخفاض في نشاط مثبط التربسين بعد طبخ كل من القرصان، الحنيني، الكبسة والجريش هو 79.1%، 64%، 26.3%، 15.1% على التوالي. وجد أن عملية الطبخ تزيد معنوياً ($P\leq0.05$) هضم البروتين والنشا للكبسة، والقرصان، الجريش، السليق والحنيني. من بين الأحماض الأمينية الأساسية، وجد أن أعلى قيمة (12.79 ملجم/100جم) هي للتايروسين والفينايل ألانين في الجريش المطبوخ، بينما أقل نسبة (1.74 ملجم/100جم بروتين) هي للتربتوفان في الجريش غير المطبوخ. الطبخ يزيد من قيم الأحماض الأمينية الأساسية عدا الثريونين الذي تنخفض قيمته بعد الطبخ ، كما يقلل الطبخ من قيم الأحماض الأمينية ومعدلاتها في القرصان عدا التربتوفان الذي يزيد بدرجة طفيفة من 1.93 الى 2.05 جم/100جم بروتين. وجد أن نسبة فعالية البروتين المحسوبة تتفاوت من 1.35 الى 2.04 وعند مقارنتها بالكيزين وجد أنها منخفضة قبل وبعد طبخ العينات.

CHAPTER ONE
INTRODUCTION

Many widely-consumed foods in Saudi Arabia are made mainly from cereals, legumes and oilseed crops. These foods are good sources of proteins, minerals and vitamins for humans and they can make a significant contribution to meet the nutritional requirement of populations, particularly to those of low income (FAO, 1987). The traditional cereals and legume-based foods form an important part of the diet of people in Saudi Arabia. They are greatly divergent in their recipes, processing methods, baking conditions and cooking procedures. Protein/energy malnutrition is a worldwide problem especially in developing countries (Blackburn, 2001). Al-Mokhalalati, (1990) reported moderate to mild types of protein/energy malnutrition were recorded in Saudi Arabia. Improvement of quality of protein and other nutrients in foods commonly consumed in the Arab World are available (Al-Khalifa, 1993; Al-Kanhal *et al*., 1994; Al-Nozha *et al*., 1996; Kenawi, 2000). Traditional diets in Saudi Arabia are those diets related to food habits and culture of Saudi people and which prepared locally and consumed in different regions of the country. The ingredients and way of preparation of these diets may differ from one region to another. 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, 1989). Other traditional foods include for example: Mataziz jcrish, qursan, harris, 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.

In the present study chemical assays will be used to investigate some nutritional aspects of proteins in traditional foods; these include amino acid composition and scoring, *in vitro* protein digestibility and computing of C-PER (calculated protein efficiency ratio). Anti-nutritional factors will be determined, since these factors are reported to affect protein utilization (Liener and Kakade, 1980; Van Buren and Robinson, 1969; Knuckles, 1985). Also minerals such as Na, K, Ca, Mg, P. Fe, Cu, and Co will be quantified.

Objectives of the research:

The overall objective is to evaluate the nutritional value 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 or no information is available concerning protein nutritive value. The specific objectives may be outlined as follows:

1. Determination of proximate composition of five diets collected from different regions in Saudi Arabia.
2. Determination of amino acid content and calculation of the chemical score for each diet.
3. Calculation of C-PER for each diet using amino acid content and *in vitro* digestibility data.
4. Investigating the levels of protease inhibitors, tannins and phytic acid in these diets.
5. Quantifications of major and trace elements in these diets.

CHAPTER TWO
LITERATURE REVIEW

2.1 Traditional foods

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. A great emphasis has been recently made on the role of traditional foods in improving the nutritional status of the people. 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 rapid change in food habits in the Arab Gulf countries, which has resulted from high increases in per capita income, has adversely affected the consumption of many traditional foods. Consequently, these foods have gradually disappeared from the food table (Musaiger, 1987). Nowadays, the Gulf countries have been making substantial efforts to increase their food production and promote health and the nutritional well-being of the community. 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. The traditional cereals and legume-based foods form an important part of the diet of people in Saudi Arabia. They are greatly different in their recipes, processing methods, baking conditions and cooking procedures. Fermented foods continue to provide an important part of human diets all over the world. Fermented foods and beverages worldwide provide some

20-40% of our food intake (Campbell-Platt, 1994). Fermented foods have a positive image among consumers because of the desirable organoleptic quality, better nutritional attributes, and improved shelf-life without added chemical preservatives (Joshi *et al*., 1993). Fermented foods are of great significance because they provide and preserve vast quantities of nutritious foods in a wide diversity of flavors, aromas, and textures which enrich the human diet (Steinkraus, 1996). Campbell-Platt (1994) reported that in terms of total production and consumption, the three major groups of fermented foods worldwide are dairy food products, beverages, and cereals. A large number of lactic fermented products in Africa are cereal-based and the products include porridges, bread, and both alcoholic and non-alcoholic beverages (Oyewole, 1997). Chavan and Kadam (1989) indicated that cereal-based fermented beverages, both alcoholic and nonalcoholic, are common throughout the world and these beverages are consumed mainly for their taste, flavor, and aesthetic properties. Some examples of the beverages are busa in Kenya (Nout, 1980), bouza in Egypt (Okafor, 1990), obiolor and ogi in Nigeria (Achi, 1990; Adegoke and Babalola, 1988), and masvusru and mangisi in Zimbabwe (Zvauya *et al*., 1997). Sobia is a sweet-sour beverage that is prepared traditionally from malt and/or wheat flour which are suspended in water. Sugar and spices (cardamon and cinnamon) are added to the mixture during processing (Gassem, 2002). In Makkah Al-Mukarrmah, sobia is a popular beverage and is consumed daily. During the month of fasting (Ramadan), it is consumed in other parts of the kingdom. In previous work in our laboratory on isolation and identification of microbial flora in different samples of sobia beverage, lactic acid bacteria (Lactobaccillus, Leuconostoc, Pedio-

coccus) were found at level of 8.19 log cfu/ml. Some yeast, mainly Saccharomyces, Candida, and Rhodotorula, were also present (Gassem, 2002). The pH of the samples ranged from 3.37 to 5.53.

2.1.1 Food habits and cultural aspects

Several factors have been found to determine the dietary habits of the people in the Arab world. Food consumption pattern has dramatically changed in some Arab countries as result of sudden increase in income from oil revenue. It is believed that food subsidy policy has adversely affected the food habits in the Gulf States by encouraging the intake of sugar, rice, wheat flour and meat. Socio-cultural factors such as religion, beliefs, food preferences, gender discrimination, education and women's employment all have noticeable influence on food consumption patterns in this region. Mass media, especially televised food advertisements, play an important role in modifying the dietary habits. The migration movement, particularly that which was carried out during the 70s has a great impact on the food practices in many Arab countries. Comprehensive studies on social, cultural and economic factors associated with food consumption patterns in the Arab region are highly recommended. The Arab region covers 21 countries extending from the Gulf in the east to Morocco in the west. These countries are varied in geography, climate, population, economic and health status. Economically they can be divided into 3 categories, high per capita income group such as oil-producing countries (Gulf countries) which are also characterized by low infant mortality and higher health standards; and middle per capita in come such as Iraq, Jordan, Syria, Tunisia and Lebanon and low per capita in come group which include

Egypt, Yemen, Somalia, Sudan, Djibouti and Mauritania. The Arab countries face two kinds of nutritional problems; those associated with under-development such as iron deficiency anemia and under-nutrition, and those associated with affluence such as obesity, diabetes, hypertension and heart diseases (WHO/EMRO, 1989). Recent studies have shown that socio-cultural and economic environment play an important role in the prevalence of malnutrition in developing countries (Bhuiya *et al*., 1986; Hassan and Ahmad, 1986). A fundamental transformation in food consumption patterns in the Arab countries has occurred and affected the health and nutritional status of people. Economic development is normally accompanied by improvements in a country's food supply and the gradual elimination of dietary deficiencies, thus improving the overall nutritional status of the country's population. Furthermore, it also brings about qualitative changes in the production, processing, distribution and marketing of food. Increasing urbanization will also have consequences in the dietary patterns and lifestyles of individuals, not all of which are positive. Changes in diets, patterns of work and leisure often referred to as the "nutrition transition" are already contributing to the causal factors underlying non-communicable diseases even in the poorest countries. Moreover, the pace of these changes seems to be accelerating, especially in the low-income and middle-income countries. The dietary changes that characterize the "nutrition transition" include both quantitative and qualitative changes in the diet. The adverse dietary changes include shifts in the structure of the diet towards higher energy density diet with greater quantities of fat and added sugars in foods, greater saturated fat intake (mostly from animal sources), reduced intakes of complex carbohydrates and

dietary fiber, and reduced fruit and vegetable intakes (FAO, 2003). These dietary changes are compounded by lifestyle changes that reflect reduced physical activity and leisure time (WHO, 2003). At the same time, however, poor countries continue to face food shortages and nutrient inadequacies. Diets evolve over time, being influenced by many factors and complex interactions. Income, prices, individual preferences and beliefs, cultural traditions, as well as geographical, environmental, social and economic factors all interact in a complex manner to dietary consumption patterns.

2.1.2 Nutritive value

Food legumes as a valuable source of dietary proteins contribute to the diets of most people in the world. Although the protein content in legumes on dry basis is higher than that of meat, fish and eggs (Khan, 1987) yet the protein quality is unsatisfactory because of their low content of methionine (Khan, 1980; Khan *et al*., 1979a, 1995). However, legumes, being rich in lysine, they improve the protein quality of cereal-based diets (Khan *et al*, 1979b) and are comparable with the protein quality of meat-based diet (Khan and Eggum, 1978). Legume-based products were reported to have medicinal properties of being astringent, antibilious, aph-rodisiac, diuretic and were also effective in the management of hyper-cholesterolemia and diabetes (Chopra *et al*., 1956; Khan, 1991; Khan *et al*., 1995). In Saudi Arabia, an increasing trend in the *per capita* availability of food legumes has been reported to be 178% during the last decade (Khan and Al-Kanhal, 1997). According to the National Nutritional Survey (KACST. 1995) the average consumption of legume-based products and dishes in Saudi Arabia is 63g/head/day,

contributing to 2.6, 3.9,8 and 34% of the total energy, protein, dietary fiber and iron intake, respectively. Although some work on the chemical composition of food dishes 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) and in Bahrain (Musaiger and Al-Dallal, 1985) has been reported, yet adequate data on the nutritional quality of Saudi dishes is scares. It is important for dietitians and doctors to know the nutrients composition and nutritional quality of Saudi dishes 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 dishes are limited, for lack of knowledge in their quantity of ingredients or the way of preparing or cooking. Chemical composition and nutritional quality of five Saudi dishes based on legumes were evaluated. On fresh weight basis, the dishes contained 35.3-78.1% moisture, 4.4-10.2% protein (N x 6.25) 1.2-19.1% fat, 8.0-24.8% carbohydrates, 2.4-7.7% dietary fiber, 1.4-2.9% ash and 71-311 kcal (297-1301 KJ) per 100g. The contents of vitamin A (retinol equivalent), thiamin, riboflavin and vitamin C ranged from 85-378 mg, 0.01-0.12 mg 0.02-0.46 mg and 0.3-1.2 mg per 100g, respectively. The calcium content was 119.1-624.8 mg/100g. The dishes contributed 13-25%, 15-64% and 16-60% of the total food energy of protein, fat and carbohydrates, respectively. Most of the dishes were good sources of dietary fiber, vitamin A and iron. The chemical composition of these dishes showed that: Qishta was the most rich energy source (343.6 Kcal/100 grams) while harris is lowest (67.7 Kcal/100 gram). The results indicated that the national Saudi dishes contain lower calories and fat 1compared to

dishes from fast restaurants. The way of cooking of all dishes destroyed vitamin C, and vitamin C, which was not detected. Dishes of almuhalla and almataziz are the rich sources of iron and carotene, respectively. The chemical and amino acid compositions of traditional foods commonly consumed in the Arabian Gulf states were investigated. These foods are two kinds of fermented fish sauces (tareeh and mehiawah) and two types of bread made from date and cheese. The results indicated that tareeh had higher levels of protein, ash, Ca, Na, Mg, P and Zn than mehiawah, whereas the second fish sauce had higher amounts of moisture, fat, carbohydrates, Fe and K. For the breads, cheese bread (khubez-jebin) had higher levels of protein, fat, ash, Cu, P and Na than date bread (Khubez- tamer). However, the breads made from dates were higher in most minerals (Fe, K, Mg, Cu and Zn) than cheese bread. The amino acid profiles in both fermented fish sauces were superior to those of date or cheese breads. It was concluded that these traditional foods can provide substantial amounts of nutrients to the normal daily diets of Arab Gulf inhabitants. Nevertheless, attention should be paid to the high sodium levels in fermented fish sauces. Proximate, mineral, fatty acid and cholesterol compositions of 20 dishes consumed in Oman were analysed. Protein level ranged from 0.4 to 7.6%, while the fat content ranged between 0.3 and 28.1%. The dishes were found to be poor in Fe, Zn and Ca. Except for three dishes which had sodium levels less than 70 mg per 100g, sodium ranged from 108 to 571mg 100g. Two dishes were high in cholesterol (69.3 and 32.7mg per 100g), while the cholesterol level ranged from 0.0 to 9.64mg per 100g. The fatty acid analysis showed that palmitic, oleic and linoleic acids were predominant. In general, the chemical compositions of Omani dishes

are similar to those of other Arabian Gulf countries. The importance of food composition data has long been recognized by the Food and Agriculture Organization, 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). Seventeen traditional Qatari dishes, prepared by the Home Economics Department of Qatar University were chemically analysed. The moisture, crude protein (N × 6.25), crude fat, ash, nitrogen-free extract (NFE), (carbohydrate), and mineral contents were determined. The energy content was also calculated. The results indicated that in general the foods had high moisture, low protein, high fat and variable carbohydrate content. Also, a low mineral content was observed. The relationship between these findings and possible health problems is discussed in relation to the findings of other workers in this field of study. Recommendations are also made for improvement of these traditional Qatari dishes for the health and well-being of the Qatari population. The importance of food composition and food consumption data for understanding of the nutritional status of the population has been recognized (Windham *et al*., 1983). Studies on the nutrient composition and nutritionality of some native Saudi Arabian meals have been undertaken (Al-Jebrin *et al*., 1985a, b; Sawaya *et al.,* 1986; Salji *et al*., 1963). Similar investigations have to been carried out in Bahrain (Musaiger and Sungpuag, 1985; Musaiger *et al*., 1990). Chemical composition and nutritional quality of six Saudi Arabian dishes based on cereals and/or legumes were investigated on a fresh weight basis, the dishes contained 54.0-78.5% moisture, 2.6-7.5% protein (N × 6.25), 0.5-

4.9% fat, 0.1-1.8% crude fiber, 0.3-1.8% ash, 12.6-38.7% carbohydrates (by difference) and 386-811kJ (92-193 Cals) energy per 100g. The essential amino acids most deficient in the dishes were either tryptophan (in four dishes), or lysine (one dish) or total sulphur amino acids (methionine + cystine, in one dish). The chemical scores ranged from 26 to 67% (FAO/WHO, 1973). The *in vitro* protein digestibility (IVPD) and calculated protein efficiency ratio (C-PER) values ranged between 77.9-88.9% and 0.45-2.01, respectively. Under identical conditions, the Animal Nutrition Research Council casein showed IVPD and C-PER values of 90.0% and 2.50, respectively. The significance of these results were discussed. The relationship between diet and degenerative diseases has renewed public and professional interest in many countries of the world about food consumption and composition. The tremendous progress that Saudi Arabia has achieved with respect to food availability through improvement in the local agricultural output and liberal imports has led to the demand for reliable data on food composition. 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. Fourteen popular Saudi Arabian dishes containing a significant amount of animal protein (meat, fish and egg) were investigated. On fresh weight, the dishes contained 46.6-82.6% moisture, 3.6-9.4% protein (N × 6.25). 0.7-14.7% fat, 0.1-1.1% crude fiber, 0.8-2.4% ash, 3.9-40.9% nitrogen free extract and 82-236 Cal, 0.34-0.99 mg/100g food. The dishes had reasonably good amounts of K. P, Fe, Cu, Mn and some B-vitamins. Vitamin-A, folic and ascorbic acid content were generally presenting lower amounts. Amino acid profiles were adequate when compared

with that of FAO/WHO (1973) reference protein except for one dish (Motabak mamoz), which had lower content of both lysine (2.8g/16g N) and tryptophan (0.6g/16 g N). The chemical score ranged from 70-100, except Motabak mamoz, for which the chemical score was low. Tryptophan was generally the first limiting essential amino acid except in two dishes where methionine + cystine or lysine were the first limiting essential amino acids. The *in vitro* protein digestibility values ranged between 80.6-90.3% in comparison to Animal Nutrition Research Council (ANRC) casein value of 90.0%. The calculated protein efficiency ratio varied between 1.51-3.06 when adjusted to ANRC casein value of 2.50. The kingdom of Saudi Arabia is a fast developing country in the Arabian Peninsula with a per capita Gross National Product (GNP) in 1979 of U.S.S 7.370 (Waslien, 1981). With the increase in food production and availability, personal earnings and education attainment, a shift in the traditional food consumption pattern was foreseeable. There is now more awareness among the local population about their dietary intakes and nutritional well-being. Increasingly, the professional health-care personnel, the food industry, educators and consumers now need more information about the local food composition data emerging from interest in the relationship between diet and health status. This has led to the necessity of compiling more complete food composition tables, yielding information not only about the traditional nutrients but also on micronutrients, fatty acids, cholesterol, amino acids, fiber content and digestibility. There is no information on the nutrient composition of typical Saudi Arabian diets except for information on six dishes based on cereals and/or legumes (Al-Jebrin *et al*., 1985) and on the cholesterol and fatty acid contents of some dishes reported recently

(Sawaya *et al*., 1986). In some reports, results are presented on the chemical composition and protein nutritional quality of fourteen popular Saudi dishes containing significant amounts of animal proteins such as meat, fish and eggs. The selection of the dishes for the study was based on their popularity and higher frequency of intake. Plant-originated foods make up the most crucial part of human nutrition. They cost less than animal-originated foods, but most irnportantly; they are more popular and are produced more easily than the animal-originated ones. Third World Countries depend wholly on plant-originated foods since most of the protein of these countries come from plant sources. Grain legumes, rich and less expensive sources of proteins, are an important component of the diets of Third World populations, and in the Middle Eastern Countries. Like all other legumes chickpea is processed and cooked by a variety of methods based on tradition and taste preferences. The fruits (dates) of the date palm (*Phoenix dactylifera* L.) contain a high percentage of carbohydrate (total sugars, 44-88%), fat (0.2-0.5%), 15 salts and minerals, protein (2.3-5.6%), vitamins and high percentage of dietary fiber (6.4-11.5%). The flesh of dates contains 0.2-0.5% oil, whereas the seed contains 7.7-9.7% oil. The weight of the seed is 5.6- 14.2% of the date. The fatty acids occur in both flesh and seed as saturated and unsaturated acids, the seeds containing 14 types of fatty acids, but only eight of these fatty acids occur in very low concentration in the flesh. Unsaturated fatty acids include palmitoleic, oleic, linoleic and linolenic acids. The oleic acid content of the seeds varies from 41.1 to 58.8%, which suggests that the seeds of date could be a source of oleic acid. There are at least 15 minerals in dates. The percentage of each mineral in dried dates varies from 0.1 to 916 mg/100g depending on

the type of mineral. In many varieties, potassium can be found at a concentration as high as 0.9% in the flesh while it is as high as 0.5% in some seeds. Other minerals and salts that are found in various proportions include boron, calcium, cobalt, copper, fluorine, iron, magnesium, manganese, potassium, phosphorous, sodium and zinc. Additionally, the seeds contain aluminum, cadmium, chloride, lead and sulphur in various proportions. Dates contain elemental fluorine that is useful in protecting teeth against decay. Selenium, another element believed to help prevent cancer and important in immune function, is also found in dates. The protein in dates contains 23 types of amino acids, some of which are not present in the most popular fruits such as oranges, apples and bananas. Dates contain at least six vitamins including a small amount of vitamin C, and vitamins B (1) thiamine, B (2) riboflavin, nicotinic acid (niacin) and vitamin A. The dietary fiber of 14 varieties of dates has been shown to be as high as 6.4-11.5% depending on variety and degree of ripeness. Dates contain 0.5-3.9% pectin, which may have important health benefits. The world production of dates has increased 2.9 times over 40 years, whereas the world population has doubled. The total world export of dates increased by 1.71% over 40 years. In many, dates may be considered as an almost ideal food, providing a wide range of essential nutrients and potential health benefits. The nutrient composition of seventeen cooked dishes commonly consumed in the Arabian Gulf States was chemically examined. Five dishes were analysed for proximate, vitamin and mineral composition. It was found that they contain little amounts of water soluble vitamins and iron. Twelve dishes were analysed for proximate composition alone. Generally of the dishes analysed could supply an appropriate amount of protein and calories if

consumed in sufficient quantity. Food consumption pattern and nutritional status in the Arabian Gulf States are essentially similar, with common economic, social and geographical characteristics (Autret and Miladi, 1980). Although these States have the highest per capita income in the world, under nutrition and over nutrition continue to exist (Miladi and Pellet, 1980). The food habits of the Arabian Gulf States have been influenced by immigrants from many parts of the world, mainly from India, Pakistan and the Middle-East. Many dishes have been introduced by the immigrants and have become popular in these states. For example, the wide use of spices and curry powder is an indication of the influence of Indians on food practices in this area (Musaiger, 1982). The ingredients and cooking methods of most of these dishes have been modified according to the existing food resources and traditions of Arab inhabitants of the Gulf.

The basic foods in the Arabian Gulf States are rice with fish or meat or chicken. These foods are commonly eaten at the main meal, around midday (lunch). Bread (made from wheat flour) is of minor importance at lunch, but it is often consumed at breakfast and dinner. The proximate composition of 12 dishes consumed in the Arabian Gulf countries was studied. The dishes differed in their nutritional composition. The energy content between 343 KJ (82 Kcal) and 1013 KJ (242 Kcal) per 100g, while the amounts of protein varied between 3g and 8.1g per 100g. The rice used in the Arabian Gulf countries is polished rice, which has a lower proportion of nutrients than the unpolished cereal. The custom of repeatedly washing, boiling and straining the foods leads to the removal of some nutrients. Additionally the custom of cooking of the dish for a relatively long

time may adversely affect the nutritional value of foods. Processing can both increase and decrease digestibility of protein. The adverse effect of overheating is that it may degrade protein quality by blocking the epsilon amino group of lysine in the intact protein, with resultant inhibition of hydrolysis by trypsin (Borenstein, 1980). The excessive heating of foodstuffs may render some of the amino acids in the protein unavailable to the body (Gopalan *et al*., 1982). It appears from the nutrient composition of the dishes analysed, most of them could supply an appropriate amount of protein and calories if consumed in adequate quantity. However, this would only be true if the distribution of food among the family members is shared appropriately, as Musaiger (1982) found that in some areas of Bahrain, many families separate the foods into two grades; that of the best quality and quantity to be presented to men; the other to women. This division decreases the chance of mothers and children getting their recommended allowances. On some occasions, the whole family eats together from the same plate. In this case, the older members can get more high protein (foods high biological value), whereas children are likely to receive smaller amounts of such foods. On the other hand overweight is one of the common public health hazard in this area. It is believed that lack of physical exercise and the high consumption of energy-rich foods contribute to prevalence of obesity in these countries. For instance, in Kuwait it was found that the daily per capita calories intake is 13.7 MJ (3269 Kcal), with 48% of these calories being supplied by cereals (Autret, 1979). Spices were widely used in most dishes. Many spices are rich in protein, ash and fiber (Murphy, *et al*., 1978), but their contribution to the daily intake is small due to the low amounts used in any one dish. However, the

same researchers found that some spices contain high amounts of sodium. These include cumin, coriander leaf, and cloves which are commonly used in the Arabian Gulf dishes. Furthermore, salt is much used in their cooking. It was observed that the level of sodium is high in all such dishes. Consequently more attention should be paid to the spice content of sodium-restricted in hospitals. An attempt was made to calculate the nutrient constituents of the dishes from food composition tables, in order to compare the difference between the analysed and calculated composite dishes. There are no detailed food tables available for the Gulf region. The food tables that are currently used (Pellet and Shadarevian, 1970; FAO, 1982) are lacking of many foods commonly consumed in the region; for example black dried lemons, mixed spices, dried shrimps, crushed wheat and various kinds of local fish. A better reference to be used for comparison would be a "Composition of Food Consumed in Kuwait" (Kamil and Allam, 1979). However, this document does not contain scientific names and vitamin analysis of the foods. This created difficulties when calculating the composite dishes, particularly for vitamins. Therefore, they were excluded from the calculation. In general, the values for protein, energy, fat, calcium and iron obtained by chemical analysis are lower than the values obtained by calculation using a combination of the above three tables of food composition. The percentage of the difference of results from chemical analysis and calculation show a great variability. For example, the percentage of the difference in protein ranged between 54% and 23%, while that for energy ranged between 34% and 10%. At this stage, we can conclude that the food composition tables evaluation of nutritional intakes estimated the recipe compositions. An establishment of a comprehensive nutrient

base of indigenous and imported foods consumed in the Arabian Gulf states, therefore, is highly recommended.

2.1.3. Commonly consumed dishes in Saudi Arabia

2.1.3.1. Kabsa

2.1.3.1.1. Areas of consumption in the kingdom

Kabsa is consumed in a wide area in Saudi Arabia, in the central, northern and southern.

2.1.3.1.2. Ingredients and way of preparation

The ingredients of Kabsa include rice (480 g), chicken meat (500 g), tomato (250 g), oil (40 g), onion (180 g), hot pepper (15 g) and spices (5 g). Kabsa is prepared by frying onion with oil then chicken meat will be added with tomato paste. Thereafter, water and salt will be added and then the constituents will be cooked. Prior to the end of cooking rice will be added (Al-Jassir *et al*., 1998).

2.1.3.1.3. Nutritive value

Research conducted revealed that Kabsa contained about 64.7 g/100g moisture, 2.8 g/100g protein, 1.7 g/100g fat, 1.2 g/100g ash, 0.8 g/100g fiber, 28.8 g/100g carbohydrate and 142 kcal/100g energy. Also, it has been reported to contain 56 μg/100g retinol, 0.04 mg/100g thiamin, 0.64 mg/100g riboflavin and it lacks vitamin C (Musaiger, 2006). Compared to other traditional foods Kabsa is very nourishing diet.

2.1.3.2. Hunaini

2.1.3.2.1. Areas of consumption

Hunaineni is consumed in a wide area in Saudi Arabia, in the central and eastern regions.

2.1.3.2.2. Ingredients and way of preparation

The ingredients of Hinaini include date (1000 g), brown flour (500 g) and butter (120 g). Hinaini is prepared by removing the seeds of the date and then the date will be milled and mixed with flour and water and then cooked for about 30 min. prior to the end of cooking batter will be added (Al-Jassir *et al*., 1998).

2.1.3.2.3. Nutritive value

Research conducted revealed that Hinaini contained about 28.97 g/100g moisture, 5.19 g/100g protein, 3.67 g/100g fat, 1.57 g/100g ash, 1.59 g/100g fiber, 59.01 g/100g carbohydrate and 289.8 kcal/100g energy. Also it has been reported to contain 5.12 mg/100 Fe, 112.5 mg/100g P, 27.72 mg/100g Ca, 543.2 mg/100g K and 271.5 mg/100g Na (Al-Jassir *et al*., 1998). Compared to other traditional foods Hinaini is very nourishing diet.

2.1.3.3. Garish

2.1.3.3.1. Areas of consumption

Garish is consumed in a wide area in Saudi Arabia, in the central, eastern and northern regions.

2.1.3.3.2. Ingredients and way of preparation

The ingredients of Garish include low fat milk (1200 g), ground wheat (480 g), rice (240 g), hot pepper (10.2g), butter (10g), ground Kamon (5g), salt (3g) and animal fat (15g). Garesh is prepared by boiling the above ingredients with low fat milk for about 30 min prior to the end of cooking, garish and rice are added and the mixture is left for 3-5 hour. At the end of cooking garish is compacted using wood

spoon and then a small amount of butter is added at the top (Al-Jassir *et al*., 1998).

2.1.3.3.3. Nutritive value

Research conducted revealed that garish contained about 81.33 g/100g moisture, 2.35 g/100g protein, 2.95 g/100g fat, 11.1 g/100g ash, 0.27 g/100g fiber, 11.99 g/100g carbohydrate and 83.9 Kcal/100g energy. Also it has been reported to contain 2.80 mg/100 Fe, 54.48 mg/100g P, 18.50 mg/100g Ca, 70.80 mg/100g K and 40.20 mg/100g Na (Al-Jassir *et al*., 1998). Compared to other traditional foods garish is not very nourishing diet compared the above ones.

2.1.3.4. Gursan

2.1.3.4.1. Areas of consumption

Gursan is consumed in a wide area in Saudi Arabia, in the central, eastern and northern regions.

2.1.3.4.2. Ingredients and way of preparation

The ingredients of gursan include green beans (12 g), kosa (12 g), carrot (12 g), yellow pumpkin (12g), gursan (500 g), boneless meat (500 g), tomato (500 g), oil (30g), tomato paste (60 g), onion (250 g), hot pepper (15 g) and ground spices (5 g). Gursan is prepared by cooking the vegetables with boneless meat and concentrated, then fried onion and gursan is added (Al-Jassir *et al*., 1998).

2.1.3.4.3. Nutritive value

Research conducted revealed that gursan contained about 77.90 g/100g moisture, 5.98 g/100g protein, 4.55 g/100g fat, 1.28 g/100g ash, 0.51 g/100g fiber, 9.28 g/100g carbohydrate and 102.0 Kcal/100g energy. Also it has been reported to contain 1.48 mg/100 Fe, 72.72

mg/100g P, 21.37 mg/100g Ca, 122.40 mg/100g K and 93.30 mg/100g Na (Al-Jassir *et al*., 1998). Compared to other traditional foods gursan is not very nourishing diet compared the above ones.

2.1.3.5 Saleeg

2.1.3.5.1. Areas of consumption

Saleeg is consumed in a wide area in Saudi Arabia, in the western and southern regions.

2.1.3.5.2. Ingredients and way of preparation

The ingredients of Saleeg include sliced meat (1100 g), rice (470 g), powdered milk (80 g), butter (5 g), salt (3 g), water (3840 g), wheat flour (500 g), dissolved butter (120 g). Saleeg is prepared by cooking all ingredients except rice, powdered milk and batter which are added later (Al-Jassir *et al*., 1998).

2.1.3.5.3. Nutritive value

Research conducted revealed that Saleeg contained about 82.67 g/100g moisture, 1.76 g/100g protein, 1.59 g/100g fat, 1.07 g/100g ash, 0.05 g/100g fiber, 12.86 g/100g carbohydrate and 72.80 Kcal/ 100g energy. Also it has been reported to contain 0.95 mg/100 Fe, 31.21 mg/100g P, 21.74 mg/100g Ca, 4.44 mg/100g K and 27.40 mg/100g Na (Al-Jassir *et al*., 1998). Compared to other traditional foods Saleeg is not very nourishing diet compared to the above ones.

2.2. Anti-nutritional factors

Anti-nutritional factors such as the haemagglutinin, saponins, tannin, anti-vitamins, protease inhibitor and phytic acid, which interfere with mineral element absorption and utilization and react with proteins to form complex products which have inhibitory effect

on peptic digestion. Of the various anti-nutritional factors that are found in grain legumes, trypsin and chymotrypsin inhibitors, amylase inhibitors, polyphenols (commonly referred to as tannins), oligo-saccharides, and phytic acid are important in pigeon pea (Singh, 1988). In comparison with soybean, pea, and common bean, pigeon pea offers fewer anti-nutritional factor problems. Pigeon pea contains considerably higher levels of protease inhibitors than the other commonly consumed Indian grain legumes, but much lower levels than those of soybean (Sumathi and Patabhiraman, 1976). Pigeon pea contains considerable amounts of polyphenolic compounds, chymotrypsin and amylase. These are higher in pigeon pea cultivars with dark seed-coat (Singh, 1984). Phytolectins are toxic factors that interact with glycoprotein on the surface of phytolectins which are highly sensitive to heat treatment and hence may be of little nutritional significance. Pigeon pea contains traces of glycosides but not at toxic levels (Singh, 1988). Bressani, (1985); Bressani, (1989); Bressani, 1993; Bressani and Sosa (1990) found that traditional processing such as cooking, soaking, dehulling and germination help not only in making beans more acceptable to consumers but also significantly reduce anti-nutritional elements in the food grain. The most common way to process food legumes is to subject them to thermal processing. Although the main goal of thermal processing is to render the grain soft, its effects go beyond the changes in physical structure and texture (Bressani, 1985; Bressani, 1989; Bressani, 1993; Bressani and Sosa, 1990). Although heat treatment will effectively eliminate most of these undesirable substances, the application of other processes such as soaking, cooking, steeping, decorticating, or germination have also been effective in reducing anti-nutritional factors.

2.2.1. Phytate

Many widely-consumed foods in Saudi Arabia are made mainly from cereals, legumes and oilseed crops. These foods are good sources of proteins, minerals and vitamins for humans and they can make a significant contribution to meeting the nutritional requirement of populations, particularly to those of low income (FAO, 1987). Unfortunately, most of these foods may contain phytate as an anti-nutritional factor. This is an undesirable compound in foods because it may cause mineral deficiencies in humans, especially the high risk groups, i.e., children, pregnant and lactating women and the elderly (Davies, 1979). In processed foods, phytate would have the capacity to bind proteins and/or minerals such as iron, calcium and zinc to form insoluble complexes (Lasztity, 1990) which would decrease their bioavailability (Juliano *et al*., 1991). An estimate of daily phytate intake in Saudi Arabia is unknown, but the consumption of phytate-rich foods is expected to be high. Although, the chemical composition and nutritive value of the widely-consumed foods in Saudi Arabia have been determined, no data on phytic acid or phytate content in raw, baked or cooked traditional foods is avaialble in the literature. The term phytic acid, phytate and phytin refers, respectively, to the free acid, the phosphorus salt and the calcium/magnesium salt. Phytic acid in the free form is unstable, decomposing to yield orthophosphoric acid, but the dry salt form is stable. The salt form of phytate (myo-inositol 1, 2, 3, 4, 5, 6-hexaxis inositol dihydrogen phosphate), accounts approximately for 50-85% of the total phosphorus stored in many raw cereals and legumes (Ravindran *et al*., 1994). Phytate content in foods made from cereals and legumes depends on the concentration of phytate in original raw materials and

the final products to be prepared. Phytate represents a complex class of naturally occurring phosphorus compounds that can significantly influence the functional and nutritional properties of foods. Phytic acid has strong binding capacity readily forming complexes with multivalent cations and proteins. Most of the phytate-metal complexes are insoluble at physiological pH. Hence phytate binding renders several minerals biologically unavailable to animals and humans.

2.2.1.1. Chemistry and occurrence of phytate

Phytic acid (myo inositol hexaphosphate) is the chief storage form of phosphorus in cereals, legumes and oil seeds. The phytic acid content of these products varies between 0.5 and 6.0% and account for 60 to 90% of total phosphorus content of the product (Fox and Tao, 1989). Phytic acid may serve several important physiological functions during dormancy and germination of seeds. These include the storage of phosphorus, high energy phosphoryl groups and cations (Maga, 1982). Approximately 75% of the phytic acid is associated with the soluble fiber components and it has not been possible to detect its presence in the soluble fiber fraction (Frolich and Asp, 1985; Frolich and Nyman, 1988). Phytic acid content in fruits and vegetables is generally much lower than cereals (Fox and Tao, 1989; Kelsay, 1987; Maga, 1982), while oil seeds contain the highest level in nature e.g sesame contain 5.18%, cottonseed 2.8 - 4.29%. The chemical structure of phytic acid as it exists in nature is still controversial subject (Fox and Tao, 1989; Hartman, 1979). There is diagreement about whether the actual structure of phytic acid is $C_6H_{18}O_{24}P_6$ or $C_6H_{24}O_{27}P_6$ (Jacobsen and Slotfeldt-Ellingsen, 1983). At neutral pH phosphate groups have either one or two negatively charged oxygen

atoms. It is apparent that various cations could strongly chelate between two phosphate groups or weakly within a phosphate group. However, it is well known that the molecule of phytic acid can be dephosphorylated by means of enzymes or as a result of high-temperature processing to yield large numbers of positional isomers myoinositol, bis-, tris-, tetra-, penta-, and hexaphosphates (IP2 – 1P6) (Hartman, 1979; Sandberg and Ahdernne, 1986; Phillipy *et al.*, 1986). Thus during food processing and digestion in the human gut, it is likely that lower inositol phosphates are formed (Fox and Tao, 1989; Sandberg and Ahderinne, 1986). Phytic acid is normally found in the form of complexes with essential minerals or/and proteins (Hartman, 1979; Fox and Tao, 1989). Many of these complexes are insoluble and are not biologically available for humans under normal physiological conditions (Ali and Baker, 1981; Fox and Tao, 1989; Nosworthy and Caldwell, 1988). As the pH increases and under certain phytate concentrations, phytic acid can interact with minerals and/or minerals and protein. Since phytate cannot be absorbed and humans have limited capacity to hydrolyze the phytate molecule, a negative effect of phytic acid on mineral bioavailability can be expected (Pawar and Ingle, 1988; Champagne *et al*., 1989; Fordyce *et al*., 1987; Velencia *et al*., 1999; Sripria *et al*., 1997; Khetarpaul and Chauhan, 1989).

2.2.1.2. Phytic acid content

The amount of phytic acid varies from 0.5 to 1.89% in cereals (except polished rice), from 0.4 to 2.06 in legumes, from 2.00 to 5.20% in oil seeds (except soybean and peanuts), and from 0.4 to 7.5% in protein products (Reddy *et al*., 1982). Among cereals, lgumes and other oil seeds sesame had higher amount of phytic acid; phytic

acid phosphorus in several seeds and grains constitutes the major portion of total phosphorus. Doherty *et al*. (1987) analysed several varieties of sorghum and found that in the whole grain phytin phosphorus ranged from 170 to 380 mg/100g; over 85% of total phosphorus was bound as phytin phosphorus. In pearl millet, values reported for phytin phosphorus varies from 172 to 327 mg/100g (Chauhan *et al*., 1986). A range of 1 to 2.3% of phytic acid in soybean reported by Liener, (1994); Anderson and Wolf (1995).

2.2.1.3. Interaction of phytic acid with mineral and proteins

Phytic acid may reduce the bioavailability of some metals in particular calcium and phosphorus due to formation of insoluble chelates that cannot be absorbed in the intestine under physiological conditions as well as proteins (Fox and Tao, 1989). Phytic acid has six strongly dissociated protons and six weakly dissociated protons (Fox and Tao, 1989; Pawar and Ingle, 1988). Due to dissociated ions of these ionizable protons phytate can form very stable complexes with metalic cations. The true mechanism(s) of interactions of phytic acid and minerals is not well understood, although it is possible that phytic acid could complex a cation within a single phosphate group or between two phosphate groups on either the same or different molecules (Fox and Tao, 1989; Erdman, 1979). Normally, the divalent cations form insoluble penta - and hexa - substituted salts. Mono-di-tri-and tetra substituted salts are not frequently found (Nolan *et al.*, 1987; Martin and Evans, 1987; Evans and Martin, 1988). The relative binding strength of different minerals to phytic acid varies greatly (Martin and Evans, 1987; Evans and Martin, 1988). *In vitro* studies have shown that there are a number of factors that may influence

mineral and protein availability. These factors include; the amount of phytic acid, mineral concentration, size and valency, an association of phytic acid with protein, heat treatment of the food, the pH and the presence of other metal ions (Synergestic effect) (Martin and Evans, 1987; Evans and Martin, 1988).

2.2.1.4. Effect of processing on phytate

Whole meal cereal products contain considerable amounts of phytic acid (myo inositol hexaphosphate acid) which chelates with minerals such as calcium, iron and zinc (Heany *et al.,* 1991; Rossandar *et al.,* 1992) forming insoluble complexes rendering minerals unavailable for absorption in the human intestine. One way of solving this is to reduce phytate by processing to activate the instrinsic enzyme phytase which degrades phytate to free myo-inositol and inorganic phosphate (Irving *et al.*, 1980). In cereals and legumes different traditional processing techniques such as cooking (Valencia *et al*., 1999), soaking (Vijayakumari, *et al*., 1998), incubation with malt (El Khalil *et al.,* 2001), milling (Mahgoub and Elhag, 1998), fermentation (Marfo, *et al.,* 1990; Ketarpaul and Chauhan, 1989) and germination (Sripnya *et al.,* 1997, Khetarpaul and Chauhan, 1989) were practised to reduce or to eleminate phytates in foods.

2.2.1.4.1. Effect of cooking on phytate content

Phytate is fairly stable to heat (Maga, 1982). Cooking has a little reducing effect on phytate levels of cereals and legumes; 17 - 31% reduction in cereals and 16.8 - 17.1% reduction in legumes but cooking is very effective in reducing phytate of tubers (Marfo *et al*., 1990). Ordinary cooking of soaked mung bean seeds lowered phytic acid by 20%. Kumari *et al.* (1998) reported a reduction of 43% and

29% of phytic acid for seeds of *Vign aconitifolia* and *Vigna sinensis*, respectively as a result of cooking. The decrease in phytic acid content of legume seeds during cooking may be partly due to formation of insoluble complexes between phytate and other components such as phytate-protein and phytate-protein-mineral complexes. Kumur *et al.* (1978) investigated the effect of cooking on characteristics of legumes: green gram, cowpea and chickpea. Their results indicate that cooking processes decreased both water and acid extractable phosphate phosphorus in all legumes.

2.2.1.4.2. Effect of germination on phytate content

The sprouts of various cereals have been used for centuries in many traditional dishes in the orient. The practice has recently become popular in the Western World. The sprouting of cereal grains for a limited period has been reported to improve nutritional compositions (Chavan and Kadam, 1989). The phytate is utilized as a source of inorganic phosphate during seed germination and the inorganic form becomes available for purposes of plant growth and development. The liberation of phosphate from phytate occurs by enzyme hydrolysis. Phytase is the currently accepted enzyme, which is responsible for the complete hydrolysis of phytate (inositol hexaphosphate) into inositol and phosphate. Several seeds or grains are known to contain phytase enzyme and its activity varies widely. Phytase activity increased during germination of several seeds (Kataria *et al*., 1989; Valencia *et al*., 1999). The principal function of phytase in seeds or grains is to liberate phosphate from phytate during germination. Germination reduces and/or eliminates considerable amounts of phytate from the seeds or grains. Valencia *et al.* (1999) reported a significant reduction

of phosphate of 38% and 35% in quinoa seed samples. Sandberg and Anderson (1988) reported 35% reduction phytic acid content in germinated white sorghum. Kataria *et al*. (1989) reported that germination of soaked seeds of mungbean for 24 h reduced phytic acid significantly. As the period of germination was raised, the concentration of phytate declined further. They found that phytase activity appeared to increase with increased germination time and that phytate hydrolysis did not begin to occur rapidly until 72 h after germination. Phytin phosphorus decreased significantly from 38 to 20% on germination. However, in finger and foxtail millets the decrease in phytin phosphorus was very small (FAO, 1995). Kumar and Chauhan (1993) reported that sprouting of millet grain resulted in a significant decrease in phytic acid content at all temperatures studied (25, 30 and 35^{o}C), the longer the period of germination, the greater extent of decrease. Honke *et al*. (1998) observed a 15 and 78% reduction in inositol phosphate (IP_6) after 48 and 72 h, germination of faba bean ,respectively. The consumption of cereal sprouts and the products prepared from the flour of sprouted cereals is becoming popular in the world. Sprouting is easy and can be carried out without sophisticated equipments. Sprouting of grains causes increased activities of hydrolytic enzyme, improvement in the content of total proteins, fat, ash, total sugars, vitamins and decrease in dry matter, starch and anti-nutrients. The increase in protein content and total ash are apparent and attributable to the disappearance of starch. However, improve-ments in B-group vitamins, protein and starch digestabilities and decrease in phytates and protease inhibitors are metabolic effects of sprouting process.

2.2.1.4.3. Effect of fermentation on phytate content

Fermentation of cereals and legumes appreciably reduces the phytate content due to endogenous phytase of cereals and legumes (Reddy *et al*., 1982). Marfo *et al*. (1990) showed that the fermented products of all samples investigated had relatively lower levels of phytate as compared with unfermented samples, especially for the tubers where the extent of reduction of phytate content by fermentation was about 86, 98 and 65% for cassava, cocoyam and yam, respectively. For cereals the greatest loss of phytate was found for rice (80%) and the least loss was observed for red sorghum (52.03%). Reduction of phytate levels was more pronounced up to 48 h of fermentation and was gradual after that period. The decrease in the capacity of fermentation to reduce phytate levels which occurred after 48 h fermentation may be due to denaturation of phytase, product inhibition of phytase or inaccessibility of phytate (Tangkongchitr *et al*., 1982). A study by Sharma and Khetarpaul (1998) showed that fermented rice-legume mixtures had reduced phytic acid content compared to control products containing unfermented blends. Spripria *et al*. (1997) reported that fermentation was more effective in reducing pH, phytate and increasing the mineral bioavailability, free sugars, and amino acids of pearl millet. Mahgoub and Elhag (1998) reported that fermentation of a Sudanese sorghum for 12 h (The usual practice in Sudan) resulted in a reduction range higher than that reported by Ketarpaul and Chauhan (1989) for the fermentation of millet for 27 h. Yadav and Khetarpaul (1995) reported that unfermented black-grain-dhal wadi mixture contained 1000 mg/100g phytic acid. Fermentation of the mixture reduced the phytic acid content significantly ($P<0.05$). The legume product fermented at

35°C for 18 h had only one half of the phytic acid content of that present in the unfermented mixture. An increase in the fermentation period from 0 to 12 h and from12 to 18 h at different temperatures, resulted in 18 – 43% decrease in phytic acid content. The higher the temperature and longer the period of fermentation, the greater was the reduction in the content of phytic acid. A decrease in phytic acid content during fermentation has also been reported in various foods including soy-rabadi (Grewel, 1992), fermented rice-legume mixture (Sharma and Khetarpaul, 1998). A wide range of microflora has been known to posses phytase activity (Lopez *et al*., 1983) which may be partly responsible for reducing phytic acid content in the fermented samples. The optimum temperature for phytase activity from plants and microbial sources has been known to range from 35 to 45°C (Lopez *et al*., 1983).

2.2.2. Tannins

Tannins are polyphenolic substances having a molecular weight greater than 500 D (Linear, 1994). In plant extracts, these substances exist as polyphenols of varying molecular size and complexities. However, many nonpolyphenolic substances in plants also have all the chemical properties of tannin but have not been tested for their ability to produce leather hides. There are also other substances that turn hides into leather but are not of plant origin (Chung *et al*., 1998). Tannins have been found in a variety of plants utilized as food and feed. These include food grains such as sorghum, millets, barley, dry beans, faba beans, peas, carobs, pigeon peas, wing beans and other legumes (Chavan *et al*., 1977; Salunkhe *et al*., 1982). Fruits such as apples, bananas, dates, grapes, peaches pears, strawberries also

contain an appreciable quantity of tannins (Goldstein and Swain, 1963). Likewise, phenolic compounds are present in wines and tea (Hoff and Singleton, 1977; Sanderson *et al*., 1975). Forages also reported to contain tannins (Jones and Mangan, 1977). Vegetable tannins as water-soluble phenolic compounds having a molecular weight between 500 and 3000 D. These polyphenols contain a large number of hydrozyl or other functional groups, which are capable of forming cross-linkage with proteins and other macromolecules. The low-molecular phenolic compounds (Molecular weight <500) and those of high molecular weights (molecular weight >3000) are ineffective tanning agents. Tannins can be classified into two categories: hydrolyzable and nonhydrolysable or condensed tannins. Hydrolyzable tannins contain a central core of polyhydric alcohol such as glucose and hydroxyl groups, which are estrified either partially or wholly by gallic acid (ellagitannins). After hydrolysis by acids, bases, or certain enzymes gallotannins yield glucose and gallic acid. The hydroxydiphenic acid for ellagitannins undergoes lactonization to produce ellagic acid (Chung *et al*., 1998). Condensed tannins are structurally more complex than hydrolyzable tannins, their complete structure is yet to be determined. They are mainly the polymerized products of flavan-3-ols and flavan-3-4-diols or a mixture of the two. The polymers referred to as “flavolans” are popularly called condensed tannins. Condensed tannins are widely distributed in fruits, vegetables, forage plants, cacao, red wine and certain food grains such as sorghum, finger millet and legumes (Chung *et al*., 1998). Flavan-3-ols are often referred to as catechin. Because catechin molecules possess two asymmetrical carbon atoms at the C_2 and C_3 position, four isomers exists. These are (+) and (-)

catechin in which 2-phenyl and 3-hydroxyl groups are trans. The (-)-epicatechin can be isolated from cacobeans. The (-)-epigallocatechin and its 3-gallate are also present. Flavan 3-4-diols belong to the class of compounds called leucoanthocynins, because after heating in acidic solution, they polymerize into phlobaphene-like products and produce antho-cyandines. A flavan 3-4-diols molecule possesses asymonetric carbon atoms at C-2, C-3 and C-4 hence eight isomers are present. Some structurally known flavan3-4-diols are leucocyanidine. Tannins protect the grain against insects, birds and weathering (Waniska *et al*., 1989). The rate of preharvest germination or early sprouting is significantly lowered in most high tannin cultivars. These beneficial effects ensure that brown sorghum will continue to be produced in certain pest-ridden areas of the world (Bulter, 1990).

2.2.2.1. Tannins as anti-nutrient

Tannins are often considered to be nutritionally undesirable. The anti-nutrient effects of tannins in sorghum grain have been thoroughly reviewed (Salunkhe, *et al*., 1990, Elmaki *et al*., 1999). Tannins form complexes with proteins, starch, minerals and digestive enzymes to cause a reduction in nutritional value of foods. They can cause browning in foods through the action of polyphenol oxidase by darkening reactions adversely affecting the acceptability of such foods. Most of the early reports related to the anti-nutritional effects of tannins were centered on tannic acid and other hydrolyzable tannins. However, as hydrolyzable tannins are present only in trace amount in commonly consumed foods, the more predominant condensed tannins are of more concern when discussing the anti-nutritional effects of tannins. Ingestion of tannin may not be a nutritional problem for those

people whose diets includes animal protein and cereals, such as rice, wheat or barley. However, those compounds may exert anti-nutritional effects on people living in semi-arid regions of Asia and Africa whose diets are based mainly on sorghum, millets and pulses. The anti-nutritional effects of dietary tannins and their interaction with enzymes and other proteins have been reviewed previously (Salunkhe *et al*., 1982; Reddy *et al*., 1985). Tannins have been reported to be responsible for decreases in feed intake, growth rate, feed efficiency, net metabolizable energy and protein digestibility (Salunkhe *et al*., 1982; Hulse, 1980). Other deleterious effects of tannins include damages to mucosal lining of the gastrointestinal tract, alteration of excretion of certain cations and increased excretion of proteins and essential amino acids (Kramling and Singleton, 1969). Tannins have been shown to reduce bioavailability of iron and vitamin B_{12} (Leiner, 1980). Toxic effects have been attributed to the consumption of excessive amounts of other high tannins containing feed including carob, sorghum, rapeseed meal and grapeseed meals. Tannins can interact with protein, but their molecular size is important for such interactions. Tannins were reported to interfere with the digestion and/or absorption of carbohydrates from sorghum (Blakeslee and Wilson, 1979). Zitko and Rosik (1962) reported that one tannin molecule could bind to two or more peptide groups, possibly through formation of cross-links between protein chains. The degree of cross-linkages depends upon the number and accessibility of protein carbonyl groups, as well as relative concentrations of the reactants. Hagerman and Bulter (1980) reported that under optimal conditions sorghum tannins is capable of binding and precipitating at least 12 times its own molecular weight of proteins. High tannins sorghum

grains contains more than enough tannins to bind to seed proteins and profoundly affects the properties and availability of these proteins. Barley, rye and common beans contain low quantity of tannins and higher level of proteins, therefore, the quality of seeds proteins is less affected by tannins (Price and Bulter, 1980). Tannins, particularly the condensed tannins types are reported to inhibit enzymatic activities of cellulase and amylase (Griffiths and Jones, 1977), proteolytic enzymes (Griffiths and Moseley, 1980); and those microbial activities involved in fermentation of cereal grains (Watson, 1975). Inhibition of enzymes by tannins is reported to be non-competitive (Watson, 1975). The decreased enzymatic activity also comes from the binding of tannins with protein substrate, resulting in formation of complexes resistant toward hydrolysis (Oh and Hoff, 1986). Tannins are known to affect the utilization of vitamins and minerals. They form insoluble complexes with divalent iron and render them less absorbable (Sritriantia, 1976). Belavady (1977) found a marked reduction in iron absorption by human subjects fed sorghum containing 1500 ppm tannins. Motilva *et al.* (1983) also reported that faba beans tannins exhibit high iron-binding capacities.

2.2.2.2. Reduction of tannins

Several mechanical and chemical methods have been reported to overcome the toxic effect of high tannin grains. Much work has been reported on efforts to remove or inactivate tannins in sorghum (Salunkhe *et al*., 1990), through direct removal, extraction, cooking, germination, fermentation, combination of germination and fermentation and incubation with malt. Because tannins are concentrated in the testa or seed coat of the grain removal of that layer should eliminate

the tannins. However, using traditional milling processes as well as mechanical methods was shown to result in considerable losses in nutrients (Rooney and Saldivar, 1999). The most common and practical ways are by decortication. Decortication removes the pericarp and testa and, therefore, most tannins. However, decortication is sometimes insufficient, because most brown sorghums have soft-floury endosperm (Reichert *et al*., 1988). Parboiling of brown colour sorghum prior to decortication can be better alternative for tannin removal (Young *et al*., 1990). Different methods have been tried to inactivate or detoxify the tannins in bird resistant sorghum to improve their nutritional quality (Salunkhe *et al.,* 1990). Moisturizing the gains with alkali several hours prior to utilization, including treatment of the whole grains with dilute aqueous ammonia, was found to be quite effective (Price and Butler, 1980). In traditional processing of high-tannin sorghum prior treatment of the grain with alkali is an important step. In making sorghum beer, the grains are soaked overnight with moistened wood ash, the alkalis released from ash product were found to reduce extractable tannins up to 97% and improve protein digestibility (Mukuru *et al*., 1992). Muindi and Thomke (1981) found that treatment of high-tannin sorghum with mugadi soda solution was also effective in detoxification of tannins. Other methods suggested to improve the nutritional quality of bird-resistant sorghum include treatment with formaldehyde (Daiber and Taylor, 1982); high moisture reconstitution (Teeter *et al*., 1986); supplementation of high-tannins diet with dicalcium phosphate (Ibrahim *et al*., 1988). Babiker and El Tinay (1992) reported that extractable tannins content of sorghum cultivars was markedly reduced by imbibing NaOH or KOH solution into whole seeds. Chavan *et al*. (1977) reported a decrease of

75 – 80% in tannin content after soaking sorghum grain in 0.05 sodium hydroxide for 24 h at room temperature. Similar observation was made on sorghum by Agrawal and Chitinis (1995), where the reduction in tannins content reached about 77%.

2.2.2.2.1. Effect of cooking on tannin content

Barampara and Simard (1993) reported a decrease of 59.8% for tannin content of cooked dry beans, and of 84.6% of soaked-cooked beans, they stated that the reduction is probably due to diffusion of tannins in water or formation of insoluble tannin-protein complexes. Kaur and Kapour (1990) reported a decrease in tannins of soaked and cooked rice bean, while the decreased content probably due to the leaching of the phenols into water during cooking and change in the chemical reactivity. Jood *et al*. (1987) reported a similar trend by thermal processing. Alonso *et al*. (2000) reported a significant reduction of condensed tannins and polyphenols due to thermal processing methods; also Kataria *et al*. (1989) reported a similar trend by thermal processing.

2.2.2.2.2. Effect of germination on tannin content

Sprouting of seeds has been reported to decrease the tannin content in cereals such as millets and sorghum (Chavan and Kadam, 1989). Germination of high-tannin sorghum for 24 h decreased the content of assayable tannin by 29.4%, such reduction in tannin content can be increased up to 70.6% when the sprouting process is extended up to 72 h. Bulter (1982) observed that a 5 day germination of high-tannin sorghum grains eliminated most of assyable tannins. Subramanian *et al*. (1992) reported a reduction in tannins in four sorghum cultivars tested until 48 h germination. Okoh *et al*.

(1989) reported that the absolute amount of tannin was unchanged until the 4th day of germination, but decreased considerably by the 6th day. Subramanian *et al*. (1992) reported that after 24 h germination condensed tannins concentration (catechin equivalents) is reduced by 60 and 40% for brown and white sorghums, respectively. Osuntogun *et al*. (1989) also reported a decrease in tannin content due to germination. In contrast, Agrawal and Chitnis (1995) found that water-soaked and germinated seeds for 72 h were ineffective in reducing tannins. However, the observed reduction in tannin content in germinated seeds has been attributed to the formation of a hydrophobic association of tannin with seed proteins and enzymes and not to the actual loss or degradation of tannins (Butler, *et al*., 1984). Glennie *et al*. (1983) observed that tannins in bird-resistant-high-tannin sorghum form complexes with proteins during malting. These reports indicated that sprouting treatment did not decrease the tannin content of grain, but favors the formation of complexes between testa tannins and endosperm proteins. The problem of tannins however, is not of a significance in low tannin types and other cereals that do not contain appreciable amounts of tannins.

2.2.2.2.3. Effect of fermentation on tannin content

Ikemefuna *et al*. (1991) reported that combination of cooking and fermentation of sorghum improved nutritional quality and drastically reduced the tannin content to safe levels much greater than any other processing methods. Romoparada *et al*. (1985) reported that fermentation decreases the tannin content of high tannin sorghum cultivar by 92%. Barampama and Simard (1994) reported that tannin content of dry beans decreased by cooking andfermentation (89.2%).

Hassan and El Tinay (1995) reported that when sorghum fermented for 14 h the tannin content was reduced up to 63%. Reduction of tannin contents caused by fermentation may be due to activity of fermentation organisms (microflora) (Grewal, 1992).

2.3. *In vitro* protein digestibility (IVPD)

The protein quality of food or feed depends on its amino acid composition and digestibility. The protein digestibility primarily determines the availability of its amino acids (Hahn *et al*., 1983). One of the main factors affecting the nutritive value of legume proteins is their limited susceptibility to hydrolysis by digestive enzymes. This proteolytic resistance has been attributed to the structural characteristic as well as to the presence of anti-nutritional compounds such as trypsin inhibitors, polyphenols, and phytic acid (Clemente *et al*., 2000). Kumar and Singh (1984) reported that the condensed tannin present in sorghum might have inhibited the activities of proteolytic enzymes like pepsin digestibility in high concentration of tannin. Low digestibility is a major nutritional problem in high-tannin sorghum cultivars. The digestion of protein appears to depend on phytic acid in the diet. Carnovale *et al*. (1983) reported that a reduction of 6.8, 5.7 and 8.7%, respectively, in digestibility of whole flour, protein concentrates, and protein isolates of faba bean samples following the addition of 10mg of phytic acid. Sangronis and Machado (2005) found 76.8% *in vitro* protein digestibility in *Phaseolus vulgaris*. The protein digestibility of the raw food legumes ranged from 33.8 to 37.6%. *In vitro* protein digestibility of pumpkin seed kernel flour was 90% and for watermelon seed kernel flour was 87.9% reported by El-Adawy and Taha (2001). The IVPD of the

dishes commonly consumed in the Arabian Gulf States ranged between 77.9% to 88.9% with Asedah dish and Sheariyah dish showing the lowest and highest IVPD, respectively. The IVPD values of all the dishes were lower than ANRC-Casein value of 90.0%. Sheariyah dish showed a relatively close value to that of casein. The IVPD values, in general, are close to those reported for cereal and legume based products (FAO, 1970). The C-PER values of the dishes showed a range of 0.45-2.01 compared to ANRC-Casein value of 2.50. The low C-PER values of Sheariyah dish and Foul Madammas dish are in line with the low chemical scores of these two dishes. The C-PER values of the remaining dishes are comparable to data of FAO (1970) for similar foods. These data suggest that Sheariyah dish and Foul Madammas dish, despite their good digestibility, have nutritional quality while other dishes, especially Ruz mufalfal dish, have a reasonably good protein digestibility and nutritional quality.

2.3.1. Effect of processing on *in vitro* protein digestibility (IVPD)

Processing can improve the digestibility of legume protein by the destruction of trypsin inhibitor and the opening of protein structure through denaturation (El-faki *et al*., 1984). Bressani (1993) observed that dehulling followed by cooking increased protein quality and digestibility. Dehulling was found to improve protein quality and protein digestibility due to the removal of the seed coat tannin (Berssani *et al*., 1993), which may contribute to decrease protein digestibility. True protein digestibility was significantly increased by cooking in both whole seed and dhal samples Singh *et al*. (1991). However, cooking in boiling water resulted in improvement in protein of the food legumes by 86.9 and 93.3% (Zia-ur-Rehman, 2005).

Cooking significantly increased protein digestibility for the control and all treated samples (Elsheikh *et al*., 2000). Giami and Wachuku (1996) reported that the processing (roasting, boiling, dehulling and soaking) significantly ($P \leq 0.01$) improved *in vitro* protein digestibility. Removal of tannin through chemical or physical treatment was found to improve *in vitro* protein digestibility and weight gain, but removal or lowering the content of tannin through genetic means is an important goal in both cereal and legumes.

2.4. Proteins and amino acids composition

The relationship between diet and health can be examined at the level of food components, foods and dietary patterns. Until recently, the study of food components, particularly nutrients, has been the dominant approach in nutritional epidemiology. The approach has clear advantages. If the development of disease is causally related to the intake of a food component, the examination of that food component will be the approach with the greatest power to identify its effect, in addition, results for food components can be compared with associations observed in other populations. Knowledge on the level of food components can be used to produce foods with higher or lower levels of the component. For example, reduction of the amount of trans-fatty acids in margarines has probably resulted in substantial health benefits (Oomen *et al*., 2001). However, the effect of a food component can differ depending on the food that it is derived from due to interactions between food components or physical characteristics of foods. For example, folate from beer may provide less health benefits than the same amount of folate from bread, because alcohol reduces intestinal folate uptake, interferes with folate

metabolism and increases urinary loss of folate (Jiang *et al*., 2003). Effects of food consumption on disease risk can be different from predictions based on known effects of food components, because our knowledge on the myriad possible beneficial or detrimental aspects of foods (Jacobs and Murtaugh, 2000) is still limited. The study of foods and food groups accounts for interactions between different components of a food, and for effects of physical characteristics and unknown components. Dietary intake of proteins is essential for normal growth and development. In Western societies, protein consumption has increased considerably during the past 50 years and is now thought to exceed by 80% the recommended dietary intake (Franz *et al*., 2002). Although our understanding of fat and carbohydrates as nutrients affecting glucose and energy metabolism has greatly increased in the past two decades, the roles of proteins and amino acids in glucose homeostasis and insulin resistance and the mechanisms behind their effects are still poorly characterized. Numerous studies have shown that an increased consumption of dietary proteins results in greater body weight loss (Halton and Hu, 2004). What is unclear at this point is whether high-protein diets reduce body weight by reducing energy intake through satiety signal(s) or by increasing energy expenditure. On one hand, some studies support the concept that the consumption of a high protein diet decreases circulating ghrelin, an orexigenic gut peptide, whereas it increases the concentrations of the anorexic peptides cholecystokinin and glucagon-like peptide (Bloom *et al*., 2006). On the other hand, however, other studies suggest that the satiety induced by high-protein diets is unrelated to changes in circulating ghrelin (Moran *et al*., 2005). Genetic evidence also supports a role for the anorexic peptide

in protein-mediated reduction in food intake. High-protein diets may also promote a negative energy balance by increasing energy, expenditure. This has been attributed to the heightened thermal effect of dietary proteins (23%-30%) as compared with that of carbo-hydrates (5%-10%) and lipids (2%-3%). Dietary proteins may also increase energy expenditure through up-regulation of uncoupling proteins (UCPs) and facultative thermogenesis. The data on amino acid analysis when compared with the FAO/WHO (1973) reference protein of common dishes consumed in the Arabian Gulf States, all the dishes studied showed deficiency in certain essential amino acids. Ruz mufalfal dish was most deficient in tryptophan followed by lysine, while the concentration of the third limiting amino acid, threonine was adequate. Other essential amino acids in this dish were more than 100% of the reference protein. Mejaddara dish was equally limiting in tryptophan and sulphur amino acids (methionine + cystine), while other amino acids were present in adequate amounts (90% or more of the reference protein). Sawekah dish was most limiting in tryptophan followed by lysine and sulphur-amino acids (methionine + cystine). The limiting essential amino acids in Sheariyah dish were lysine, tryptophan and threonine. Foul Moudammas dish showed deficiency only in two amino acids, sulphur amino acids and tryptophan, which were the first and second limiting amino acids, respectively. Asedah bil shourbar dish was deficient in tryptophan, threonine and lysine. In reviewing the nutritional status in the Middle East, McLaren and Pellet (1970) have demonstrated that unlikely most countries of the region are limited in S-amino acids (methionine + cystine), lysine and tryptophan. The chemical score, which is an index of protein quality, ranged from 26 for Sheariyah dish to 67 for Asedah

bil shourbar dish. The low protein quality of Sheariyah dish could be attributed to the low lysine content of the vermicelli, base of this dish and a further reduction of lysine during cooking (frying) of this product in large quantities of sugar resulting in Maillard reaction. Similarly, the lower chemical score of Foul Moudammas dish could be due to the presence of lower amounts of sulphur amino acids (methionine + cystine) in the beans from which the dish was prepared.

2.5. Vitamins and minerals composition

Results obtained for five dishes (rice with chicken, rice with meat, rice with shrimps, crushed wheat with shrimps and bread with chicken stew) commonly consumed in the Arabian Gulf countries showed that they contained little amounts of thiamin, riboflavin, niacin and ascorbic acid; whereas vitamin A content was higher than that of other vitamins. Few reports have been published on the nutritional deficiency in this area (Musaiger *et al*., 2006). Generally, vitamins deficiency is fairly low when compared to other developing countries. Avitamimosis A was observed among 8% of children in Kuwait (Autret, 1979), compared with 3% among school boys in Qatar (Autret and Miladi, 1980). The five dishes also contained little amounts of iron. Amine (1980); and Miladi and Autret (1980) have shown that anaemia was very common in the Arabian Gulf states. Amine (1980) attributed the prevalence of anaemia in this area to the nature of the diet consumed, which was mostly carbohydrates and relatively low in iron rich foods; parasitic infections; and sickle cell anaemia which may be responsible in part for the low haemoglobin level observed among preschool and school children.

CHAPTER THREE
MATERIALS AND METHODS

3.1 Materials

1. 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 in 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 mentioned foods were collected from local markets in Riyadh city. Ten samples of each food were collected from different places and pooled.
2. Small portions of the three samples of each food item were kept for proximate analysis, the rest of the samples were freeze dried, ground to powder and kept at -20^{o}C for further analysis.
3. Five samples of individual food items, namely: date, rice, brown flour, chicken and lamb meat were purchased from markets in Riyadh. The fresh samples of these items were freeze dried and all samples were ground to fine powder and kept as above.

Table (1): Ingredients of foods used in the study

Food	Ingredients
Kabsa	Rice (480g), chicken meat (500g), tomato (250g), oil (40g), onion (180g), hot pepper (15g), spices (5g)
Garish	Low fat milk (1200)g), 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)

3.2 Chemical analysis of samples

3.2.1 Moisture content

Moisture content (MC) of each sample was determined according to the Standard Official Methods of Analysis (AOAC, 1995). The moisture percent was calculated as shown below:

$$MC\ \% = \frac{W_1 - W_2}{W_1} \times 100$$

Where: W_1, Original weigh of sample; W_2, Weight of sample after drying.

3.2.2 Crude oil

Crude oil was estimated following the Official Methods of Analysis (AOAC, 1995). The crude oil was calculated as:

$$\text{Crude oil}\ \% = \frac{W_2 - W_1}{S} \times 100$$

Where: W_1, Weight of empty receiver; W_2, Weight of receiver plus oil; S, Weight of sample

3.2.3 Crude protein

Total nitrogen of the samples was determined using the micro-Kjeldahl procedure as described by AOAC (1995). The crude protein content (CP) was calculated as N% X 6.25.

Calculations:

$$CP\ \% = \frac{\{(A\ mL - B\ mL) \times N \times 14 \times 100 \times 6.25\}}{1000 \times S}$$

Where: A, Milliliters of HCl titrated against sample; B, Milliliters of HCl titrated against blank; N, Normality of HCl; 14, Nitrogen equivalent weight; S, Original weight of the sample; 1000, No. of milligrams in one gram; 6.25, Protein conversion factor.

3.2.4 Crude fiber

Crude fiber (CF) of each sample was assessed according to the method described by Southgate (1976). Two grams of the defatted sample were digested in 200 mL boiling 0.255 N H2SO4 under reflux, for 30 minutes. Then the digest was filtered, under suction, using a linen piece. The obtained residue was washed with hot distilled water to remove any traces of acid. A second alkali digestion for the residue was done using 200 mL boiling 0.344 N NaOH for 30 minutes, then similarly filtered as above. The residue was successively washed with hot acid and hot distilled water, dried at 105˚C overnight and weighed. The dried residue was incinerated in a muffle furnace at 550˚C for 2 h and then re-weighed after cooling in a desiccator.

Calculations:

$$\text{CF \%} = \frac{W_1 - W_2}{S} \times 100$$

Where: W1, Weight of sample before ignition; W2, Weight of sample after ignition; S, Original weight of sample.

3.2.5 Total ash

Total ash of a sample was estimated according to the Official Methods of Analysis (AOAC, 1995). The ash content was calculated using the formula:

$$\text{Total ash \%} = \frac{W_2 - W_1}{S} \times 100$$

Where: W1, Original weight of sample; W2, Weight of sample after ignition.

3.2.6 Carbohydrates determination

Total carbohydrates of samples were calculated by subtracting the value of protein, oil, fiber, ash and moisture content from 100.

Calculation:

Total carbohydrate (%) = 100-{CP% + CF% + Crude oil% + ash% + MC %}.

3.2.7 Total energy

Energy was calculated as described by Osbrne and Voogt (1978) using the Atwater factors 1g of carbohydrate (C.) provides (4 Kcalories), 1g of protein (P.) provides (4 Kcalories), and 1g fat (f.) provides (9 Kcalories).

c. (g) × 4: Kcal of carbohydrate.

p. (g) × 4: Kcal of protein.

f. (g) × 9: Kcal of fat.

3.3. Determination of mineral content by atomic absorption spectrophotometer

Determination of Macro- and Micro-elements was carried out following the method described by AOAC (1990) using atomic absorption spectroscopy. Samples (100g) were dried in 20 % sulphuric acid and then ashed at 500°C under gradual increase (about 50°C/h) in temperature. 6 N HCl (1:1) is added and the solution is evaporated to dryness. Ash was dissolved in 2 mL of HNO_3 1:1 (v/v) (analytical grade Merck, Germany) allowed for 18 h to dissolve completely and passed through a filter paper. Macro elements Na, K, Ca, Mg and micro elements Fe, Zn, Mn, Cu were determined by means of an atomic absorption spectrometer (HITACHI-Z-5000), equipped with hollow cathode lamps (AOAC, 1990).

3.4 Determination of anti-nutritional factors

3.4.1 Determination of tannin content

Tannin content (TC) of pearl millet samples was estimated using modified Vanillin-HCl in methanol as described by Price *et al*. (1978). About 0.2g of ground sample was placed in 100 ml conical flask. Ten milliliters 1% HCl in methanol (v/v.) were added. The

contents were mechanically shaken for 20 minutes and centrifuged at 2500 rpm for 5 minutes. One milliliter of supernatant was pipetted into a test tube and 5 milliliters of vanillin-HCl regent (mixing equal volume of 8% concentrated HCl in methanol and 1% vanillin in methanol) were added. The optical density was read using a colorimeter (Lab System Analyzer- 9filters, J, Mitra and Bros. Pvt. Ltd). At 500nm after 20 minutes incubation at 30˚C, a blank sample was carried out with each run of samples. A standard curve was prepared expressing the result as catechin equivalents, i.e. amount of catechin (mg per ml) which gives color intensity equivalent to that given by tannin after correcting for blank.

Calculation:

$$TC\ \% = \frac{C \times 10}{200} \times 100$$

Where: C = concentration corresponding to optical density; 10= volume of extract in ml; 200= sample weight in mg

3.4.2 Determination of phytate content

Phytate content of the samples was determined according to the modified method of Wheeler and Ferrel (1971). One gram of finely ground sample was weighed into a 100 mL conical flask, and then 50 mL of 3% TCA solution (W/V); containing 10% (W/V) sodium sulfate was added. After shaking for an hour, the slurry obtained was centrifuged at 3000 rpm for 15 minutes. Ten milliliters of the supernatant were transferred into 50 mL boiling tubes. Then, 4 mL of $FeCl_3$ solution (2 mg Fe^{3+}/mL 3% TCA), centrifuged at 3000 rpm for 15 minutes and the clear supernatant was carefully decanted. The precipitate was then washed twice by dispersing well into 25 mL 3% TCA, heating in a boiling water bath (10 minutes) and centrifuged.

Washing was repeated once with water. The precipitate was dispersed in a few milliliters distilled water enriched with 3 mL 1.5 N NaOH with mixing. The volume was made approximately 30 mL with distilled water and heated in the water bath for 30 minutes. The contents of the tube were filtered hot through Whatman No. 1 filter paper and the filtrate was discarded. The precipitate from the paper was dissolved with 40 mL hot 3.2 N HNO_3 into a 100 mL volumetric flask. The paper was washed with several portions of distilled water. The contents in the flask were cooled and diluted to volume with distilled water. Five milliliters aliquots were transferred into another 100 mL volumetric flask and diluted to approximately 70 mL with distilled water. Then, 20 mL of 1.5 M KSCN (Potassium thiocyanate) were added; completing the volume up to mark. The intensity of color was immediately read at 480 nm (Corning, 259). A blank probe was run with each set of sample. The iron content was calculated from prepared standard curve of Fe $(NO_3)_3$. The phytate was estimated from the assumption that it contains 28.2% P (De Boland, *et al*., 1975) and phytate phosphorous from a molar ratio of 4:6 Fe:P.

3.4.3 Standard curve preparation of phytic acid

The standard curve of phytate was obtained by weighing 0.4321g ferric nitrate {Fe $(NO_3)_3$} and then dissolved in distilled water in 1 L volumetric flask up to mark. This prepared stock solution of 100 µg/mL Fe^{3+} ions. Concentrations of 0, 5, 10, 15, 20, and 25 µg/mL were prepared by pepetting 0, 5, 10, 15, 20 and 25 mL of the stock solution into a series of 100 mL volumetric flasks. Then the density of the color was read after addition of 1.5 M KSCN as previously described. A standard curve was obtained by plotting concentrations

against corresponding readings of absorbance giving a linear relationship.

3.4.4 Trypsin inhibitor activity assay

Trypsin inhibitor activity was assayed in 0.05M sodium citrate sample extracts following the method of Kakade *et al*. (1969) using BAPA (N-benzoyl-DL-arginine-P-nitroanilide hydrochloride (Sigma Chemical Comp., St. Louis, MO) as substrate. Trypsin type III from bovine pancreas (Sigma Chemical Co.) was used for the assay. One trypsin unit (TU) was arbitrarily defined as an increase of 0.01 absorbance unit at 410 nm in 20 min for 10 ml of reaction mixture, under the conditions described in this method, and the trypsin inhibitor activity as the number of trypsin units inhibited (TUI).

3.5 *In vitro* protein digestibility

To determine *in vitro* digestibility the procedure of Hsu *et al*. (1977) as modified by Satterlee *et al*. (1979) was used. The drop of pH of casein (control) and the samples after 20 minutes hydrolysis by proteolytic enzymes was measured using an Orion research digital ionalyser/501 (USA). The enzymes used were trypsin type IX from porcine pancreas, chymotrypsin type II from bovine pancreas, peptidase type III from porcine intestine and protease type VI from streptomyces griseus. All enzymes were supplied by Sigma Chemical Company (St. Louis, MO. USA). Percent *in vitro* digestibility was calculated from the pH drop using the following equation (Satterlee *et al*., 1979).

% *in vitro* digestibility = 234.84 – 22.56 (X)

Where X = The pH after 20 min. hydrolysis.

3.6 *In vitro* starch digestibility

A suitable amount of the sample containing 25mg starch dispersed in 1.0ml of 0.2 M phosphate buffer, pH 6.9. Pancreatic amylase (20mg) dissolved in 50ml of the same buffer and 0.5ml was added to the sample suspension and incubated at 37^{o}C for 2 hr, after the incubation period, 2ml of 3.5 dinitrosalicyclic acid reagents quickly added and the mixture heated for 5 min in a boiling water bath. After cooling, the solution made to 25ml with distilled water and filtrated prior to measurement of the absorbance at 550nm. A blank run simultaneously by incubating the sample first and 3,5-dinitrosalicyclic acid added before the addition of the enzyme solution. Maltose used as the standard and the values expressed as mg of maltose released per gram of sample.

3.7 Amino acid

3.7.1 Amino acid analysis

For 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. Amino acid analysis was performed on reverse phase-high pressure liquid chromatography (Shimadzu LC-10 AD, Shimadzu Corporation, Kyoto, Japan). Samples were analysed 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 spectro-photometrically according to the method of Davaries *et al*. (1980).

3.7.2 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).

3.8 Calculation protein efficiency ratio (CPER)

The **CPER** was estimated following the procedure of Satterlee *et al*. (1982).

3.9 Statistical analysis

Each sample was analysed in triplicate and the figures were then averaged. Data were compared using analyses of variance (ANOVA) (Snedecor and Cochran, 1987) and by the Duncan multiple range test with a probability ($P \leq 0.05$).

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Proximate composition of traditional Saudi dishes

An attempt was made to compare the chemical composition of various traditional Saudi dishes included in this study. The proximate composition data of traditional Saudi dishes, expressed as fresh weight basis, are shown in Table 4.1. The moisture content of cooked kabsa, gursan, garish, saleeg and hunaini was significantly ($P \leq 0.05$) different from commercial and uncooked kabsa, gursan, garish, saleeg and hunaini, respectively. In general the moisture content for all samples decreased after cooking. The moisture content ranged from 25.0% for commercial hunaini to 84.5% for saleeg before cooking. The high moisture content of the traditional dishes suit the hot weather most prevalent in Saudi Arabia. Moisture content of kabsa, gursan, garish, saleeg and hunaini after cooking were comparable to the values reported by Al-Jassir *et al*. (1998) for the same foods. The moisture content of the ingredients used for preparation of such diets was lower in rice and brown flour (7.1%) and higher in chicken (70.8%) and meat (68.5%), respectively. Low values of protein content were found in saleeg (2.47-2.94%) whereas high values were found in gursan (8.5-8.67%). Higher concentration of protein in gursan comes from the green beans and lamb meat used in the preparation of this diet. Similar observation was reported by Al-Jassir *et al*. (1998) who found that qursan had higher protein content compared to kabsa, garish, hunaini and saleeg. Cooking does not affect the protein content of gursan compared to commercial and uncooked samples, whereas it significantly ($P \leq 0.05$) affect the protein content in kabsa (8.27%),

Table (4.1): Proximate composition fresh weight in traditional diet

Sample	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Fiber (%)	Carbohydrate (%)	Energy (Kacl)
Kabsa before cooking	68.40±0.10[b]*	8.15±0.46[b]	4.15±0.03[c]	1.40±0.03[b]	0.43±0.03[b]	17.50±0.19[b]	140±7.84[b]
Kabsa after cooking	67.63±0.20[c]	8.27±0.05[a]	4.50±0.07[a]	1.10±0.08[c]	0.37±0.02[c]	18.20±0.17[a]	146±5.52[a]
Kabsa-commercial	71.6±0.20[a]	7.32±0.07[c]	4.48±0.05[b]	1.50±0.04[a]	1.07±0.08[a]	14.00±0.05[c]	126±7.71[c]
Gursan before cooking	77.40±0.40[a]	8.63±0.01[a]	4.27±0.03[a]	1.80±0.06[a]	1.07±0.04[b]	6.85±0.25[c]	100±3.91[c]
Gursan after cooking	76.20±0.20[b]	8.67±0.53[a]	4.13±0.03[b]	1.70±0.02[b]	1.18±0.06[a]	8.14±0.13[b]	104±5.54[b]
Gursan-commercial	72.10±0.15[c]	8.50±0.19[a]	4.02±0.05[a]	1.51±0.03[c]	0.53±0.03[c]	13.3±0.32[a]	125±6.13[a]
Garish before cooking	80.10±0.10[a]	3.82±0.06[a]	3.17±0.07[a]	1.75±0.06[b]	0.51±0.03[b]	11.1±0.15[c]	88.2±4.13[c]
Garish after cooking	76.40±0.30[b]	3.70±0.04[b]	2.84±0.01[b]	1.68±0.03[a]	0.38±006[a]	14.9±0.21[b]	100±3.76[b]
Garish-commercial	64.50±0.56[c]	3.12±0.01[c]	2.73±0.04[b]	0.90±0.003[c]	0.80±0.04[a]	27.9±0.16[a]	149±4.58[a]
Seleeg before cooking	84.50±0.05[a]	2.94±0.09[a]	3.79±0.07[a]	1.15±0.06[c]	0.31±0.01[a]	7.30±0.13[b]	75.1±2.29[b]
Seleeg after cooking	83.70±0.33[b]	2.57±0.06[b]	3.20±0.02[b]	1.64±0.04[a]	0.31±0.02[a]	8.55±0.22[b]	73.3±4.36[c]
Seleeg-commercial	68.30±0.22[c]	2.47±0.05[b]	3.70±0.08[a]	1.53±0.03[b]	0.26±0.01[b]	23.7±0.20[a]	138±6.54[a]
Hunaini before cooking	28.20±0.27[a]	5.33±0.01[b]	4.23±0.03[b]	0.90±0.005[c]	1.2 7±0.05[b]	59.9±0.14[b]	300±4.29[c]
Hunaini after cooking	27.20±0.22[b]	5.85±0.02[a]	4.63±0.06[a]	1.07±0.04[b]	1.55±0.04[a]	59.7±0.45[b]	304±3.83[b]
Hunaini-commercial	25.00±0.24[c]	5.59±0.04[b]	4.23±0.12[b]	1.23±0.02[a]	1.56±0.02[a]	62.4±0.24[a]	309±2.23[a]
Date	12.00±0.10	1.87±0.01	0.00	1.64±0.02	2.04±0.07	82.42±0.41	337.2±1.14
Rice	7.10±0.10	8.54±0.13	1.34±0.01	1.44±0.07	1.29±0.04	80.29±0.13	367.4±0.94
Chicken	70.80±0.10	20.50±0.24	6.85±0.16	1.84±0.04	0.00	0.00	144.6±1.42
Brown flour	7.10±0.10	13.87±0.13	2.48±0.08	1.58 ±0.01	1.85 ±0.04	73.2±0.10	370.3±0.82
Meat (lamb)	68.50±0.48	20.1 0±0.78	10.12±0.06	1.12 ±0.06	0.14 ±0.03	0.00	171.5±2.72

*Mean ± standard deviation (N= 3).

Carbohydrates by difference, Energy (Kcal): by multiplying g protein , fat, carbohydrate by 4 , 9 , 4 Kcal respectively.

Duncan's groupings a, b, c refer to Significant differences between the same diets in a column.

garish (3.70%), saleeg (2.57%) and hunaini (5.85%). In the ingredients used for preparations of such traditional dishes higher protein content (20.5%) was observed in chicken, while lower content was found in date (1.87%). There are no big differences in the fat content for kabsa, gursan and hunaini (ranged from 4.02-4.63), whereas slight lower content was found in garish and saleeg (ranged from 2.7-3.79%). Fat content of cooked hunaini and kabsa was significantly ($P \leq 0.05$) higher than that of commercial and uncooked samples of both diets. Higher ash content was observed in cooked saleeg (1.64%), whereas lower one in commercial garish (0.9%). Cooking significantly ($P \leq 0.05$) affect ash, fiber and carbohydrate content of all traditional diets. For all investigated samples, carbohydrate content was inversely related to moisture content. Energy content of hunaini (300-309 kcal) was higher compared to that of kabsa (126-140Kcal), gursan (100-125Kcal), garish (88.2-149Kcal) and saleeg (73.3-138Kcal). The high energy of hunaini is due to the fact that both date (337.2 Kcal) and brown flour (370.3 Kcal) is the main ingredient of this diet. Similar observation was reported by Al-Jassir *et al*. (1998) for same diets. There are significant ($P \leq 0.05$) differences in energy content of the diets before and after cooking. Generally, energy content of commercial traditional Saudi foods are higher compared to cooked and uncooked diets except kabsa after cooking showed higher energy content. The data in Table 4.2 showed a proximate composition of Saudi traditional dishes expressed on dry weight basis. The results are consistent with those expressed on the wet weight basis. As a general trend, there are significant ($P \leq 0.05$) differences in moisture, protein, fat, fiber, ash and carbohydrate between cooked and uncooked dishes.

Table (4.2): Proximate composition dry weight in traditional diet

Sample	Protein (%)	Fat (%)	Ash (%)	Fiber (%)	Carbohydrate (%)
Kabsa before cooking	25.79±0.46[a]	13.2±0.36[b]	4.46±0.15[a]	1.36±0.03[b]	55.17±0.90[a]*
Kabsa after cooking	26.57±0.85[a]	13.90±0.70[b]	3.83±0.08[a]	1.14±0.02[b]	55.56±0.62[a]
Kabsa-commercial	25.78±0.71[a]	15.78±0.85[a]	4.97±0.17[a]	3.77±0.08[a]	49.70±0.30[b]
Gursan before cooking	38.23±0.01[a]	18.91±0.33[a]	7.14±0.07[a]	4.74±0.09[a]	30.99±0.28[c]
Gursan after cooking	36.42±0.53[b]	17.35±0.18[b]	6.47±0.18[a]	4.95±0.08[a]	34.81±0.3[b]
Gursan-commercial	30.46±0.19[c]	15.05±0.85[c]	4.80±0.08[b]	1.90±0.03[b]	47.79±0.32[a]
Garish before cooking	19.18±0.09[a]	15.92±0.67[a]	6.83±0.02[a]	2.56±0.03[a]	55.51±0.27[c]
Garish after cooking	15.66±0.04[b]	12.01±0.30[b]	6.42±0.06[a]	1.60±0.06[c]	64.49±0.42[b]
Garish-commercial	8.79±0.01[c]	7.69±0.14[c]	2.92±0.06[b]	2.25±0.06[b]	78.35±0.92[a]
Seleeg before cooking	18.96±0.90[a]	24.45±0.57[a]	8.41±0.11[a]	2.00±0.06[a]	46.18±0.56[c]
Seleeg after cooking	15.78±0.36[b]	19.66±0.22[b]	8.69±0.33[a]	1.91±0.01[a]	53.96±0.20[b]
Seleeg-commercial	7.80±0.17[c]	11.68±0.38[c]	4.40±0.03[b]	0.82±0.02[b]	76.30±0.20[a]
Hunaini before cooking	7.42±0.18[b]	5.89±0.13[ab]	1.54±0.05[c]	1.77±0.095[a]	84.38±0.10[a]
Hunaini after cooking	8.03±0.23[b]	6.35±0.02[a]	1.62±0.04[a]	2.13±0.007[a]	81.87±0.10[b]
Hunaini-commercial	7.45±0.24[b]	5.64±0.0[b]	1.79±0.02[a]	2.08±0.01[a]	83.04±0.20[a]
Date	2.29±0.01[b]	-----	1.73±0.03	2.45±0.01	93.53±0.40
Rice	9.19±0.13	1.44 ±0.01	1.55±0.07	1.38±0.04	86.44±0.74
Chicken	70.53±0.24	23.76 ±0.26	5.71±0.41	-----	-----
Brown flour	14.83±0.13	4.65 ±0.1	1.60±0.01	-----	78.92 ±0.80
Meat (lamb)	64.50±0.78	31.49 ±0.65	4.01±0.01	-----	-----

*Mean ± standard deviation (N= 3).

Carbohydrates by difference.

Duncan's groupings a, b, c refer to significant differences between the same diets in a column

4.2 Mineral content of traditional Saudi dishes

The mineral content of five traditional Saudi dishes (kabsa, gursan, garish, saleeg and hunaini) and their ingredients, as mg/100g sample on dry weight basis, are presented in Table 4.3. The dishes of kabsa, gursan, garish, saleeg and hunaini contained variable amounts of macro-elements (potassium, calcium, sodium, magnesium, and manganese) and trace elements (iron, copper and zinc). Both macro and trace elements are important to human nutrition. Such variation among the 5 dishes could be due to difference in food ingredients of each dish, and the preparation/cooking methods used. Throughout all dishes higher amount of potassium was obtained compared to other elements. In the investigated traditional Saudi dishes higher potassium content was found in hunaini (488.5-637.5 mg/100g), while lower content was found in kabsa (72.3-100.5 mg/100g). Dates as the main ingredient for hunaini contained the highest amount of potassium (883.2 mg/100g), consequently the three hunaini samples contained higher amount of potassium compared to others samples. Although, the values of potassium content in this study are higher than those reported previously (Al-Jassir *et al*., 1998) for the same dishes, the highest potassium content in hunaini (453.2 mg/100g) was also reported by Al-Jassir *et al*. (1998). On the other hand, lower potassium content in kabsa might be due to the fact that rice (171.3 mg/100g) and lamb meat (134.7mg/100g) are the main ingredients of kabsa. Cooking significantly ($P \leq 0.05$) decreased the potassium content in kabsa, gursan, garish and saleeg, whereas it significantly ($P \leq 0.05$) increased potassium content in hunaini. Calcium content of the dishes

Table (4.3): Minerals content of tradition foods mg/100 sample

Sample	K	Ca	Na	Mg	Mn	Fe	Cu	Zn
Kabsa before cooking	100.50±0.40^{a}	81.40±0.2^{a}	190.40±0.4^{c}	19.50±0.3^{a}	0.09±0.009^{a}	1.77±0.02^{a}	0.10±0.00^{a}	0.70±0.00^{a}
Kabsa after cooking	72.30±0.24^{c}	49.20±0.1^{c}	262.00±0.2^{b}	16.30±0.23^{b}	0.06±0.002^{a}	1.60±0.03^{c}	0.02±0.001^{b}	0.20±0.01^{b}
Kabsa-commercial	95.40±0.30^{b}	62.50±0.22^{b}	395.70±0.3^{a}	16.00±0.1^{b}	0.02±0.001^{a}	6.90±0.41^{b}	0.04±0.002^{b}	0.23±0.01^{b}
Gursan before cooking	439.00±0.10^{a}	79.10±0.1^{a}	395.50±0.1^{b}	59.30±0.1^{a}	0.93±0.06^{a}	9.50±0.40^{a}	0.15±0.005^{a}	9.00±0.08^{a}
Gursan after cooking	313.40±0.10^{c}	50.00±0.4^{c}	412.30±0.2^{a}	42.70±0.2^{c}	0.60±0.001^{b}	0.05±0.001^{b}	0.04±0.002^{b}	0.83±0.02^{b}
Gursan-commercial	415.70±0.40^{a}	52.40±0.1^{b}	323.20±0.2^{c}	49.30±0.2^{b}	0.40±0.01^{b}	0.043±0.001^{b}	0.10±0.00^{ab}	0.43±0.01^{b}
Garish before cooking	237.20±0.40^{a}	104.20±0.4^{b}	567.50±0.1^{a}	39.30±0.3^{a}	0.43±0.02^{a}	6.30±0.30^{b}	0.10±0.00^{a}	0.40±0.02^{a}
Garish after cooking	214.20±0.25^{b}	95.50±0.2^{c}	155.20±0.2^{c}	36.50±0.2^{b}	0.20±0.01^{b}	0.05±0.003^{c}	0.08±0.002^{a}	0.43±0.05^{a}
Garish-commercial	135.60±0.30^{c}	118.80±0.1^{a}	299.50±0.1^{b}	26.40±0.2^{c}	0.20±0.00^{b}	7.90±0.00^{a}	0.10±0.00^{a}	0.53±0.03^{a}
Seleeg before cooking	204.40±0.30^{b}	115.30±0.2^{a}	66.20±0.2^{c}	26.50±0.1^{a}	0.10±0.00^{b}	1.40±0.01^{c}	0.10±0.00^{a}	1.30±0.00^{b}
Seleeg after cooking	105.30±0.30^{c}	79.10±0.1^{c}	379.30±0.2^{b}	19.80±0.1^{c}	0.20±0.00^{a}	2.50±0.00^{b}	0.04±0.002^{b}	6.00±0.00^{a}
Seleeg-commercial	264.30±0.10^{c}	109.00±0.0^{b}	584.00±0.1^{a}	23.20±0.1^{b}	0.10±0.00^{b}	7.80±0.10^{a}	0.05±0.001^{b}	0.70±0.00^{c}
Hunaini before cooking	488.50±0.40^{a}	45.70±0.7^{c}	26.30±0.3^{c}	69.40±0.1^{c}	1.00±0.00^{b}	7.70±0.10^{b}	0.20±0.00^{b}	0.23±0.010^{c}
Hunaini after cooking	637.50±0.36^{a}	147.40±0.1^{b}	46.40±0.2^{b}	82.50±0.0^{a}	0.10±0.00^{c}	7.70±0.10^{b}	0.20±0.00^{a}	4.20±0.20^{b}
Hunaini-commercial	514.40±0.56^{b}	174.50±0.4^{a}	115.20±0.3^{a}	76.00±0.1^{b}	1.20±0.05^{a}	9.10±0.20^{a}	0.20±0.00^{c}	11.60±0.60^{a}
Date	883.20±0.15	194.40±0.3	36.10±0.2	71.30±0.3	0.30±0.00	7.50±0.10	0.20±0.00	9.80±0.10
Rice	171.30±0.21	101.80±0.2	49.30±0.2	42.60±0.2	0.30±0.00	4.70±0.20	0.20±0.00	8.90±0.00
Chicken	435.30±0.30	36.00±0.3	376.10±0.1	29.40±0.3	0.20±0.00	4.90±0.00	0.05±0.001	0.50±0.01
Brown flour	557.30±0.35	214.40±0.1	62.40±0.3	184.80±0.0	0.40±0.02	21.30±0.10	0.30±0.00	3.13±0.15
Meat (lamb)	134.70±8.50	85.40±0.4	132.50±0.5	32.70±0.2	0.30±0.00	9.50±0.50	0.08±0.002	11.13±0.08

*Mean ± standard deviation (N = 3).

**a, b, c Duncan´s groupings referring to significant differences among means of the same diet in a column.

showed considerable variation. In hunaini calcium content was 45.7 mg/100g before cooking and was 174.5 mg/100g for commercial one. In all dishes cooking significantly affect calcium content of investigated dishes. The higher amount of calcium in hunaini may be due to addition of brown flour (214.4 mg/100g) as a main ingredient in this diet. Calcium content in this study is considerably higher than those reported by Al-Jassir *et al*. (1998). This variation might be due to differences in the experimental conditions between the two studies. Although calcium content of investigated samples in this study is higher than previous report (Al-Jassir *et al*., 1998), but it is still far below the daily allowances for calcium (1200 mg) recommended by National Research Council (NRC, 1989). Sodium content of the investigated traditional Saudi dishes varied between dishes and was 26.3 mg/100g for hunaini before cooking and 584.0 mg/100g for commercial saleeg. Similar to others macro-elements, cooking significantly ($P \leq 0.05$) affect calcium content of the dishes. The amount of sodium is higher than those reported previously for the same dishes (Al-Jassir *et al*., 1998). Magnesium content of the investigated dishes was 16.0 and 82.5 mg/100g for commercial kabsa and cooked hunaini, respectively. Highest amount of magnesium was found in hunaini (69.4-82.5 mg/100g) while the lowest amount was found in kabsa (16.0-19.5 mg/100g). High magnesium content in hunaini come from brown flour (184.8 mg/100g) and date (71.3 mg/100g) as they are the main ingredients of this dish. There were significant ($P \leq 0.05$) variations in magnesium between cooked, commercial and uncooked dishes. Manganese content in traditional Saudi dishes was 0.02 and 1.20 mg/100g for commercial kabsa and commercial hunaini, respectively. Iron content of the investigated

dishes was 0.04 and 9.5 mg/100g for commercial and uncooked gursan, respectively. In all samples, cooking significantly ($P \leq 0.05$) reduced iron content. The iron content obtained in the present study is consistent with that reported previously for the same dishes (Al-Jassir *et al*., 1998). Iron content of traditional foods received more attention than others elements as observed in other studies (Al-Jassir *et al*., 1998; Al-Nozha *et al*., 1996; Al-Kanhal *et al*., 1994). This may explained the fact that traditional foods may be considered as dietary source to counteract iron deficiency among population. Considerably lower amounts copper were detected in all tested traditional Saudi dishes, which ranged from 0.02-0.2 mg/100g. Variable amounts of zinc were obtained in the investigated dishes with highest amount found in commercial hunaini (11.6 mg/100g) and lowest found in cooked kabsa (0.2 mg/100g). Generally, the values for the various mineral elements in this study were within the range reported in literature for different processed foods (Pennington and Calloway, 1973; FAO/ USDA, 1982) and corresponded to values for some of the mineral elements in Middle Eastern dishes reported by Pellett and Shadarevian (1970).

4.3 Antinutritional factors

4.3.1 Tannin content of Saudi traditional dishes

Tannins are often considered to be undesirable compounds since they cause a reduction in nutritional value of foods. The tannin content (on dry matter basis) of five Saudi Arabian traditional dishes (kabsa, gursan, garish, saleeg and hunaini) is shown in Table 4.4. Tannin content of the dishes varied between samples and it was 0.009 and 0.363% for cooked garish and cooked gursan, respectively.

Table (4.4): Tannin content (%) of traditional diets

Sample	% (catechin equivalent) on dry weight basis
Kabsa before cooking	0.0130±*0.001[b]**
Kabsa after cooking	0.0170±0.002[b]
Kabsa-commercial	0.0700±0.009[a]
Qursan before cooking	0.2750±0.013[c]
Qursan after cooking	0.3630±0.01[a]
Qursan-commercial	0.3240±0.002[b]
Garish before cooking	0.0150±0.003[a]
Garish after cooking	0.0086±0.002[a]
Garish-commercial	0.1186±0.0090[a]
Saleeg before cooking	0.0310±0.002[b]
Saleeg after cooking	0.0496±0.008[a]
Saleeg-commercial	0.0163±0.001[c]
Hunaini before cooking	0.2560±0.015[b]
Hunaini after cooking	0.3260±0.012[c]
Hunaini-commercial	0.1830±0.01[c]
Date	0.8390±0.002
Rice	-------
Chicken	-------
Brown flour	0.4640±0.002
Meat (lamb)	-------

*Mean ± standard deviation (N = 3).

**a, b, c Duncan´s groupings referring to significant differences among means of the same diet in a column.

The highest amount of tannin was found in date (0.839%). In general, cooking increased tannin content of kabsa, gursan, saleeg and hunaini, whereas it hugely decreased tannin content of garish. Commercial preparations of kabsa and garish showed higher tannin values compared to cooked and uncooked samples of such dishes, while commercial preparations of gursan, saleeg and hunaini showed lower tannin content than cooked and uncooked samples. Generally, cooking significantly ($P \leq 0.05$) affect the tannin content (increasing or decreasing) of the dishes. The increment of tannin content after cooking may be due to the hydrolysis of complex tannin. Tannin is reported to interact with protein (both enzymes and non enzymes protein) to form tannin protein complexes resulting in protein insolubility (Griffiith, 1999). Tannin also complex with enzymes of the digestive tract and adversely affecting utilization of proteins and carbohydrates and resulting in reduced growth, feeding efficiency, metabolizable energy and bioavailability of amino acids (Onyango *et al*., 2005). In contrast to our results, decrease in tannin contents after cooking of some legumes was reported by many investigators (Elsheikh *et al*., 2000; Sharma and Sehgal 1992; Zeina *et al*., 1991). In feeding trials with rat (Reichert *et al*., 1980; Yasaman *et al*., 1990) and chicks (Armstrong *et al*., 1974; Teeter *et al*., 1986), diets high in tannin content were found to reduce weight gain and feed conversion. Therefore, reduction of tannin contents in Saudi traditional dishes would improve its nutritional values by improving utiliztio of proteins and mineral. Generally, the effect of antnutritional factors in human and animal nutrition are related to the interaction with proteins, vitamins, and several minerals and thereby restricting their bio-availability.

4.3.2 Phytate content of Saudi traditional dishes

Phytates have been recognized as constituent of seeds and plant tissues, especially cereals, legumes and oilseeds (Murthy and Narasinga Rao, 1984). They can significantly influence the functional and nutritional properties of foods by interfering with mineral absorption and utilization, thus lowering their bioavailability (Harland and Oberleas, 1986). Phytate content of the studied Saudi traditional dishes and their ingredients are shown in Table 4.5. Phytate content of these dishes varied between samples and was found to be 0.019 for commercial kabsa and 1.132% for hunaini, respectively. Cooking slightly decreased phytate content of kabsa, gursan, saleeg and hunaini, while it does not affect that of garish. The decrease in phytate content of the dishes during cooking may be partly due to formation of insoluble complexes between phytate and other components such as phytate-protein and phytate-protein-mineral complexes. Phytate content of commercial kabsa, gursan and garish were lower than those of cooked and uncooked samples of the dishes, whereas phytate content of commercial saleeg and hunaini is higher compared to cooked and uncooked dishes. Interestingly, phytate content of the traditional Saudi dishes is far below the range (0.4-7.5% w/w) reported for many legumes, oilseeds and cereals (Reddy *et al*., 1986). Although less attention has been focused on phytate-protein interaction, the ability of phytate to complex with proteins and to inhibit action of enzymes (such as trypsin and amylase) was extensively reported (Singh and Krikorian, 1982; Murthy and

Table (4.5): Phytic acid content of traditional diets

Sample	(%) On dry weight basis
Kabsa before cooking	0.062±*0.002[a]**
Kabsa after cooking	0.060±0.002[a]
Kabsa-commercial	0.019± 0.005 [b]
Qursan before cooking	0.080±0.005[a]
Qursan after cooking	0.065±0.001[a]
Qursan-commercial	0.027±0.003[b]
Garish before cooking	0.098±0.009[a]
Garish after cooking	0.098±0.001[a]
Garish-commercial	0.097±0.007[a]
Saleeg before cooking	0.068±0.00[b]
Saleeg after cooking	0.054±0.004[c]
Saleeg-commercial	0.077±0.003[a]
Hunaini before cooking	0.045±0.001[b]
Hunaini after cooking	0.040±0.002[c]
Hunaini-commercial	1.132±0.004[a]
Date	0.059±0.001
Rice	0.275±0.002
Chicken	-------
Brown flour	1.155±0.001
Meat (lamb)	-------

*Mean ± standard deviation (N = 3).

**a, b, c Duncan´s groupings referring to significant differences among means of the same diet in a column.

Narasinga Rao, 1984). Studies, however, have shown that the interaction of phytate with protein occurred at physiological pH due to its negative charge, and thus, influence protein solubility and functional properties (Murthy and Narasinga Rao, 1984). In addition, phytate also form complex with minerals and hence lowering minerals bioavailability. Therefore, the reduced phytate content obtained in this study, expressed the improvement in nutritional quality of traditional Saudi dishes with respect to mineral bioavailability and protein and starch digestibility.

4.3.3 Trypsin inhibitor activity of Saudi traditional dishes

The digestibility of food proteins is dependent on protein structure and the presence of antinuritional factors such as trypsin inhibitor, phytate and tannin. To get clear image about the protein digestibility of traditional Saudi dishes, attempt was made to quantify the trypsin inhibitor activity in these dishes as well as to characterize the effect of cooking on trypsin inhibitor activity. The results of trypsin inhibitor activity of the investigated dishes are shown in Table 4.6. Trypsin inhibitor activity of dishes varied between samples and was found to be 0.5 U/mg protein for cooked hunaini and uncooked kabsa. For the ingredients of the dishes, 12.8 U/mg protein for high trypsin inhibitor activity was found in brown flour (27.5 U/mg proteins) and rice (26.5 U/mg proteins) this why high trypsin inhibitor activity was recorded in kabsa (6.166-12.82 U/mg protein). Cooking significantly ($P \leq 0.05$) decreased trypsin inhibitor activity in all dishes except saleeg which showed slight increase (11.4%). The reduction in trypsin inhibitor activity of gursan, hunaini, kabsa and garish was 79.1%, 64.0%, 26.3% and 15.1%, respectively. Commercial gursan,

Table (4.6): Trypsin inhibitor activity of traditional diets

Sample	TIU (trypsin inhibitor unit) per mg protein
Kabsa before cooking	12.82±*1.49[a]**
Kabsa after cooking	9.45±0.135[b]
Kabsa-commercial	6.166±0.23[c]
Qursan before cooking	3.44±0.329[b]
Qursan after cooking	0.72±0.00[c]
Qursan-commercial	10.766±0.50[a]
Garish before cooking	3.50±0.05[a]
Garish after cooking	2.973±0.01[a]
Garish-commercial	1.053±0.013[b]
Saleeg before cooking	3.116±0.23[b]
Saleeg after cooking	3.516±0.075[b]
Saleeg-commercial	9.70±0.64[a]
Hunaini before cooking	1.39±0.11[a]
Hunaini after cooking	0.50±0.00[b]
Hunaini-commercial	1.493±0.10[a]
Date	1.616±0.05
Rice	26.466±1.66
Chicken	-------
Brown flour	27.533±0.88
Meat (lamb)	-------

*Mean ± standard deviation (N = 3).

**a, b, c Duncan´s groupings referring to significant differences among means of the same diet in a column.

saleeg and hunaini showed high trypsin inhibitor activity compared to cooked and uncooked dishes while commercial kabsa and garish showed lower trypsin inhibitor activity than cooked and uncooked dishes. The trypsin inhibitor is known to inhibit protein digestive enzymes such as trypsin and chymotrypsin, and hence, cause growth depression and pancreatic hypertrophy in rats and chicks(Liener and Kakade,1980). Therefore, the reduction of trypsin inhibitor activity by cooking may improve the nutrition quality of the dishes with respect to protein digestibility.

4.4 *In vitro* protein digestibility of Saudi traditional dishes

The *in vitro* protein digestibility (IVPD) is a way of judging the nutritive value of a protein, and hence, it is widely used to measure the extent to which amino acids can released from protein by digestive enzymes (Hsu *et al*., 1977). Values of IVPD of the investigated traditional Saudi dishes and their ingredients are presented in Table 4.7. Casein as a control showed the highest value of digestible protein (93.61%) followed by commercial kabsa (89.55%), commercial gursan (87.90%) and commercial garish (87.22%), while commercial saleeg showed the lowest value (80.30%). Cooking temperature significantly ($P \leq 0.05$) increased the protein digestibility of kabsa (from 83.61% to 87.15%), gursan (from 85.04% to 86.89%) and garish (from 80.46% to 83.54%). Youssef *et al*. (1986) reported that cooking resulted in an appreciable increase in IVPD which amounted to be 98.4% for nabet soup (Egyptian food made from faba bean) being close to that of casein (99.6%). Kataria *et al*. (1989) reported that IVPD was higher when soaked seeds of mung beans were cooked compared to unsoaked samples. In contrast, the reduction of IVPD as

Table (4.7): *In vitro* protein digestibility of traditional diets

Sample	Digestible protein (%)
Kabsa before cooking	83.613±1.07[c]*
Kabsa after cooking	87.146±0.78[b]
Kabsa-commercial	89.553±1.62[a]
Qursan before cooking	85.040±0.45[c]
Qursan after cooking	86.996±1.13 [b]
Qursan-commercial	87.900±1.03[b]
Garish before cooking	80.456±3.4[d]
Garish after cooking	83.536±0.13[c]
Garish-commercial	87.220±1.24[b]
Saleeg before cooking	81.660±0.9 [d]
Saleeg after cooking	80.560±0.55[d]
Saleeg-commercial	80.300±0.68[d]
Hunaini before cooking	-------
Hunaini after cooking	-------
Hunaini-commercial	-------
Date	-------
Rice	-------
Chicken	86.546±0.52[b]
Brown flour	84.740±0.25
Meat (lamb)	-------
Casein	93.613±0.81[a]

*Mean ± standard deviation (N = 3).

a, b, c, d, Duncan´s groupings referring to significant differences among means of the diets in a column.

a result of cooking has been reported by many investigators (Arbab and El Tinay, 1997; Yousif, 2000; Fageer and El Tinay 2004). Cooking (as heat treatment) is a suitable method of improving protein quality particularly in legumes based foods. However, the beneficial effect due to heat treatment (as stated by Khan and Eggum, 1979) might be reversed, and thus damage the protein. Various processing and cooking methods could improve the protein digestibility of legume seeds by decreasing the level of some antinutrients (Bishnoi and Khetarpoul, 1994). Moreover, an increase in protein digestibility after thermal treatment may be attributed to some other factors such as disruption of protein structure and cell wall encapsulated starch of the legume seeds (Tovar *et al*., 1991). High concentration of anti-nutritional factors in food based on less refined cereals and legumes are responsible for poor digestibility of protein (Babiker and El Tinay, 1992) and they further reported that tannins and phytates form complexes with protein there-by reducing their digestibility.

4.5 *In vitro* starch digestibility of Saudi traditional dishes

Starch digestibility results of traditional Saudi dishes and their ingredients are shown in Table 4.8. The highest digestible starch was found in rice (471.7 mg maltose released/g dry sample) that used as ingredient of many traditional foods, whereas the lowest was found in commercial hunaini (67.5 mg maltose released/g dry sample). Cooking significantly ($P \leq 0.05$) increased the digestibility of starch as evidenced for cooked kabsa, cooked gursan, cooked garish, cooked saleeg and cooked hunaini (Table 4.8). The present finding is in agreement with the study of Alonso *et al*. (2000), who stated that

Table (4.8): *In vitro* starch digestibility of traditional diets

Sample	mg maltose released per gram dry sample
Kabsa before cooking	304.10±4.36[c]*
Kabsa after cooking	354.80±7.53[b]
Kabsa-commercial	353.03±9.51[b]
Qursan before cooking	288.30±11.44[cd]
Qursan after cooking	334.56±6.36[b]
Qursan-commercial	269.26±4.61[d]
Garish before cooking	298.26±3.9[c]
Garish after cooking	336.26±6.20[b]
Garish-commercial	362.86±16.6[b]
Saleeg before cooking	332.36±9.22[b]
Saleeg after cooking	359.63±9.27[b]
Saleeg-commercial	346.70±7.04[b]
Hunaini before cooking	72.16±2.85[e]
Hunaini after cooking	84.07±1.62[e]
Hunaini-commercial	67.50±0.97[e]
Date	-------
Rice	471.70±9.90[a]
Chicken	-------
Brown flour	353.60±13.40[b]
Meat (lamb)	-------

. *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

thermal treatment was most effective in improving starch digestibility of faba and kidney beans.

4.6 Amino acids content

4.6.1 Amino acids content of dishes ingredients

Amino acids content and scores of the main ingredients used in the preparation of the above discussed Saudi traditional dishes are shown in Tables 4.9 and 4.10. 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 10) 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 levels of most of the essential amino acids in rice (the main ingredient of saleeg, kabsa and garish) were 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 4.10. The essential amino

Table (4.9): Amino acids ratios and scores of date, rice, brown flour

		Reference protein (FAO/WHO,1991) (g/100 g protein)			amino acids in date, rice, brown flour (g / 100 g protein)			Amino acids scores in date, rice, brown flour		
		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	-----	-----	-----

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

Table (4.10): Amino acids ratios and scores of meat and chicken

		Reference protein (FAO/WHO,1991) (g / 100 g protein)			amino acids in meat, chicken (g / 100 g protein)		Amino acids scores in meat, chicken	
		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		-----

* Mean ± standard deviation (N = 3).

** a, b, c, Duncan´s groupings referring to significant differences among means in a raw.

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 meat and chicken meat were lysine, leucine and threonine. Although all ingredients used in the investigated Saudi traditional dishes were deficient in threonine, likely in all traditional dishes adequate amounts of this amino acid were observed.

Overall, investigated Saudi traditional dishes contained adequate and even excess levels of essential and nonessential amino acids, and they are unlikely lacking lysine and leucine. Supplementation such dishes 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, 2008).

4.6.2 Amino acid conent of traditional dishes

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 the Saudi traditional dish “garish” are presented in Table 4.11. 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.

Table (4.11): Amino acids ratios and scores of garish

		Reference protein (FAO/WHO,1991) (g/100 g protein)			l amino acids in garish (g/100 g protein)			Amino acids scores in garish		
		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.

Cooking significantly (P≤0.05) increased the amino acids values of the essential amino acids, except threonine which was significantly (P≤0.05) decreased by 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, 2008). Contrary to our results, cooking of *Canavalia cathartica* seeds decreased all amino acids (Seena *et al*., 2005). Onyango *et al*. (2004) 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. These 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, Mahmoud (2009) 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; Mohmoud, 2009), 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≤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 Saudi traditional dish "gursan" are presented in Table 4.12. 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; Mahmoud, 2009). The decrease in amino acids of gursan after cooking might be due to non-enzymatic browning reactions as explained by Onyango *et al*. (2004) 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 for such amino acids (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; Mahmoud, 2009). 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

Table (4.12): Amino acids ratios and scores of qursan

		Reference protein (FAO/WHO,1991) (g/100 g protein)			amino acids in qursan (g/100 g protein)			Amino acids scores in qursan		
		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.

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 Saudi traditional dish "kabsa" are shown in Table 4.13. 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 dishes 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

Table (4.13): Amino acids ratios and scores of kabasa

		Reference protein (FAO/WHO,1991) (g/100 g protein)			amino acids in kabasa (g/100 g protein)			Amino acids scores in kabasa		
		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.

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 in saleeg are shown in Table 4.14. 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 dishes investigated in this study, lysine and leucine 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 dishes. 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 4.15. The results obtained demonstrated that cooking significantly ($P \leq 0.05$) reduced the values

Table (4.14): Amino acids ratios and scores of saleeg

		Reference protein (FAO/WHO,1991) (g/100 g protein)			amino acids in saleeg (g/100 g protein)			Amino acids scores in saleeg		
		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 (4.15): Amino acids ratios and scores of hunaini

		Reference protein (FAO/WHO,1991) (g/100 g protein)			amino acids in hunaini (g/100 g protein)			Amino acids scores in hunaini		
		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.

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 hugely decreased 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*., 2004), 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 affect of cooking on the level of alanine was observed.

4.7 Calculated protein efficiency ratio of Saudi traditional diets

The calculated protein efficiency ratio (C-PER) was considered as rapid chemical method for dietary protein nutritional evaluation with camparable results protein efficiency ratio (PER) using rats (Hsu *et al*., 1977; Satterlee *et al.*, 1982). The C-PER values of saudi dites and ingredients are presented in Table (4.16). C-PER values ranged from 1.35 to 2.04 compared to reference casin value of some dites (4-16) compared to casin could be due in part to deficiency in some essential amino acids e.g. lysine, and in the other part to low *in vitro* protein digestibilty of some these dites compred to casein. Some dietary soures have high C-PER values as repoted by Saway *et al.* (1984) for Camel milk (2.69) and by Babji *et al*. (1977) for deboned raw chicken (2.44) and cooked chicken meat (2.41). On the other hand Wolzak, *et al*. (1981) have reported C-PER values for corn, rice, wheat and white bean as 1.23, 1.89, 1.59, and 1.33 respectively.

Refering to the results in Table 4.16 the vaules of C-PER of the dites investigated are comporble to the data of FAO (1970) for similar composite foods . The results of C-PER of some traditional saudi diets suggest that the protein of these dits have reasonably good nutritional vule.

Table (4.16): Calculated protein efficiency ratio of traditional diets (C-PER)

No.	Sample	C-PER
1	Kabsa before cooking	1.35±*0.02^{ef} **
2	Kabsa after cooking	1.58±0.012^{ed}
3	Kabsa-commercial	1.62±0.017^{d}
4	Qursan before cooking	1.54±0.021^{ef}
5	Qursan after cooking	1.56±0.003^{e}
6	Qursan-commercial	1.57±0.023^{e}
7	Garish before cooking	1.40±0.004^{h}
8	Garish after cooking	1.41±0.001^{h}
9	Garish-commercial	1.50±0.035^{gf}
10	Saleeg before cooking	1.47±0.013^{g}
11	Saleeg after cooking	1.41±0.005^{h}
12	Saleeg-commercial	1.48±0.029^{g}
13	Hunaini before cooking	-------
14	Hunaini after cooking	-------
15	Hunaini-commercial	-------
16	Date	-------
17	Rice	-------
18	Chicken	1.99±0.052^{c}
19	Brown flour	1.49±0.042^{gf}
20	Meat (lamb)	2.04±0.084^{b}
21	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.

CHAPTER FIVE
CONCLUSION AND RECOMMENDATION

5.1 Conclusions

The need to establish food composition tables in Saudi Arabia has been emphasized by many scientists and specialists in the food and health area. 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. The importance of food composition tables has also been recognized by all levels of governments, consumer organizations and individual consumers throughout the world.

In the present study, comprehensive data on the nutritive value of five Saudi Arabian traditional dishes (before and after cooking) have been reported, including proximate composition, minerals, antinutritional factors (tannin and phytate), amino acid content, and *in vitro* protein and starch digestibilities.

Saudi traditional dishes (kabsa, gursan, garish, saleeg and hunaini) contain considerable amounts of moisture, fat, protein, ash, carbohydrate and energy. The amounts of such components are in the range that recommended by FAO and WHO. Thus such dishes are considered to be good from the nutritional stand points.

Furthermore, the dishes contained variable amounts of macro-elements (potassium, calcium, sodium, magnesium, and manganese) and trace elements (iron, copper and zinc).

Moreover, these dishes contained high values of the essential amino acids except lysine and leucine.

Cooking significantl decreased the antinutritional factors such as tannin, trypsin inhibitor and phytate with a concomitant increase in protien digestibility.

5.2 Recommendations

1. Fortification or supplementation of the dishes with dietary soures rich in lysine e.g ,soybean protein isolate will improve the nutritional values of these dishes.
2. Further investigations on composition and the effect of cooking and processing on the nutritional quality of other traditional Saudi dishes are highly recommended, in order to provide adequate data on food composition in this part of the world.
3. Chemical determination should be expanded to include fatty acid profile and cholesterol content of traditional foods, as these components are important from the public health point of view.
4. From the nutritional stand point further research should carried out on the experimental animals to study the effect of such traditional diets on some diseases such as diabetes, kidney and heart diseases which are the most common disease in Saudi Arabia.
5. Further biological evaluation of the protein in these dites can be carried to determine parameters such as protein digestibility and protein utilization.

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