Traditional Sudanese Foods

Traditional Sudanese Foods:

Sources, Preparation, and Nutritional and Therapeutic Aspects

Edited by

Abdalbasit Mariod

Cambridge
Scholars
Publishing

Traditional Sudanese Foods: Sources, Preparation,
and Nutritional and Therapeutic Aspects

Edited by Abdalbasit Mariod

This book first published 2023

Cambridge Scholars Publishing

Lady Stephenson Library, Newcastle upon Tyne, NE6 2PA, UK

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

ISBN (10): 1-5275-9313-4
ISBN (13): 978-1-5275-9313-8

TABLE OF CONTENTS

CHAPTER ONE

KISRA: A TRADITIONAL FERMENTED FLATBREAD FROM SORGHUM AND MILLET

LAMIA OSMAN HUSEIN[1], DAWLA ALI ADAM[2] AND SUZY MUNIR SALAMA[3]

Abstract

Kisra is a traditional Sudanese flat pancake made primarily by women in their homes in various parts of Sudan. Sorghum-based kisra is processed from fermented flour that is milled from different sorghum varieties, such as feterita and tabat. The fermented batter is made with a previously made starter made from bacterial or fungal fermentation of sorghum flour. The health benefits of sorghum-based kisra are attributed to its high nutritional values of sorghum, including the main nutritional components, minerals, and vitamins. Additionally, the phytochemical ingredients found in sorghum grains, such as phenolic acids and polyphenols, reflect the biological activities of kisra bread as having anti-cholesterol, anti-inflammatory, anti-diabetic, and anticancer properties. Tannins in sorghum have been found to interact with protein digestibility and reduce feeding efficiency in humans and animals. The fermentation of the batter formed during the processing of kisra had a significant impact on the improvement of protein digestibility and the health benefits of kisra bread.

Keywords: sorghum, millet, kisra, nutritional value, tannins, polypheols

[1] Department of Home Economics, Faculty of Science and Arts, King Khalid University, Abha, Saudi Arabia. Email: Lohosain@kku.edu.sa
[2] Department of Home Economics, Faculty of Science, Belgurashi, Al-Baha University, Saudi Arabia. Email: Dawlaa30@yahoo.com
[3] Indigenous Knowledge and Heritage Center, Ghibaish College of Science and Technology, Ghibaish, Sudan. Email: s.salama999@hotmail.com

1.1. Introduction

The fermentation of foods plays a crucial role in securing food, elevating its nutritional situation, and improving the nutritional and social status of many people globally. Furthermore, food fermentation has been shown to improve food safety by removing anti-nutritional compounds from fermented foods (Ojokoh and Bello, 2014). Fermentation also develops a new flavor and appearance in 21 food products and is also utilized as a technique of preservation (Onwurafor et al., 2014). Sorghum is a cereal that is cultivated mainly in many Sudanese areas due to its numerous uses, such as making the local Sudanese (kisra) bread, (aceda) porridge, gruel (Nasha), boiled food (balela), and beverages (such as hulu-mur) (Dirar, 1993; Mahgoub et al., 1999).

Sorghum bicolor L. Moench is the world's fifth most important cereal, ranking second only to maize in many African regions (Taylor, 2003). Sorghum fermentation is primarily lactic fermentation by *Lactobacillus* sp., with some yeast and acetic acid fermentation. Fermentation, as well as pretreatment and germination, also improves digestibility by reducing anti-nutritional factors (Abd Elmoneim et al., 2006). Commercially, Ali and Mustafa (2009) concluded that bacterial fermentation using *Lactobacillus* and fungal fermentation using *Saccharomyces* cultures have been significantly used in lowering fermentation times by 4.5-fold (Ali and Mustafa, 2009; Zaroug et al., 2014). Kisra is an indigenous bread that is consumed by most Sudanese people. It is baked from fermented flour made from sorghum or millet grains in the form of a sheet. The processing procedure is simply by mixing the flour with water to make a dough that is left for fermentation using a previously processed starter (Ali and Mustafa, 2009). The various types are given such names as kisra rahifa, kissra-kerr, kissrat-kass, and kissra-habashiya. Two types of kisra can be classified according to the method of shaping and baking the dough after fermentation: kissrat-kass and kissrat-gergriba (Dirar, 1993). Additionally, Hamad et al. (1992) indicated that the characteristic changes in the biochemistry of the dough through microbial fermentation play a key role in the commercial production of kisra.

According to Dirar (1993), the traditional starter used in sorghum dough (Ajin) fermentation is simply a portion of the previous batch of fermented dough (Khammar), usually left behind in the fermentation jar (Khummara). The changes brought by the growth of microorganisms in the dough are profound; they include textural, nutritional, and flavor changes, as well as safety factors. Sudanese houses have evolved into small industries for the

commercial production of kisra bread as time has progressed and technology and urbanization have advanced (Abdalla, 2018).

The main component of kisra in Sudan is sorghum flour of all kinds. Whole or refined wheat flour and millet flour may be added (Mariod et al., 2016). The tools used to make the sheet have varied with the advancement of technology and the emergence of many modern tools and devices. Tefal and electric saj ovens are used instead of traditional ones, and natural gas instead of coal and wood. This chapter reports the procedure for processing kisra, the nutritional values of the sorghum and millet varieties from which kisra is prepared, and the health benefits of sorghum-based kisra.

1.2. Discussion

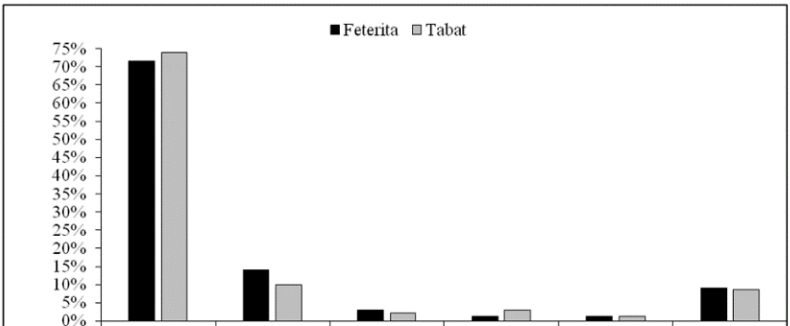
1.2.1. Method of processing Kisra

According to Mahgoub et al. (1999) and Mariod et al. (2016), sorghum-based kisra is traditionally prepared by soaking feterita grains in water for 24 hours, followed by spreading the grains on a special tray and leaving them for 6 days to germinate with regular wetting. The germinated grains are then allowed to dry for three days before being milled into flour using a mechanically milled stone. Kisra batter is prepared by mixing the milled flour with water in a 1:1.25 ratio, and fermentation starts after adding a previously prepared starter to the batter, which is then left for 24 hours for complete fermentation via the microorganisms found in the starter. Finally, the fermented batter, which has a liquid like texture and is called Ajin, is shaped into thin sheets and baked on hot iron plates for 20-30 seconds (Figure 1.1).

Figure 1.1: Kisra thin sheets baked on a hot iron plate

1.2.2. Nutritional value of Kisra bread

Studies have shown that sorghum is rich in protein, vitamins, and minerals, and therefore is considered a convenient cereal-based food for many poor Sudanese people (Salim et al., 2017). In Sudan, there are many sorghum varieties that contain high levels of nutritive components such as feterita and tabat, as shown in Figures 1.2 and 1.3.



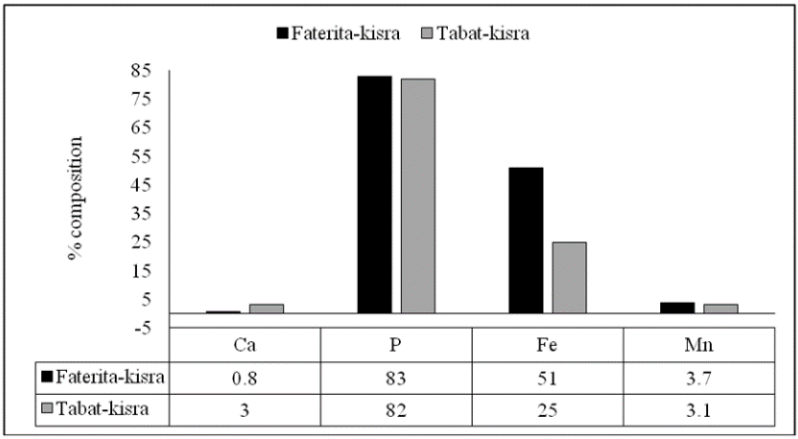
	Carbohydrates	Protein	Fat	Fiber	Ash	Moisture
Feterita	72%	14%	3.0%	1.3%	1.3%	9%
Tabat	74%	10%	2.2%	3%	1.2%	8.7%

Figure 1.2: The nutritional values of feterita and tabat varieties of sorghum in Sudan

The carbohydrate and amylase contents of the different types of sorghum play an important role in selecting the type of sorghum that is suitable for processing a specific food product (Dicko et al., 2006). Sorghum cultivars determine the quality of the sorghum-based kisra produced from each variety. Studies suggest that sorghums with the lowest percentage of phenolic tannins are considered the most suitable type for producing good quality kisra and gluten-free food products (AwadElkareem and Taylor, 2011). Sorghum cultivars (tabat and feterita) and their final products (kisra and hulu-mur) contain great levels of carbohydrates, protein, K, P, Fe, and Mn (Figure 1.3) and the essential amino acids tyrosine, valine, leucine, phenylalanine, and isoleucine (Mariod et al., 2016). Beverages prepared from sorghum, such as obiolor and pito, are considered functional foods due to their high calorie content as well as their antioxidant activities in preventing Aflatoxin B1-mediated oxidation of lipids and proteins (Ajiboye et al., 2014).

In western Sudan in Kordofan and Darfur, kisra is made of millet characterized by a high nutritional value due to the availability of many minerals and trace elements beneficial to health. This is why nutrition experts recommend eating it more than once a week. Millet is among the most widely consumed grains in Europe, due to its many health benefits. Nutrition scientists have concluded that millet grains contain many minerals and trace elements that are beneficial to the body. Millet contains silicon, iron and magnesium. It is noteworthy that these substances are what make

millet a food that has positive effects on bones, joints, scalp and nail growth. Millet is considered a type of gluten-free grain, which is why it is loved by people who eat gluten-free items. This applies to people with stomach and digestive problems. In addition to its role in healthy hair growth and strengthening nails, the silicon in millet is useful for strengthening bones and moisturizing the skin. This substance also has another positive feature in terms of its addressing the causes of infections (Saleh et al. 2013).

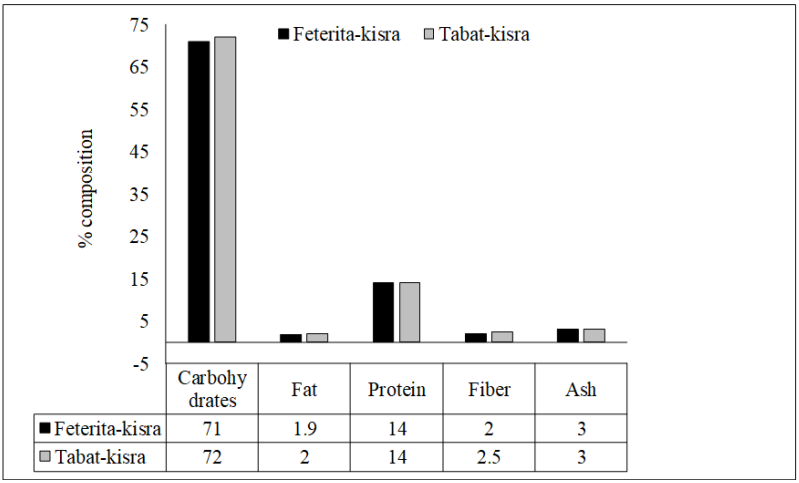


	Ca	P	Fe	Mn
Faterita-kisra	0.8	83	51	3.7
Tabat-kisra	3	82	25	3.1

Figure 1.3: Mineral composition of feterita-kisra and tabat-kisra

1.2.3. Effect of fermentation on the characteristics of kisra

The carbohydrate and amylase contents of the different types of sorghum play an important role in selecting the type of sorghum that is suitable for processing a specific food product (Dicko et al., 2006). Sorghum cultivars determine the quality of the sorghum-based kisra produced from each variety. Studies suggest that sorghums with the least percentage of phenolic tannins are considered the most suitable types for producing good quality kisra and gluten-free food products (Awad, Elkareem and Taylor, 2011).



	Carbohydrates	Fat	Protein	Fiber	Ash
Feterita-kisra	71	1.9	14	2	3
Tabat-kisra	72	2	14	2.5	3

Figure 1.4: Changes in the nutritional components of feterita-kisra and tabat-kisra after fermentation

1.2.4. The effect of some additives on the nutritional value of kisra

Researchers found that the valuable fatty acids and minerals, together with the protein content of sorghum-based kisra, have been significantly increased with the addition of flour milled from bambara groundnut, reducing the anti-nutritional factor (Abdualrahman et al., 2019). The same study reported that adding bambara groundnut flour could reduce the anti-nutritional compounds. Yousaf et al. (2021) published an advanced review of the studies conducted between 2013 and 2021 on the effects of different processing techniques on the nutritive values and biological activities of millet-based food products. A study conducted on three varieties of sorghum grains in Saudi Arabia has reported that the longer the period of fermentation, the more essential acids are contained in the resulting traditional khamir bread (Almaiman et al., 2021).

1.2.5. Health benefits of kisra

The health benefits of sorghum-based kisra come mainly from the bioactive compounds concentrated in sorghum grains. Sorghum is one of the cereals that is rich in phytochemicals such as tannins, phytic acid, and polyphenols. Tannins are phenolic compounds that are found in the grains' testa with a

concentration depending on the cultivar and represent 19% of the total antioxidant capacity of dietary foods (Floegel et al., 2010). Studies found that Sudanese sorghum contains different concentrations of tannins depending on the sorghum's variety (Osman, 2004). On the other hand, Osman (2004) found that fermentation could cause a decrease of 15–35% in the concentration of tannins in the fermented sorghum flour and a 5–7% improvement in the protein digestibility of the fermented food product. The antioxidant power, anti-cholesterol potential, and anti-cancer activity of the phosphorus storage compound phytic acid have been reported (Admassu, 2009; Al-Fatlawi et al., 2014). Awika and Rooney (2004) reported that the tannin content of sorghum reduces protein digestibility and, accordingly, decreases the health benefits of tannins and protein in sorghum. Sorghum polyphenols have been shown to improve glucose and lipid metabolism while also reducing inflammation and oxidative stress (Girard and Awika, 2018).

1.2.6 How kisra is used

Tabikh, i.e., edam, which is made from vegetables such as potatoes and beans, was not known in Sudan until the Turkish-Egyptian rule, much like lentils and Egyptian beans. Kasra and aceda (porridge) are the popular dishes that were prevalent before that in northern Sudan. Kisra is eaten with the "Umm Sha'ifa" or "Umm Bullot" edam, the "Sukhina" edam, and sometimes "Al-Sharmout," which means dried meat.

Figure 1.5: Kisra and sharmout edam

1.3. Conclusion

In conclusion, the Sudanese kisra has high nutritional values concentrated in its main dietary components, in the minerals and vitamins contained in sorghum, and in the millet, grains used in processing. Furthermore, the bioactive compounds found in sorghum and millet grains are responsible for the dietary kisra's health benefits in improving glucose and lipid metabolism. Although the tannin content of sorghum shows considerable interaction with the protein digestibility of kisra, the fermentation of sorghum flour during the processing of kisra batter has a reduced tannin content and improved protein digestibility during consumption of kisra in the diet of humans and animals. Further studies are required to explore more of the health benefits of kisra bread.

1.4. References

Abdelmoneim, O. E., Bernhardt, R., Bonomi, F., Iamett, S., Pagani, M. A., and Zardi, M. 2006. Fermentation modifies protein-protein and protein-starch interactions in sorghum dough. *European Food Research and Technology*, pp. 559–64.

A. Abdalbasit, Y. Idris, N. M. Osman, M. A. Mohamed, A. Sukrab, and B. Matthaus. 2017. Value and chemical composition of Sudanese millet-based fermented foods as affected by fermentation and method of preparation are presented. *Acta Scientiarum Polonorum Technologia Alimentaria,* vol. 16, no. 1, pp. 43–51.

Abdallah, K. M. A. 2018. *Production of Standard "Kissra" Starter Culture.* Sudan University of Science and Technology (Sudan University of Science and Technology).

Abdualrahman, M. A. Y., MA, H., Yagoub, A. E. A., Zhou, C., Ali, A. O., & Yang, W. 2019. Sudanese sorghum-based kissra bread fortified with bambara groundnut (Voandzeia subterranea) seed flour: nutritional value, protein quality, and antioxidant activity. *Journal of the Saudi Society of Agricultural Sciences,* 18, 32–40.

Admasu, S. 2009. Potential health benefits and problems associated with phytochemicals in food legumes. *East African Journal of Sciences,* vol. 3, no. 3, doi:10.4314/eajsci.v3i2.53210.

Ahmed, A. S. M., Zhang, Q., Chen, J., Shen, Q. (2013). Millet Grains: Nutritional Quality, Processing, and Potential Health Benefits. *Comprehensive Reviews in Food Science and Food Safety*, Volume 12, Number 3: 281-295.

AJIBOYE, T. O., G. A. ILIASU, A. O. ADELEYE, F. A. ABDUSSALAM, S. A. AKINPELU, S. M. OGUNBODE, S. O. JIMOH, and O. B. OLOYEDE. Nutritional and antioxidant properties of Nigerian sorghum and millet-based beverages. *Food Science and Nutrition,* vol. 2, pp. 597–604.

AL-FATLAWI, A. A., M. M. A. RIZVI, and A. AHMAD. 2014. Anticarcinogenic activity of rice bran phytic acid against human breast cancer cell line (MCF-7). *Asian Journal of Pharmaceutical and Clinical Research,* 7**,** 151-155.

Ali, A. A. and Mustafa, M. M. 2009. Use of starter cultures of lactic acid bacteria and yeasts in the preparation of kisra, a Sudanese fermented food. *Pakistan Journal of Nutrition,* vol. 8, no. 8, pp. 1349–1353.

ALMAIMAN, S. A., RAHMAN, I. A., GASSEM, M., ALHUTHAYLI, H. F., MOHAMMED, M. A., HASSAN, A. B., FICKAK, A., and OSMAN, M. 2021. Biochemical Changes During Traditional Fermentation of Saudi Sorghum (*Sorghum bicolor* L.) Cultivars' Flour into Khamir (Local Gluten Free Bread). *Journal of Oleo Science,* 70**,** 409-415.

Awadelem, A. M. & Taylor, J. R. 2011. Protein quality and physical characteristics of kisra (fermented sorghum pancakelike flatbread) made from tannin and non-tannin sorghum cultivars. *Cereal Chemistry,* 88**,** 344-348.

AWIKA, J. M., & ROONEY, L. W. (2004). Sorghum phytochemicals and their potential impact on human health *Phytochemistry,* 65**,** 1199-1221.

DICKO, M. H., H. GRUPPEN, A. S. TRAORÉ, A. G. VORAGEN, and W. J. VAN BERKEL. Relevance of starch and amylase activities in Sorghum grain as a human food in Africa: relevance of starch and amylase activity content. *African Journal of Biotechnology*, 5(3), 384–395.

DIRAR, H. 1993. *Handbook of Indigenous Fermented Foods*, 196-200.

FLOEGEL, A., KIM, D.-O., CHUNG, S.-J., SONG, W. O., FERNANDEZ, M. L., BRUNO, R. S., KOO, S. I., and CHUN, O. K. and validation of an algorithm to establish a total antioxidant capacity database for the US diet. *International Journal of Food Sciences and Nutrition,* 61**,** 600-623.

Girard, A. L., and Awika, J. M. (2018). Sorghum polyphenols and other bioactive components as functional and health-promoting food ingredients *Journal of Cereal Science,* 84**,** 112-124.

S. H. HAMAD, G. BÖCKER, R. F. VOGEL, and W. P. HAMMES. Microbiological and chemical analysis of fermented sorghum dough for Kisra production. *Applied Microbiology and Biotechnology,* 37**,** 728-731.

Mahgo U. B., S. E., Ahmed, B. M., Ahmed, M. M., and El Nazeer, A. 1999. The effect of traditional Sudanese processing of kisra bread and

andhulu-mur drink on their thiamine, riboflavin, and mineral contents is unclear. *Food Chemistry,* 67**,** 129-133.

MAKAWI, A. B., MUSTAFA, A. I., ADIAMO, O. Q., & AHMED, I. A. M. 2019. Kisra's quality characteristics are derived from sorghum flour fermented with baobab fruit pulp flour as a starter. *Food Science and Technology,* vol. 56, pp. 3754–3763.

MARIOD A. A., Y. M. IDRIS, N. M. OSMAN, M. A. MOHAMED, A. M. SUKRAB, M. Y. FARAG, and B. MATTHAUS. Three Sudanese sorghum-based fermented foods (kisra, hulu-mur and abreh): Comparison of proximate, nutritional value, microbiological load, and acrylamide content. *The Ukrainian Journal of Food Science,* 4**,** 216-228.

Ogunzo, O., Banwoo, K., Ogunremi, O. & Sanni, A. 2015. Microbiological and physicochemical properties of sourdough bread made from sorghum flour. *International Food Research Journal,* 22**,** 2610–2618.

Ojokoh, A. & Bello, B. 2014. The effect of fermentation on the nutrient and anti-nutrient content of millet (Pennisetum glaucum) and soyabean (Glycine max) blend flours. *Journal of Life Sciences,* 8**,** 633-639.

Onwuraffor, E., Onweluzo, J., & Ezeoke, A. 2014. Effect of fermentation methods on chemical and microbial properties of mung bean (*Vigna radiata*) flour *Nigerian Food Journal,* 32**,** 89-96.

Osman, M. A. Changes in sorghum enzyme inhibitors, phytic acid, tannins, and in vitro protein digestibility occurring during Khamir (local bread) fermentation. *Food Chemistry,* 88**,** 129-134.

OSMAN, M. A., ABDELRAHMAN, I. E., HAMAD, S. H., & DIRRAR, H. A. 2010. Biochemical changes occur during traditional Sudanese processing of Kisra bread. *Journal of Food, Agriculture, and Environment,* 8**,** 102-106.

SALIM, E., W. EL-AZIZ AHMED, and M. MOHAMED. Fortified sorghum is a potential for food security in rural areas through adaptation of technology and innovation in Sudan. *http://www.imedpub.com/food-nutrition-and-population-health/.*

Taylor, J. Overview: The Importance of Sorghum in Africa Afripro: Workshop on the Proteins of Sorghum and Millets: Enhancing Nutritional and Functional Properties for Africa, Pretoria, 2003.

YOUSAF, L., HOU, D., LIAQAT, H., & SHEN, Q. 2021. A review of its nutritional and functional changes during processing. doi.org/10.1016/j.foodres.2021.110197, *Food Research International*, 142.

Zarough, M., Orhan, I. E., SENOL, F. S., & YAGI, S. 2014. Comparative antioxidant activity appraisal of traditional Sudanese kisra prepared from two sorghum cultivars. *Food Chemistry,* 156**,** 110–116.

CHAPTER TWO

ACEDA: A FERMENTED STIFF PORRIDGE

RASHIDA ABDELFATAH MOHAMED[1],
SUZY MUNIR SALAMA[2]
AND ABDALBASIT MARIOD[3]

Abstract

Aceda is a popular dish that has historically been prevalent in Sudan. It is a hemispherical, gelatinized white block made from fermented or unfermented flour of ground wheat, sorghum, millet, or cassava plant and cooked in hot water. *Aceda* exhibits nutritional values that are improved with fermentation, cooking, and the addition of other nutritional components such as okra powder, spices, yoghurt, or honey. Additionally, *aceda* has been found to have various health benefits due to the phytochemicals present in the grains and used in its preparation. The people in each part of Sudan have their own characteristic procedures for cooking and serving *aceda*.

Keywords: *aceda*, cooking, nutritional, health benefits, serving

2.1. Introduction

Traditionally, cereals like sorghum and millet are commonly used in Sudan in making different types of healthy fermented foods with high nutritional

[1] Faculty of Nursing Sciences, University of Khartoum, Khartoum, Sudan and Nahda College, Khartoum, Sudan
[2] Indigenous Knowledge and Heritage Center, Ghibaish College of Science and Technology, Ghibaish, Sudan. Email: s.salama999@hotmail.com
[3] Indigenous Knowledge and Heritage Center, Ghibaish College of Science and Technology, Ghibaish, Sudan. Email: basitmariod@yahoo.com

values, such as unleavened bread known as *kisra*, boiled seeds known as *balela*, thin porridge or *nasha*, the beverage *hulu-mur*, and *gurrasa* pancake (Abdalla and Taha, 2015; Mariod et al., 2016). *Aceda* is one of the traditional fermented or unfermented thick porridges that are cooked from sorghum or millet flour by Sudanese women and consumed in many households in different parts of Sudan (Boutros, 1986; Elkhalifa et al., 2007). The Western Sudanese make *aceda* from fermented or unfermented pearl millet dough, while in the sorghum-cultivating areas of southern Kordofan, as well as the central and eastern parts of Sudan, *aceda* is made from fermented sorghum dough (Dirar, 1993). *Aceda* is considered the main traditional dish for breakfast during Ramadan month in the rural areas of Sudan and is consumed by Sudanese people on different occasions. On the other hand, consumption of *aceda* in Khartoum and Central Sudan is very rare, as per the Sudanese native to those areas. According to studies, the nutritional value of *aceda* porridge after cooking is comparable to that of fermented sorghum (Elkhalifa et al., 2007, Sukkar et al., 1975). This chapter explains the different methods of processing *aceda* and the health benefits of its consumption.

The Sudanese porridge (*aceda*) has become an appetizer in molds of various shapes and is often decorated, instead of being only in the traditional round shape. As many housewives explained, they form it in molds like cake molds, but there are those among the expatriates who use corn flour, semolina, and even yogurt to make it. Because of "globalization" and the exchange of cultures, the adapted porridge is in line with what is available in the markets where Sudanese immigrants live, far from the homeland they love, far from its foods, legacies, and heritage. In addition to the Sudanese Ramadan table, porridge is spread on more than one African table. It is considered a main dish and has different names and ingredients. It is also included in Al-Akarji, a dish more prevalent in Nigeria, which is made from cowpeas, onions, and salt, mixed with palm oil, which gives it a distinctive color. It is eaten with a broth of hot peppers and dried fish. It is also eaten with mixed vegetables, to which meat and chicken are added in Sierra Leone and Liberia. In Nigeria as well, and among the Yoruba tribes, the largest, richest, and most prestigious African tribe, everyone always consumes porridge. They call it "Moi moi," which is made from yam and cassava, and there are those who make it from plantains, which are plants similar to bananas, but larger in size and cooked, reddened, or boiled rather than eaten raw. Studies indicate that plantains are the richest foodstuffs and is usually sliced, fried, and eaten with a spicy sauce that tastes sweet and savory, or "sweet and sour" (https://aawsat.com).

2.2. Discussion

2.2.1. Processing of *Aceda*

Based on Middle and West African food history, *aceda* is an essential component of nutritious recipes in many African and Arab kitchens. In Sudan, *aceda* is the main dish in various states, such as western, southern, and central Sudan. *Aceda* has several names according to the region: it is *aceda* in Central Sudan, *logma* in the river Nile, *gogor* in Darfur, and *sabbara* in rural areas. Additionally, *aceda* is classified differently according to its components, degree of fermentation, and thickness. The main components of *aceda* are flour and boiled water. Corn flour is prepared (according to availability) from corn seeds, wheat grains, millet seeds, millet rice, *Nymphaea lotus* rhizomes (Soutab) or *Manihot esculenta* roots (cassava) (Figure 2.1). In many Nile tribes, people use milk instead of water as an important ingredient in preparing a certain type of *aceda* called *omhalebein* because it is eaten with milk after cooking. Based on the degree of fermentation, *aceda* can be prepared by mixing the flour with water or milk and cooking it directly, forming *feteera*. Another processing method is using fermented, dried, and ground millet seeds (*damirga*) or fermented flour. Regarding thickness, in western Sudan and on the Quran Campus of Education and Memorization, people prepare a hard type of *aceda* that is eaten by hand without using a spoon. On the other hand, people in urban areas cook a soft type of *aceda* containing a low percentage of carbohydrates that is suitable for diabetics and those who are following diet programs. The *aceda* of those in the river Nile region is soft like *mudaydah*, while those of Darfur and Kordofan consume a stiff type of *aceda* (Eltayeb, 2016). The quality of the *aceda* produced depends on the temperature of the hot water in which starch gelatinization takes place. When the starch of the flour is completely gelatinized, it gives a high quality of *aceda*; otherwise, the incompletely gelatinized starch turns water milky while cooking (Shinoj et al., 2006; Ubwa et al., 2012).

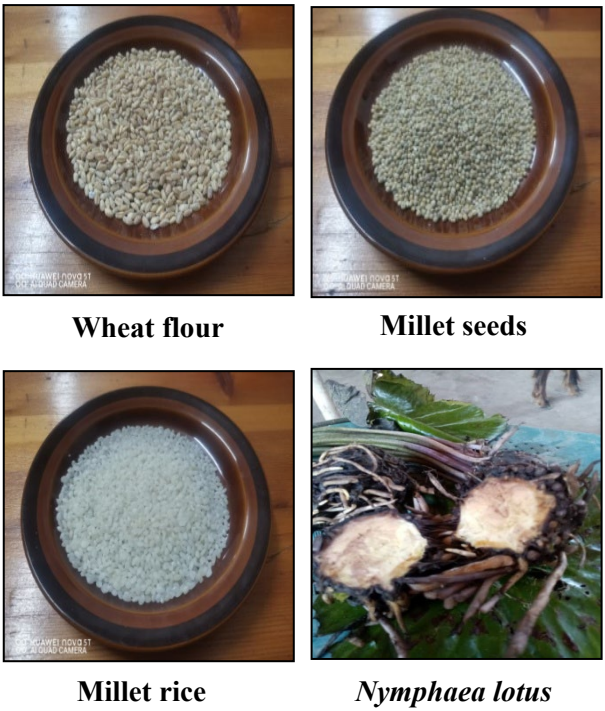


Figure 2.1: Types of grains and plants used in preparing *aceda*

2.2.2. Cooking Procedure of *Aceda*

The Sudanese used to cook *aceda* in special hollow iron containers called a *tajin*, which had a 50-cm diameter and 20-cm depth. Nowadays, people use any container for cooking *aceda* (Dirar, 1993). In a cooking container, a small amount of oil is added to boiled water or milk, followed by the addition of flour, with constant stirring using a special wooden tool called a *konush* until the mixture becomes coherent and consistent. Eventually, it is transferred to another mold container to form the definite shapes of *aceda*, as shown in Figure 2.2. According to indigenous Sudanese women, cooked *aceda* is served hot or warm and in the past was served in a special wooden container called a *gadah*, the size of which varied depending on the number of people sharing the meal. The Sudanese used to eat aceda with "mellah". That is a variety of broth or soup that differs in terms of ingredients, taste, color, and, of course, the methods of preparing it. Among the most famous *mellah* throughout the month of fasting (Ramadan) is the *tagalia*, whose

name signifies the weight of its texture, and the basis of its components is a large amount of well-roasted onions, plus minced beef, a tomato paste, and spices (coriander and powdered red pepper, which give it a bright red beautiful color). These ingredients are mixed and ripened together, then a little dried powdered okra is added to it, and they call it "waikeh." The finished dish has almost magical properties, as the addition of the okra gives the mixture a cohesive texture and a lovable viscosity, along with various nutritional benefits. Unlike *tagalia*, the Sudanese housewife diversified her table with "Al-Naimiya" *mellah*, which is lighter in texture than *tagalia* and has a softer texture, and it includes "yoghurt" milk as an essential ingredient.

With the spread of health awareness and attempts to significantly reduce the consumption of meat despite the Sudanese love for it, new ideas have entered the industry, such as replacing minced meat with a quantity of lentils or ground beans with fried onions, yogurt, tomato, and of course "Al-Waikeh." Usually *Al-Naimiya mellah* is light orange in color.

A third and very popular type of the most important Ramadan *mellahs* is the yoghurt *mellah*, or the "whiteness" *mellah*. The name is a reference to its white color, as it consists mainly of yoghurt, and for its success, it is necessary to use the best types of full-fat milk. The yoghurt *mellah* is made from boiling some garlic cloves and a significant number of onions, divided into large parts, whose water is filtered and added to yogurt that is placed on a low heat, and then the process of mixing it continuously begins with the addition of spoons of flour or rice powder. Recently, there are those who have used spoonful of starch or cornflower instead (https://aawsat.com).

Figure 2. 2: Shapes of the ready-cooked *aceda* depending on the shape of the mold

2.2.3. Nutritional Composition of *Aceda*

Based on Khartoum's National Health Laboratory, the proximate composition of the main nutrients of *aceda* is carbohydrates at 17%, protein at 2.39%, fat at 2.2%, fiber at 1%, and ash at 0.5% (Figure 2.3). Additionally, the same laboratory reported that *aceda* contains approximately 56.9 mg/100g of phosphorus, 20 mg/100g of calcium, and 0.2 mg/100g of iron (Figure 2.4).

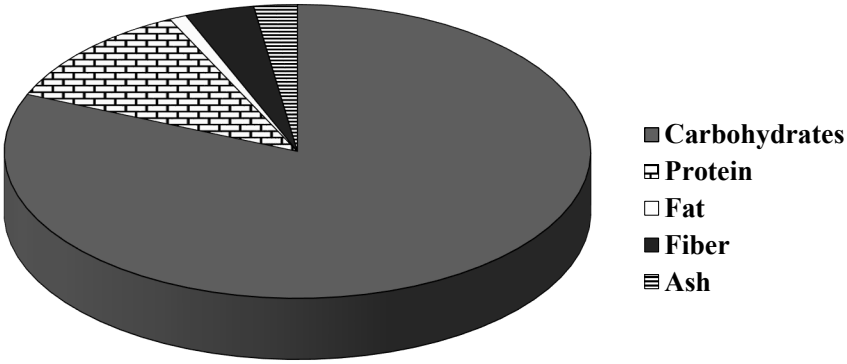


Figure 2.3: Proximate composition of the main nutrients of *aceda*

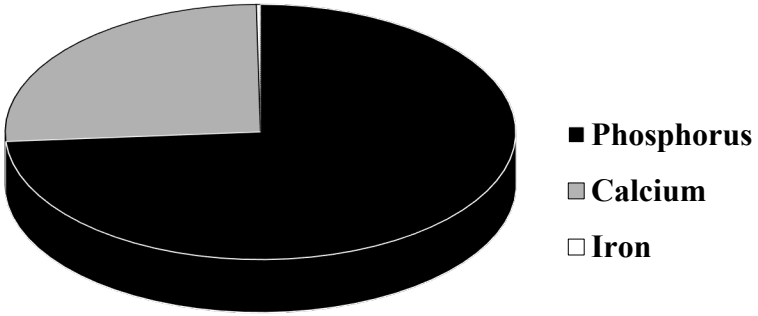


Figure 2.4: Mineral composition of *aceda* in mg/100g

2.2.4. Health Benefits of *Aceda*

Sorghum and millet grains are considered cereals that contain health-promoting factors and biotic phytochemicals, particularly polyphenolic compounds (Shahidi and Chandrasekara, 2013; Taylor et al., 2014; Taylor and Duodu, 2015). Additionally, sorghum and millet contain high percentages of tannins, which are considered anti-nutrients and affect the activities of digestive enzymes, the bioavailability of minerals (Al-Mamary et al., 2001) and protein digestibility (Taylor and Duodu, 2015, Towo et al., 2006). Taylor and Taylor (2002) stated that fermentation of sorghum-based porridges results in changes in the structure of the prolamins and glutelins stored in the grains. These structural changes in proteins enhance protein digestibility, making porridge a good diet for children. Studies have shown that fermenting sorghum and millet-based food products at different temperatures significantly reduces their phenolic content (Dhankher and Chauhan, 1987; Taylor and Duodu, 2015). In addition, spontaneous fermentation has been shown to reduce sorghum tannins by approximately 27% (Obizoba and Atii, 1991; Taylor and Duodu, 2015). According to the few *aceda* studies, unfermented porridges processed by West Africans have poor protein digestibility, like that of un-cooked, thin sorghum-based porridge as tested in pre-school children (MacLean Jr et al., 1982). Recent studies have reported that bacterial and fungal fermentation of sorghum significantly improves protein digestibility (Almaiman et al., 2021; Wedad et al., 2008).

2.3. Conclusion

In conclusion, *aceda* is one of the traditional dishes in Africa, particularly in Sudan. It is prepared by cooking fermented or unfermented flour in hot water until it is completely gelatinized, then served by adding other components such as yoghurt, okra powder, tomato sauce, or milk and honey. *Aceda,* like other cooked breads, has satisfying nutritional values and health-promoting factors that make it suitable food for children and adults as well.

2.4. References

Abdallah, S. & Taha, A. 2015. Analysis of food consumption patterns and diversity intake: using food frequency. *Global Journal of Agriculture and Food Security*, 1-17.

AL-MAMARY, M., MOLHAM, A.-H., ABDULWALI, A.-A. & AL-OBEIDI, A. 2001. *In vivo* effects of dietary sorghum tannins on rabbit digestive enzymes and mineral absorption. *Nutrition Research,* 21**,** 1393-1401.

ALMAIMAN, S. A., RAHMAN, I. A., GASSEM, M., ALHUTHAYLI, H. F., MOHAMMED, M. A., HASSAN, A. B., FICKAK, A., and OSMAN, M. 2021. Biochemical Changes during Traditional Fermentation of Saudi Sorghum (*Sorghum bicolor* L.) Cultivars' Flour into Khamir (Local Gluten Free Bread). *Journal of Oleo Science,* 70**,** 409-415.

BOUTROS, J. 1986. Sudan food composition tables. *National Chemical Laboratories, Ministry of Health, Khartoum, Sudan*.

Dhankher, N. & Chauhan, B. 1987. Temperature and fermentation time have an effect on the phytic acid and polyphenol content of rabadi, a fermented pearl millet food. *Journal of Food Science, 52: 828–829.*

DIRAR, H. 1993. *Handbook of Indigenous Fermented Foods*, 196-200.

E. O., Ali, A. M., and El-Tiny, A. 2007. Fermented sorghum foods of Sudan: a review. *Journal of Food Science and Technology*, 44(3), 343–349.

Eltayeb, A. 2016. *Changing Customs in Sudan*, Khartoum University.

MACLEAN Jr., W., G. LOPEZ DE ROMANA, R. PLACKO, and G. GRAHAM. Sorghum nutrition in preschool children: digestibility, utilization, and plasma free amino acids. Proceedings of the International Symposium on Sorghum Grain Quality, ICRISAT Center, Patancheru, India, 28–31 October 1981, publication editor JV Mertin, 1982. Patancheru, India: Semi-Arid Crops International Research Institute.

MARIOD, A., Y. M. IDRIS, N. M. OSMAN, M. A. MOHAMED, A. M. SUKRAB, M. Y. FARAG, and B. MATTHAUS. Three Sudanese sorghum-based fermented foods (kisra, hulu-mur and abreh): Comparison of proximate, nutritional value, microbiological load, and acrylamide content. *The Ukrainian Journal of Food Science,* 4**,** 216-228.

OBIZOBA, I. C. & ATII, J. 1991. Soaking, sprouting, fermentation, and cooking effects on the nutrient composition and some anti-nutritional factors of sorghum (Guinesia) seeds. *Plant Foods for Human Nutrition,* vol. 41, pp. 203-212.

SHAHIDI, F. & CHANDRASEKARA, A. 2013. Millet grain phenolics and their role in disease risk reduction and health promotion: A review. *Journal of Functional Foods*, 5: 570–581.

SHINOJ, S., VISWANATHAN, R., SAJEEV, M., & MOORTHY, S. (2006). Gelatinisation and rheological characteristics of minor millet flours. *Biosystems Engineering*, 95**,** 51-59.

SUKKAR, M., JZ, B. & MK, Y. 1975. The composition of some Sudanese foods. *Sudan Medical Journal,* 13, 51-56.

Taylor, J. & Taylor, J. R. 2002. Through fermentation in traditional African porridges, the adverse effect of cooking on sorghum protein digestibility is mitigated. *International Journal of Food Science & Technology,* 37, 129-137.

Taylor, J. R., Bellton, P. S., Beta, T., and Duodu, K. G. (2014). Increasing the utilisation of sorghum, millets and pseudocereals: developments in the science of their phenolic phytochemicals, biofortification and protein functionality. *Journal of Cereal Science,* 59, 257-275.

TAYLOR, J. R. & DUODU, K. G. 2015. Effects of processing sorghum and millets on their phenolic phytochemicals and the implications of this to the health-enhancing properties of sorghum and millet food and beverage products. *Journal of the Science of Food and Agriculture,* 95, 225-237.

Tow, E., Matuschek, E., & Svanberg, U. 2006. Fermentation and enzyme treatment of tannin sorghum gruels: effects on phenolic compounds, phytate and in vitro accessible iron. *Food Chemistry,* vol. 94, pp. 369–376.

Ubwa, S., Abah, J., Asemave, K., & Shambe, T. 2012. Studies on the gelatinization temperature of some cereal starches. *International Journal of Chemistry,* 4, 22-28.

WEDAD, H. A., EL TINAY, A. H., MUSTAFA, A. I. & BABIKER, E. E. 2008. Effect of fermentation, malt-pretreatment and cooking on antinutritional factors and protein digestibility of sorghum cultivars. *Pakistan Journal of Nutrition*, 7, 335-341.