



Sudan University of Science and Technology
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Analytic Study of the Role of Namal in Toombak

دراسة تحليلية لدور العطرون في التمباك

**A Thesis Submitted in Partial Fulfillment of the
Requirements of Master Degree in Chemistry**

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الآية

قال تعالى:

بسم الله الرحمن الرحيم

﴿وَقَالَ رَبِّ أَوْزِعْنِي أَنْ أَشْكُرَ نِعْمَتَكَ الَّتِي أَنْعَمْتَ عَلَيَّ وَعَلَىٰ وَالِدَيَّ وَأَنْ أَعْمَلَ صَالِحًا تَرْضَاهُ وَأَدْخِلْنِي بِرَحْمَتِكَ فِي عِبَادِكَ الصَّالِحِينَ﴾

صدق الله العظيم

سورة النمل، الآية (19)

Dedication

To my family

And friends

Acknowledgments

Firstly thanks to allah to got for giving me the strength and pushing to complete successfully this research.

I would like to thank my supervisor Dr. Elmugdad Ahmed Ali for his valuable efforts through out all the steps of preparing this dissertation . Thanks are extended to the Industrial Research and Consultancy Institute at Khartoum North for their collaboration and offering their laboratories for me to conduct some chemical analysis. Thanks to Mr. Mutasim Eltuhami for supplying information's and samples needed for this research.

I appreciate the role of many people who contributed and helped me to complete this dissertation .

ABSTRACT

The two natron samples were collected from different location of different environments .The samples were analysed qualitatively and quantitatively by standard methods of analysis to determine the chemical composition and the concentration of each component .

The effect of natron on chemical structure of Toombak was studied.

The analytical techniques used in this study are:-

Flame Emission spectroscopy which was used to determine sodium and potassium ions, content and the results was 8.4%,0.45%,(sample A) 14.33% ,2.03% (sample B) respectively.

Volumetric analysis was used to determine the carbonate and bicarbonate the results obtained were 8.70%, 6.25% (sample A), 22.5%, 10.67% (sample B) respectively. While total alkalinity of sample (Omdurman market used for toombak prepared) was found to be 2800 .

The percentage of silica was determined gravimetrically the result obtained 53.20%, 36.87% respectively.

Matter insoluble in water and insoluble in acid was determined for the sample (Omdurman market used for toombak preparation) and it was found to be 60.07%, 63.55% respectively.

Finally the pH of the two samples of natron was found 9.8 and three toombak samples were found 5.6 to 5.7.

مستخلص البحث

تم جمع عينتين من العطور من بيئة مختلفة (مواقع) وتم تحليلها لتقدير المكونات الكيميائية وكمية المكونات باستخدام طرق تحليل معروفة. ثانياً أن ننظر من خلال تأثير إضافة العطور في التركيب الكيميائي للتمباك.

تم استخدام تقنيات تحليل مختلفة في هذه الدراسة، تم استخدام مطيافية الإنبعاث الذري لتحديد أيونات الصوديوم والبوتاسيوم وأعطت النتائج 8.4%، 0.45% (للعينة A)، 14.33%، 2.03% (للعينة B) علي التوالي. كما تم استخدام التحليل الحجمي لتقدير الكربونات والبيكربونات وأعطت النتائج 8.70%، 6.25% (للعينة A)، 22.5%، 10.67% (للعينة B) علي التوالي، أما نسبة القلوية الكلية لعينة أمدرمان المستخدمة في صناعة التمباك وجدت 2800.

تم استخدام التحليل الوزني لتحديد نسبة السليكا وأعطت النتائج 53.20%، 36.87% علي التوالي ونسبة المواد الغير ذائبة في الماء والغير ذائبة في الحمض لعينة أمدرمان المستخدمة في صناعة التمباك أعطت النتائج 60.07%، 63.55% علي التوالي.

أخيراً الأس الهيدروجيني (pH) لعينتي العطورون وجد 9.8 وثلاث عينات من التمباك والتي وجدت 5.6 إلى 5.7.

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CHAPTER ONE

Introduction & Literature review

1-1 Introduction:-

The oral use of smokeless tobacco either in the form of snuff as used in North America and Western Europe or mixed with lime and areca nut in the form of a betel quid as used in Asia has been unequivocally associated with human cancers, mainly of the oral cavity. However, little has been published about smokeless tobacco as it is used in Sudan and other African countries and any possible association with neoplastic diseases.

In the Sudan the prevalent oral use of smokeless tobacco is in the form of snuff (saffa, saod or toombak in local language), prepared from sun-dried tobacco leaves. The main tobacco species is *Nicotiana rustica*, the leaves of which are usually mixed with aqueous solution of natron (sodium bicarbonate). An alternative base to slaked lime used in other parts of the world by tobacco chewers until saturated, the product left in a closed container for about 24 hour before use.

A study at the River Nile state at the North of Sudan revealed that the prevalence of toombak dipping and cigarette smoking among men and women is in the range of 25-47% and 13-25% respectively.

1-2 Literature review:-

1-2-1 Classification of tobacco plant:-

The genus *Nicotiana* is classified among the family Solanaceae which comprises about 100 species. The most famous species is the largely cultivated Virginia tobacco, *Nicotiana tobacum*, Turkish tobacco and *Nicotina rustica* (Broun and Massey, 1929) .

Tobacco is believed to be native of tropical America and was cultivated and used by native inhabitants before the discovery of America.

It is the one of the few major contributions to civilization which the new world can claim. The first who used tobacco were the Indian of north and South America and spread to other countries France 1556, England 1565 and from these countries to the different parts of the world (Hussain 1984) .

The ancestry of *Nicotiana tobacum* is not known. Nicotine is the main alkaloid of the genus and is prepared commercially from waste material of the tobacco industry.

1-2-2 Family Solanaceae:-

It is herbaceous or woody plant. Leaves are without stipules, alternate, simple flowers, hermaphrodites or very rarely unisexual. Usually actinomorphic, calyx 4-6 lobed persistent corolla gamopetalous usually five lobed folded, contorted or valvate stamens inserted on the corolla lobes rarely two anther loculiparalley, ovary usually two locular. The loculi sometimes divided by a false septum

style terminal; ovule very numerous exiles, fruity capsule or berry (Andreas, 1951).

1-2-3 Nicotiana rustica:-

It is semi desert plant, grows in different areas in the Sudan but mainly in Darfur at the western region (Hiday – talla, 1983). Herb is up to four feet high. Leaves petiolate ovate obtuse at the apex, sometimes subcordate at the base, up to one feet high long glandular pubescen. Flowers greenish yellow, in terminal subpaniculate.

Racemes with or without bract. Capsule subgloose slight longer than the calyx (Broun and Massey, 1929).

1-2- 4 Definition of Toombak:-

In the Sudan, snuff locally known as toombak was introduced approximately 400 years ago. It is always processed into loose moist form, and its use widespread in the country. Tobacco used for manufacturing of toombak is of species *Nicotiana rustica*. The fermented ground powder is mixed with an aqueous solution of sodium bicarbonate. (Idris *et al.*, 1998).

Introduction of this tobacco plant to the Sudan was attributed to a koranic (Islamic) teacher who came to the Sudan, either from Egypt, Timbuktu of Mali or Morocco. It has also been suggested that toombak was introduced to the Sudan from Turkey or Arabia means sniffing of the product in the local language indicating nasal usage when it was first introduced. The commercial names for toombak include, El-sanf (of high quality) wad Amari (according to the person who was believed to have introduced it) and Sultan El- kaif) the power to improve one's state of mind.

Tobacco is primarily consumed in the Sudan in two forms oral snuff and cigarettes. Oral snuff is consumed as twice as cigarettes and named toombak in the local language, is home-made from finely ground leaves of *Nicotina rustica*. Tobacco species with an especially higher content levels of alkaloid (nicotine, anabasine, nornicotine) than *Nicotiana tabcum* used for cigarettes (Idris *et al.*, 1995), which a prime factor for popularity of tobacco.

Smokeless tobacco product (toombak) has been used in the Sudan for centuries and is widespread, especially in the northern, eastern and central parts (Idris *et al.*, 1994). The use of toombak is particularly common among the Gaalen and Shiagia tribes who reside these regions (EL-Besheir *et al.*, 1989).

So far only one study has estimated the prevalence of use of toombak in the River Nile province in the north of Sudan (Idris *et al.*, 1994) by 40% among adult male dip toombak including 9% who are also cigarette smokers among men aged 40 years or older. From many surveys performed randomly in the river Nile states to estimate the prevalence of tobacco use they found that among children and adolescents (4-7) was quite low (2%-1-2%) but there was an abrupt increase up to (25%) in late adolescents. Among the adult population aged 18 year and older the prevalence of toombak use (34%) and cigarette smoking (12%). Among males were significantly higher than among females (2.5% and 0.9% respectively).

The prevalence of toombak use among the male population aged 18 years and older was significantly higher in the rural than in the urban areas (35%to 24%), while cigarette smoking had a higher prevalence

in urban areas (18% to 12%). The highest rates of toombak use were found in rural areas among the male population ages 30 years and older (Idris *et al.*, 1998).

1-2-5 Chemical Composition of Tobacco:-

The active ingredient in tobacco is alkaloids of naturally occurring compound containing nitrogen and having the properties of an amine base, they have dramatic effects on the human system (Hommond, 1962). It was first isolated from genus *Nicotiana* in 1828 (Pavia *et al.*, 1976), nicotine is a colorless oily liquid alkaloid, and it is considered one of the most toxic drugs known to humans, a dose of 60 mg is lethal in a few minutes (Pavaia *et al.*, 1976). Hussain, (1984) reported that nicotine constitutes 0.9 to 3.8 % of *Nicotiana tobacum* and between 7-12% plant of *Nicotiana rustica*.

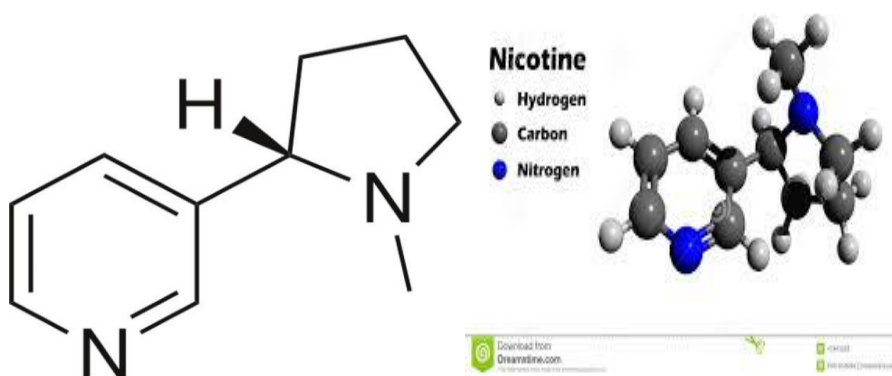


Fig .1. Structure of nicotine

1-2- 6 Prevalence of Smokeless - Tobacco in the World:-

The practices and the prevalence of smokeless, spit tobacco are significantly high in Africa and the Middle East. These products pose serious negative health consequences. Snuff, toombak, shammah (brands, bejeli, haradisharaci, black shammah), commercially packaged chewing tobacco (brands, gudkha and pan masala are several smokeless tobacco(ST) products available for oral use either (Dipping or Chewing) or nasal use in almost parts of Africa and some parts of middle Eastern countries.

Millions of people use it. The dry fermented products are especially consumed in Arab countries of North Africa, including Libya, Tunisia, and Algiers. In West Africa Malawi, Cameron, Ghana and Nigeria. Snuff product, chicambo, chic and taba respectively are consumed. Toombak is a snuff product particularly, used by more than 10 million populations of the Sudan and neighboring countries. Arabia shammah is prevalent in Yemen and southern west parts of Kingdom of Saudi Arabia in Gizan province (Idris, 1992).

There are primarily four smokeless tobacco products: loose leaf or chewing tobacco, snuff, plug tobacco and twist or roll tobacco. Chewing tobacco and snuff are the most widely distributed in the world. Originally snuff was used for nasal application (sniffing) in some parts of the world e.g. in Bavaria, Germany and in South Africa. Sniffing is still practiced to day. However, snuff is now customarily used orally by placing it between lower gum and cheek or lip (Dipping). In North America and Western Europe, snuff is manufactured from black tobacco varieties of *Nicotiana tobacum* by

curing, fermentation and aging. Also it is most often used orally as finely ground tobacco powder (IARC, 1986 and USHHS,1986).

Cigarette smoking is pandemic affecting large proportions of the population worldwide in contrast the use of smokeless tobacco is endemic, largely restricted to certain geographical areas such as North America, the Scandinavian countries, India, Bangladesh, South east Asia and parts of Africa. Of the commercially available forms of smokeless tobacco, snuff is probably the most wide spread it constitutes pulverized tobacco that is most often moist and taken orally, either in loose form or in tea bag -like small packages (sachets) placed between the gum and the chin or under the upper lip (Asplund ,2001) .

The smokeless tobacco is defined as either snuff or chewing tobacco, is a popular habit in United states with an estimated six million regular users (Creath *et al.*, 1988) and the habitual use of chewing tobacco is rising in the United states (Everett *et al.*, 1998).

Tobacco in its various forms has been used for centuries in Pakistan. Tobacco is used both in smoking as well as in smokeless form but smoking cigarettes is common throughout the country, nasswae is pan a type of smokeless tobacco popular in Karachi and some cities of Punjab, which is a powdered tobacco mixed with ash or lime and some flavoring or coloring agents is placed between the gum and the lower lip, this type of smokeless tobacco is very popular in Baluchistan and north west Frontier province (Mcmichael ,1984; Vogler *et al.*, 1962). Smokeless tobacco use is practiced in many forms.

Chewing of tobacco containing products or snuff –dipping habits vary greatly from one part of the world to another. While consumption of (ST) as oral snuff is prevalent in the USA and in Scandinavian countries (Axell, 1993). Loose tobacco is often added to betel quid in south Asia (IARC, 1985).

The use of snuff is common worldwide, but more common in the southern parts of the United States, the Scandinavian countries southern parts of the Kingdom of Saudi Arabia, southern Africa countries and in the Sudan in northeast Africa. Scandinavian snuff locally called snus, has been used for centuries in Denmark. The habit of snus dipping is widely prevalent and the quid is usually placed between the lower lip and the alveolar (Pindborg *et al.*, 1962) .

In Norway the habit of snus dipping is uncommon, but presently is increasing particularly among young individuals and the quid is placed under the upper lip (Schei *et al.*, 1990; Strom *et al.*, 1998) .

In Sweden, the habit of snus dipping is the eldest and the date back to the year 1637. In Sweden, snus consumption declined for several decades during the period 1920-69 (Andersson, 1991), and increased by 92% during the period 1970–92., and currently is the only tobacco product with increasing sale.

Snus product for oral use is moist with a pH value in the range of (7.8 -8.5) and many different brands are commercially available.

However, the majority of snus, users prefer only one or two brands. The most popular way of practicing the habit is by placing the quid in the upper gingivolabial sulcus. Sweden has the highest per capita

consumption and sale of snuff in the world (Andersson, 1991 and Hirsch, 1983).

1-2- 7 Types of products and patterns of use in the World:-

Smokeless tobacco products available in the region include premade manufactured products as well as those produced by small cottage industries, and custom- made products for personal use or for sale by street vendors. These ST products are sniffed, chewed, sucked, or applied to the teeth and gums.

Smokeless tobacco products are generally much cheaper than cigarettes (Desalu *et al.*, 2010 and Rantao *et al.*, 2012) and are more widely used by people who are socioeconomically disadvantaged and by older adults compared to younger adults) Townsend *et al.*,2006 and Peer *et al.*,2009).

In Algeria, ST especially moist snuff, has been consumed traditionally by the majority of men in all social groups. Toombak is the term given to moist snuff, which is put directly on the gums or placed in paper and then placed in the mouth. Dry snuff is called neffa, which is taken in through the nose.

In a number of West African countries, prepared from dry fermented tobacco pulverized to fine particles and mixed with natron (a mixture of sodium bicarbonate and sodium carbonate). For oral consumption, a pinch of the product is placed between the lower gum and the lip, and the pinch is left in position for a few minutes to half an hour, until some active ingredients are absorbed. (Desalu *et al.*,2010)

Toombak imported from Sudan is also fairly common in Chad, toombak is an oral snuff that is traditionally made by small local vendors in rural areas and transported to markets in the city for sale. toombak is a custom-made blend of leaves of the *Nicotiana rustica* variety of tobacco mixed with sodium bicarbonate (baking soda) and stored for two hours or longer before sale. (Idris *et al.*, 1994).

In Ghana, local snuff is prepared by mixing the dried tobacco leaf indigenous to the forested areas (*N. tabacum*) with chemicals such as saltpeter (potassium nitrate) and then grinding it into a fine powder. (Addo *et al.*, 2008)

In South Africa and neighboring countries, similarly prepared traditional homemade products and a limited range of premade products are used. Some traditional products are prepared by hand-mixing finely ground sun-dried tobacco leaf and ash (mokgako) from local plants, depending on plant availability and cultural preference. (Ayo *et al.*, 2000 and Ayo *et al.*, 2005).

In Uganda, the dry snuff known as taaba is also consumed in Uganda, particularly by the Bakiga tribe and some other rural tribes, and primarily by middle-aged men and women. Taaba is mainly sniffed, but is occasionally held in the cheek. Fresh or dried tobacco leaves are also wrapped around magadi (sodium bicarbonate) and placed in the cheek until the desired effect is obtained. (Desalu *et al.*, 2010).

1-2- 8 Cultivation of toombak in Sudan:-

Toombak grows in silty or sandy soil which receives heavier rainfalls in the North West of the Sudan, after end of the raining season September/ October toombak is planted during the months November /December and never irrigated. At first it is broadcasted in the farm and then transferred to new areas which are called (Makhamas). Harvesting starts in the months February/March when the leaves turn yellow and brownish spots start appearing (called the small pox stage). Harvested leaves are left in the field for uniform drying, tied into bundles, moistened with sprinkling of water and stored for fermentation for a couple of weeks at temperature ranging from 30 to 45°C during which bundles are separated for uniform drying during the months April/May. Tobacco leaves are ground and stored for a year for ageing (Idris, 1992).

1- 2- 9 Processing of Toombak:-

Tobacco leaves after cutting the trees are dried in a big basket fermented and the color changes from yellow to brown after the fermentation process. The leaves were then milled using electrical miller.

The product is milled to different particles size this is mainly related to consumer taste consideration. Since in Eastern part of Sudan people prefers the coarse product while in Khartoum and central region, they prefer the fine or powdered product. The milling process is done in the same areas of cultivation in Sudan. Most of milling machines are centered in El fashir town in Darfur province.

Processing of toombak for sale is usually carried out manually in toombak shops by toombak vendors. It is performed by preparing four parts of a coarse powder of dried toombak leaves in a bowl and in another the concentrate of sodium bicarbonate (1:4 natron and water) is added gradually in small amounts to the tobacco (Idris, 1992). While adding the solution, the product is mixed vigorously by both hands, and concurrently tested by sensation of the fingers tips until it becomes moist and hardened. The output is then transferred to special airtight tin containers which are then covered firmly for about 2 hours thereafter the product becomes ready for sale or use.

before buying, users generally ask for a bit to smell or test, since the aroma and test decide the quality rank of the product. Currently, toombak is sold in small plastic bags each taking about 100g. Some toombak users carry round or box shaped tin cans in his pocket named hookah and is similar to plastic bags though some people use king size. Hookah is still used by some people and it make an indentation in the pocked of user, thus one can easily guess and identify.

1-2- 10The habit of toombak in the Sudan:-

Toombak can be bought from innumerable shops in the market, and the product is advertised extensively at points of sale where vendors tend to use commercial names to attract buyers. The habit of toombak dipping is practiced by taking a small portion from the bag or hookah with the therefore-fingers, usually of the right hand, putting it in the palm of the left hand, and manipulating it by the thumb and middle fingers of the right hand until it forms a ball called (Saffa) which is of

about 10g in weight. The Saffa is not chewed but dipped and retained between gum and lip or cheeks or floor of mouth, and sucked slowly for about 10-15 minutes. Generally, men prefer dipping between the lower lip and gum, while women prefer dipping between cheeks and gum. The dipping continues for a period ranging from a few minutes to several hours, until the Saffa becomes bland. Men periodically spit the insoluble debris that is freed from the bulbous and the saliva which is secreted during toombak use, whereas women retain the Saffa without spitting because of social unacceptability. The mouth is usually rinsed with water after the quid is removed. The toombak quid is sometimes retained in the mouth during sleep (Idris, 1992).

1-2-11 Socio-Economical Background about Toombak in Sudan:-

Toombak played an essential role in socio-economic life of some Sudanese people. It is considered as an important product in many areas in Sudan mainly in the Western State. Many surveys have been conducted that the production and marketing of toombak was very profitable to the farmers and the merchants together. In Northern Darfur which is the major provinces where toombak is cultivated, and where all people are involved in this activity, they found that toombak is the main cash crop in this region and constitute about 80% of the gross domestic products. The marketing unit of toombak is hunter, on the other hand the commerce of toombak supported government by tax as Gebana and customs. In addition, some Sudanese people export the toombak to neighboring countries and sell it with high prices.

1-2-12 pH, Moisture and Nicotine in toombak:-

The moist toombak, with strong aroma highly addictive and it is used widespread particularly among males greater than women. It has pH range between (8-11), moisture content ranges 6-60% and nicotine content is from 8 to 102 mg/ g wt. (Idris *et al.*, 1998). The addition of natron which has a pH value of 9.0 raised the pH of the fine and coarse toombak.

1-2- 13The Swedish snus and the Sudanese toombak: are they different?

In Sweden, snuff (locally known as snus), was introduced since the year 1637. Presently, Sweden has the highest per capita consumption and sale figures of snuff in the world, and the habit is becoming increasingly popular. Snus is manufactured into a dry form used in the nasal cavity and a moist form used in the oral cavity. Snus manufactured for oral use is a moist ground tobacco of Dark Kentucky or Virginia species mixed with an aqueous solution of water and other blending ingredients. This form of snuff is found in two types: (1) loose and (2) portion-bag-packed. These are the most widely used. The loose moist form (1-2 g a quid) is the most popular type consumed by 73% of the males, followed by the portion-bag-packed form (0.5-1 g a quid), consumed by 13% of the males, while 14% of the males are mixed users. The majority of snus users place the quid in the vestibular area of the upper lip, and the prevalence among persons 15 years of age or older in 15.9% among males and 0.2% among females. The pH of snus has declined from a previous

range of 8-9 to a range of 7.8-8.5, moisture content ranges 35-60% and nicotine content is in the order of 5-11 mg/g dry wt tobacco-specific N-nitrosamines (TSNAs) in micrograms (N'-nitrosornicotine: NNN 5-9; 4-(methyl-nitro amino)-1-(3-pyridyl)-1-butanone: NNK 1-2; N'-nitroso anatabine: NAT 2-5).

In the Sudan, snuff, locally known as toombak, was introduced approximately 400 years ago. It is always processed into a loose moist form, and its use is widespread in the country. Tobacco used for manufacture of toombak is of the species *Nicotiana rustica*, and the fermented ground powder is mixed with an aqueous solution of sodium bicarbonate. The resultant product is moist, with a strong aroma, highly addictive and its use is widespread particularly among males. Its pH range is 8-11, moisture content ranges 6-60% and nicotine content is from 8 to 102 mg/g dry wt, and TSNAs contents in micrograms. Snus and toombak dippers develop a clinically and histological characteristic lesion at the site of dipping. Probably due to control of the TSNAs in snus, this type of snuff is associated with a lower risk of cancer of the oral cavity (relative risk: RR 5-6-fold), whereas the risk for cancer of the oral cavity among toombak users was high (RR 7.3-73.0-fold). In conclusion, the two snuff products significantly differ in many aspects. Most notable differences are tobacco species, fermentation and ageing, nicotine and TSNAs content, pH, expression of the p53 tumor suppressor gene, and keratin types 13, 14, and 19. It was, therefore, the object of the study is to highlight the oral health hazards of toombak, and to compare it with snus regarding the after mentioned differences. (Idris *et al.*, 1998)

1-2- 14 Natron (Sodium bicarbonate):-

Natron is one of the natural forms of sodium carbonate minerals. It is well known as “sesque carbonate” or “trona” in the chemical literature, and the chemical formula of the compound is $[\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}]$ or $[\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}]$.

A double salt of sodium carbonate-sodium bicarbonate, Natron is soluble in water. Crystals of this mineral are transparent or white; the color darkens with increased impurities.

Its density is 2.1g/cm^3 and hardness is 2.5-3 on Mohs scale. The formula $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ is not commonly found on the surface of alkaline deposits, because on exposure to air in arid regions, it rapidly effloresces into the monohydrate $\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$.

Natron or atron is also called sodium hydrogen carbonate. It is a mineral rock with the chemical formula $\text{Na}_2\text{H}(\text{CO}_3)_2 \cdot 2\text{H}_2\text{O}$. Its color is grey to yellowish white and is of alkaline pH. There is no information on either the history or reasons behind use of atrona as an additive to toombak. It may be used to homogenize the leaves to a fine sticky form as atron is used in the Sudan to homogenize vegetables during cooking. Atron, opposed to lime in other parts of the world, is probably added to toombak for its alkaline effects. It has been shown that at high pH (11.0-11.8), nicotine is completely protonated and its rate of absorption is increased (Brunnemann *et al.*, 1974).

Studies of nass, a type of snuff used in the former USSR which contains lime and has high pH (11-11.8), has shown that when the product is placed in the mouth, nicotine reaches the central nervous system very quickly. Thus pH value in tobacco products can influence the absorption and thereby the extent of pharmacological activity of nicotine (Brunnemann *et al.*, 1985).

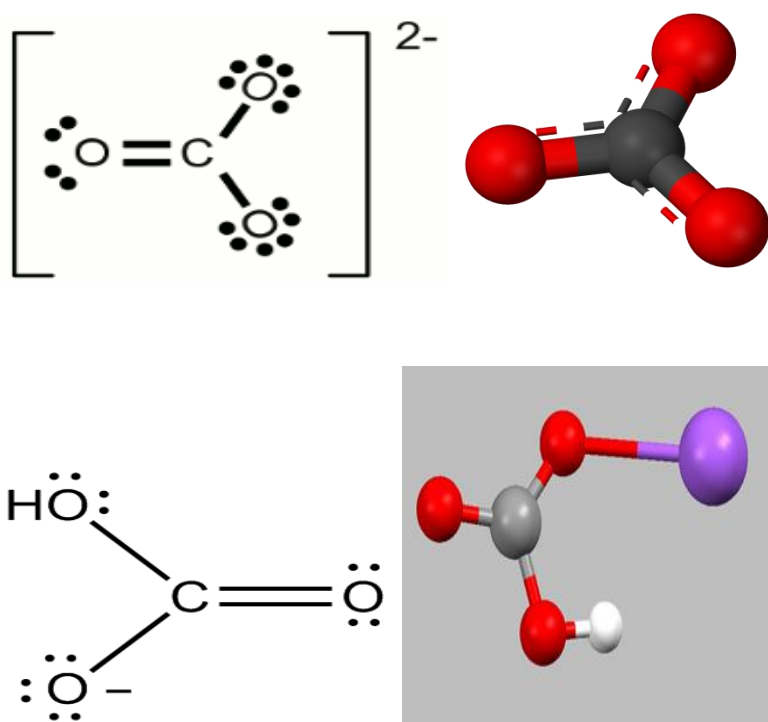


Fig .2. Structure of carbonate and bicarbonate

1-2-15 The effect of pH on the Absorption of Nicotine in the Body:-

There are a few studies that have directly examined the effects of pH on nicotine absorption, (Beckett *et al.*, 1972) found very little buccal

absorption of nicotine from tobacco when the pH was 5.5. Ten percent absorption at pH of 7, and about 30% at pH of 9.0. (Henning et al., 1990) found that rinsing with acidic beverages such as coffee or cola before chewing nicotine polacrilex nearly eliminated nicotine absorption. These results indicate that pH is an important determinant of buccal absorption of nicotine. (Benowitz et al., 1988) compared nicotine absorption from a moist snuff to that from cigarette smoking and nicotine gum.

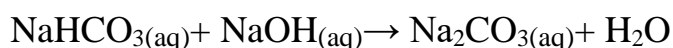
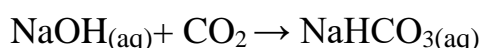
The nicotine-dosing potential of moist snuff is determined by at least three factors: The amount of nicotine in the product, the pH level of the product, and the size of the tobacco cutting. (Henning *et al.*, 1995) found that the nicotine content of six moist snuff products ranged from (7.5mg/g to 11.4mg/g) and that the pH of these products ranged from (6.9 to 8.6). The pH of the snuff is important because nicotine most readily crosses the oral mucosa in the unionized form. The degree to which nicotine is unionized depends on the higher pH levels (more alkaline).

1- 2- 16 Etymology:-

The English word natron is a Frenchcognate derived from the Spanishnatrón through Greekνίτρονnitron. This derives from the Ancient Egyptian word 'natron'. Natron refers to Wadi El Natrun or Natron Valley in Egypt, from which natron was mined by the ancient Egyptians for use in burial rites. The modern chemical symbol for sodium, Na, is an abbreviation of that element's New Latin name natrium, which was derived from natron.

1-2- 17 Geological occurrence:-

Geologically, the mineral natron as well as the historical natron is formed as transpiro-evaporite minerals, i.e. crystallizing during the drying up of salt lakes rich in sodium carbonate. The sodium carbonate is usually formed by absorption of carbon dioxide from the atmosphere by a highly alkaline, sodium-rich lake brine, according to the following reaction scheme:



Pure deposits of sodium carbonate decahydrate are rare, due to the limited temperature stability of this compound and due to the fact that the absorption of carbon dioxide usually produces mixtures of bicarbonate and carbonate in solution. From such mixtures, the mineral natron (and also the historical one) will be formed only if the brine temperature during evaporation is maximally about 20 °C (68 °F) – or the alkalinity of the lake is so high, that little bicarbonate is

present in solution (see reaction scheme above) – in which case the maximum temperature is increased to about 30 °C (86 °F). In most cases the mineral natron will form together with some amount of anchorite (sodium bicarbonate), resulting in salt mixtures like the historical natron. Otherwise, the minerals or thermonatrite and anchorite are commonly formed. As the evaporation of a Salt Lake will occur over geological time spans, during which also part or all of the salt beds might redissolve and recrystallize, deposits of sodium carbonate can be composed of layers of all these minerals.

1-2- 18 Importance in antiquity:-

Historical natron was harvested directly as a salt mixture from dry lake beds in Ancient Egypt and has been used for thousands of years as a cleaning product for both the home and body. Blended with oil, it was an early form of soap. It softens water while removing oil and grease. Undiluted, natron was a cleanser for the teeth and an early mouthwash. The mineral was mixed into early antiseptics for wounds and minor cuts. Natron can be used to dry and preserve fish and meat. It was also an ancient household insecticide, was used for making leather and as a bleach for clothing.

The mineral was used in Egyptian mummification because it absorbs water and behaves as a drying agent. Moreover, when exposed to moisture the carbonate in natron increases pH (raises alkalinity), which creates a hostile environment for bacteria. In some cultures, natron was thought to enhance spiritual safety for both the living and the dead. Natron was added to castor oil to make a smokeless fuel,

which allowed Egyptian artisans to paint elaborate artworks inside ancient tombs without staining them with soot (Mercer, 1952).

1-2- 19 Natron Sources:-

Although most of the world's requirement for sodium carbonate are met by soda ash manufactured from salt, some relatively small but locally important quantities are derived from naturally occurring deposits Natron ($\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$) or $\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$), and in salt lakes and alkaline soils.

Natron is found mainly near the Nile west of Northern province, Northern of Darfur at wadi – Hawer, Bauda Desert, and wadi- A (natron which is about 400 miles west of Khartoum).

There are thick layers of Natron one mile from Kasha mountain. Natron is available in powder form in the form of hard lumps, Natural Natron deposit, created by evaporation and dissociation processes in isolated lakes, exist in wadi Natrun, North west of Cairo Egypt this source was used in antiquity but also until today and it is considered the main or even the only source of Natron for glassmaking.

Natron deposits also existed in Greece, in the region of Macedonia.

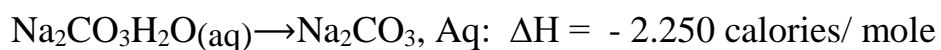
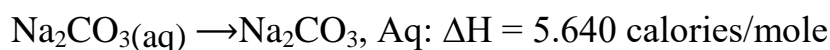
Natron is referred in literature, with earliest the quotation of Plato, who refers to it as chalastraion, used as detergent.

1-2- 20 Hydrates of Sodium carbonate:-

If a solution of sodium carbonate containing less than 5.94 percent by weight of anhydrous salt is cooled below 0°C , ice first separates,

followed. If the cooling is continued to 21C°, by mixture of ice and the decahydrate. If a solution containing between 2.94 and 31.3 percent of the anhydrous salt is cooled below 32C°, crystals of the decahydrate are deposited the monohydrate is stable in contact with its saturated aqueous solution above 35 – 37C°.

The heats of solution for the anhydrous salt, the mono and decahydrates are as follows:



1-2-20-1 Sodium carbonate mono hydrate Na₂CO₃H₂O:

A white crystalline solid prepared by evaporating a solution of revert to the monohydrate on standing in air.

When heated above 100C° the mono hydrate decomposes yielding the anhydrous salt.

1-2-20-2 Sodium carbonate dehydrate:

Na₂CO₃.10H₂O is prepared by crystallizing a solution of sodium carbonate below 32C°. it forms large transparent crystals belonging to the monoclinic system the transparent crystals effloresce in air, and become coated with an opaque layer of mono hydrate. If heated, the decahydrate loses all its water of crystallization and yields the anhydrous salt. In commerce it is known as (washing soda) although

more bulky than the anhydrous salt, of dissolving endo thermally without caking.

Table (1): show the properties of Na₂CO₃hydrates :

Formula	Na ₂ CO ₃	Na ₂ CO ₃ H ₂ O	Na ₂ CO ₃ .7H ₂ O	Na ₂ CO ₃ .10H ₂ O
Chemical name	Anhydrous	Monohydrate	Heptahydrate	Decahydrate
Common name	Soda ash	Crystal carbonate	-	Washing soda
Appreance	White powder	Colorless	Glassy crystals	
Stability in air	Hygroscopic	Stable	Effloresces	Effloresces
Preparation	By heating ahydrate or bicarbonate strongly	Crystallizes from solution between 32-35C°	Crystallizes from solution above 35.3C°	Crystallizes from solution below 32C _o
ΔH of solution	- 5.640	2.250	-	+16.160

1-2- 21 Physical properties:-

The integral enthalpy of solution of sodium carbonate is -28.1 kJ/mol for a 10% w/w aqueous solution. The Mohs hardness of sodium carbonate monohydrate is 1.3

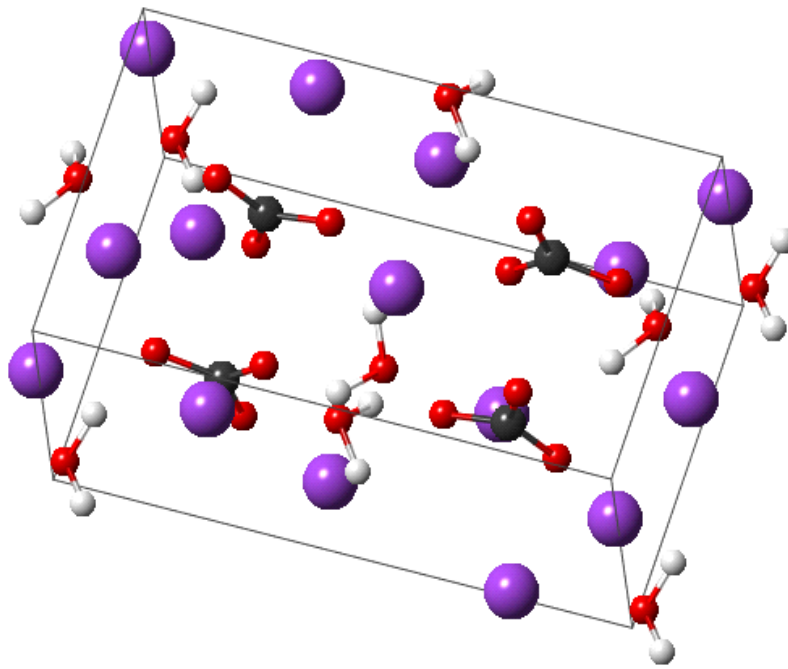


Fig .3. Structure of monohydrate at 346 K

1-2- 22As a source of soda ash:-

Sodium carbonate decahydrate is stable at room temperature but recrystallizes at only 32 °C (90 °F) to sodium carbonate heptahydrate, $\text{Na}_2\text{CO}_3 \cdot 7\text{H}_2\text{O}$, then above 37–38 °C (99–100 °F) to sodium carbonate monohydrate, $\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$. This recrystallization from decahydrate to monohydrate releases much of crystal in a mostly clear, colorless salt solution with little solid thermonatrite. The mineral natron is often found in association with thermonatrite, nahcolite, trona, halite, mirabilite, gaylussite, gypsum, and calcite. Most industrially produced sodium carbonate is soda ash (sodium carbonate anhydrate Na_2CO_3) which is obtained by calcination (dry heating at temperatures of 150 to 200 °C) of sodium bicarbonate, sodium carbonate monohydrate, or trona.

1-2- 23 Uses:-

The manufacture of glass is one of the most important uses of sodium carbonate. Sodium carbonate acts as a flux for silica, lowering the melting point of the mixture to something achievable without special materials. This "soda glass" is mildly water-soluble, so some calcium carbonate is added to the melt mixture to make the glass produced insoluble. This type of glass is known as soda lime glass: "soda" for the sodium carbonate and "lime" for the calcium carbonate. Soda lime glass has been the most common form of glass for centuries.

Sodium carbonate is also used as a relatively strong base in various settings. For example, it is used as a pH regulator to maintain stable alkaline conditions necessary for the action of the majority of photographic film developing agents. It acts as an alkali because when dissolved in water, it dissociates into the weak acid: carbonic acid and the strong alkali; sodium hydroxide. This gives sodium carbonate in solution the ability to attack metals such as aluminium with the release of hydrogen gas.

It is a common additive in swimming pools used to neutralize the corrosive effects of chlorine and raise the pH.

In cooking, it is sometimes used in place of sodium hydroxide for lyeing, especially with German pretzels and lye rolls. These dishes are treated with a solution of an alkaline substance to change the pH of the surface of the food and improve browning.

In taxidermy, sodium carbonate added to boiling water will remove flesh from the skull or bones of trophies to create the "European skull mount" or for educational display in biological and historical studies.

In chemistry, it is often used as an electrolyte. Electrolytes are usually salt-based, and sodium carbonate acts as a very good conductor in the process of electrolysis. In addition, unlike chloride ions, which form chlorine gas, carbonate ions are not corrosive to the anodes. It is also used as a primary standard for acid-base titrations because it is solid and air-stable, making it easy to weigh accurately.

1-2- 24 Other applications:-

Sodium carbonate is a food additive (E500) used as an acidity regulator, anticaking agent, raising agent, and stabilizer. It is one of the components of kansui ,a solution of alkaline salts used to give ramen noodles their characteristic flavor and texture. It is also used in the production of snus (Swedish-style snuff) to stabilize the pH of the final product. In Sweden, snus is regulated as a food product because it is put into the mouth, requires pasteurization, and contains only ingredients that are approved as food additives.

-In the brick industry as a wetting agent to reduce the amount of water needed to extrude the clay and the cotton industry to neutralize the sulfuric acid needed for acid delinting of fuzzy cottonseed.

- In toothpastes, where it acts as a foaming agent and an abrasive, and to temporarily increase mouth pH and used in some aquarium water pH buffers to maintain a desired pH and carbonate hardness (KH).

- Sodium carbonate, in a solution with common salt, may be used for cleaning silver. In a nonreactive container (glass, plastic, or ceramic), aluminium foil and the silver object are immersed in the hot salt solution. The elevated pH dissolves the aluminium oxide layer on the foil and enables an electrolytic cell to be established. Hydrogen ions produced by this reaction reduce the sulfide ions on the silver restoring silver metal. The sulfide can be released as small amounts of hydrogen sulfide. Rinsing and gently polishing the silver restores a highly polished condition.

Because of its ability to absorb CO_2 , sodium carbonate is being investigated as a carbon-capturing material for power plants and in other industries that produce green house gases (Mercer, 1952).

1-3 Objective of the study: -

- 1- To determine the chemical composition and the concentration of each component in altrona.
- 2- To measure the pH of altrona and moist toombak.
- 3- To look through the effect of addition altrona in toombak.

CHAPTER TWO

Materials and Methods

2.1 Sampling:-

2.1.1 Samples:-

Two types of natron samples and moist toombak.

2.1.2 Source of Sample:-

Natron was collected from tobacco stores dealers in Omdurman and shops.

Toombak were collected from different toombak shops in Khartoum, Omdurman and Khartoum North.

2.2 Chemicals:-

Concentrated Hydrochloric acid, Hydrochloric acid(0.1M),

Hydrochloric acid(0.05 M),Sodium chloride, Lithium chloride

Distilled water, Phenolphthalein indicator, Methyl red indicator.

2.3 Instrument:-

- pH meter (JENWAY 3310), England.
- Flame photometer (JENWAY CLINICAL PFP7), England.

2.4 Equipments:-

Conical flask 250 cm³-measuring cylinder-volumetric flask 250 cm³and 100 cm³-funnel-burette-droppers-pipette-sensitive balance-furnace-hot plate-crucible-ashless filter paper- filter paper-beakers.

2.5 Methods:-

2.5.1 Volumetric determination of Carbonate and bicarbonate:-

5 gm of natron sample were weighed and dissolved in 50cm³distilled water, then quantitatively transferred to 250 cm³volumetric flask and completed to the mark with distilled water.

From each solution of natron ,10 cm³were taken and titrated against hydrochloric acid (0.1M) using phenolphthalein and methyl red as indicators respectively.

The end point using Phenolphthalein indicates the half amount of HCl needed by the carbonate while the volume of HCl consumed using methyl red cross ponds to half the carbonate and all bicarbonate.

2.5.2Determinationof Sodium and potassium concentration using flame photometer :-

2.5.2.1 preparation of calibration curve:

0.0477 gm of KCl were accurately weighed and dissolved in water, then transferred to a 250 volumetric flask and completed to the mark with distilled water. this solution makes 100 ppm concentration of potassium ion.

From this stock solution 1,2,3,4,5 ppm were prepared by taking 1,2,3,4,5cm³ of the stock solution in a 100 cm³volumetric flask then completed to the mark with distilled water.

The flame photometer reading was adjusted by the blank which is pure distilled water to read zero.

Then the standard solutions emission was taken followed by the sample, if the sample concentration is higher than the prepared standard the solution must be diluted to suit the range of the standard.

The emission of sodium (Na⁺) and potassium (K⁺) standards and sample are shown in table (3.1.2.1).

2.5.3 gravimetric determination of Silica:-

0.4 gm of natron were weighed in a glass basin, 10-15 cm³ of water were added and stirred. The glass basin was covered with a watch glass and put on a water bath,25cm³ of (1:1) hydrochloric acid was added with stirring until the effervescence ceases. The solution was then evaporated to dryness and the residue lumps were crushed to powder using a glass rod.

The dry powder was transferred to an oven at 105°C for one hour in order to convert the silicates in to insoluble silica.

Then cooled and 1 cm³ of concentrated hydrochloric acid was added followed by 25 cm³ of distilled water and stirred well. The solution was then filtered through whattman filter paper and the

residue was washed well with boiling water until free from chlorides. Then the filter paper containing residue was taken in to a previously weighed platinum crucible and heated gradually on a buusen burner. Then transferred to a muffle furnace at 1000 °C, then cooled and weighed to constant weight.

2.5.4 Alkalinity:-

10 cm³of natron stock solution were quantitatively transferred to 250 cm³ conical flask using a pipette.

The contents were titrated against (0.1M) hydrochloric acid to phenolphthalein end point, the volume was recorded, titration continued by adding two drops of methyl red and the total volume was recorded.

Then titration was repeated by using (0.05 M) hydrochloric acid and the volume was recorded.

2.5.5 Matter insoluble in water and in acid:-

2.5.5.1 Matter insoluble in acid: (hydrochloric acid):-

10.0gm of natron sample was weighed in small beaker; 30 cm³of concentrated hydrochloric acid was added gradually and stirred with glass rod until dissolved.

Then heated on a water bath for 1 hour, the hot solution was cooled and filtered through ashless filter paper, the precipitate and filter paper was washed with warm dilute hydrochloric acid.

The precipitate and filter paper was transferred to a clean and weighed crucible, the crucible and its contents were heated at 110°C for 30 minutes and burned at 1000 °C and cooled then weighed.

2.5.5.2 Matter insoluble in water:-

10.0gm of natron sample was weighed in small beaker; 30 cm³of water was added and stirred with glass rod until dissolved.

Then heated on a water bath for 1 hour, the hot solution was cooled and filtered through ashless filter paper, the precipitate and filter paper was washed with warm water.

The precipitate and filter paper was transferred to a clean and weighed crucible, the crucible and its contents were heated at 110 °C for 30 minutes and burned at 1000 °C and cooled then weighed.

2.5.6 pH Value :-

- 5g of natron sample were dissolved in 50 cm³ of water, the pH of the aqueous suspension was determined.

The electrodes of the pH meter were immersed in the sample after calibration, for 1 min with stirring the pH was taken.

- 5g of toombak sample were dissolved in 50 cm³ of water, the pH of the aqueous suspension was determined.

The electrodes of the pH meter were immersed in the sample after calibration, for 1 min with stirring the pH was taken.

CHAPTER THREE

Results and Discussion

3.1 Results:-

The two natron samples of solution were subjected to analysis qualitatively and quantitatively by standard methods of analysis to determine the chemical composition and the concentration of each component.

The pH of the two natron samples solution and three samples of toombak were measured.

3.1.1 Volumetric determination of carbonate and bicarbonate:

Table (3.1.1) shows the concentration of carbonate and bicarbonate in the natron samples.

3.1.2. Determination of Sodium and potassium concentration using flame photometer:

Table (3.1.2.1) shows the emission and concentration of (Na^+) standards.

Table (3.1.2.2) shows the emission and concentration of (K^+) standards.

3.1.3 Gravimetric determination of Silica:

Table (3.1.3) shows the concentration of (SiO_2) in the natron samples.

3.1.4 Alkalinity:

Table (3.1.4) shows the concentrations of phenolphthalein alkalinity were measured in one sample (sample from Omdurman market used for toombak preparation).

3.1.5 Matter insoluble in water and in acid:

Table (3.1.5) shows the concentration of matter insoluble in water and in acid in the one sample of natron (sample from Omdurman market used for toombak preparation).

3.1.6 pH value:

Table (3.1.6) shows the pH of two natron samples solution and three toombak samples (Khartoum, Omdurman, Khartoum north).

Table (3.1.1) shows the concentration of carbonate and bicarbonate in the natron samples: -

Sample	A	B
CO_3^{-2}	8.70%	22.5%
HCO_3^-	6.25%	10.67%

A= sample from Omdurman market used for toombak preparation.

B= natron sample from market.

$$\% \text{ carbonate} = \frac{(2x) * N * 60/2}{1000 * 10} \frac{\times \text{total volume} \times}{\text{weight of sample}} 100$$

$$\% \text{ bicarbonate} = \frac{(y - 2x) * N * 61}{1000 * 10} \frac{\text{total volume} \times 100}{\text{weight of sample}}$$

X= volume of acid with Phenolphthalein.

Y= volume of acid with methyl red.

N= normality of hydrochloric acid.

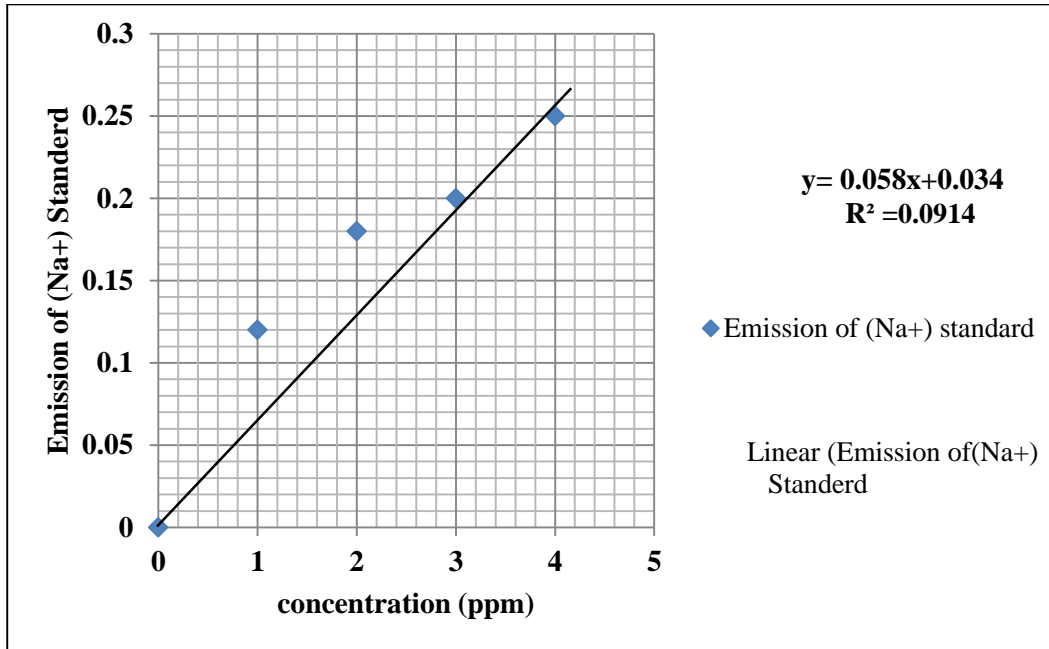
60/2= weight equivalent of carbonate.

61= weight equivalent of bicarbonate.

Table (3.1.2.1) shows the emission and concentration of (Na⁺) standards.

Concentration (ppm)	0	1	2	3	4
Emission	0	0.12	0.18	0.20	0.25

Fig .4. emission and concentration of (Na⁺) standards:



Determination of (Na⁺) by calibration curve:-

Calculation (Na⁺) from equation:

Sample (A) :

Reading Sample = 2.47

$$y = 0.058x + 0.034$$

$$x = \frac{y - 0.034}{0.058}$$

$$0.058$$

$$x = \frac{2.47 - 0.034}{0.058} = 42$$

(Na⁺) in sample (A) = 42 × 10 = 420 ppm

$$\% = \frac{R \times V \times 100}{10^6 \times \text{wt}}$$

R = reading in mg/l (ppm, mg/ml).

V = volume of glass ware (100ml).

100 = percentage .

10⁶ = factor for mg/l.

Wt = weight of dry sample.

$$\% = \frac{420 \times 100 \times 100}{10^6 \times 5} = 8.4\%$$

Sample (B):

Reading Sample = 4.19

$$y = 0.058x + 0.034$$

$$x = \frac{y - 0.034}{0.058}$$

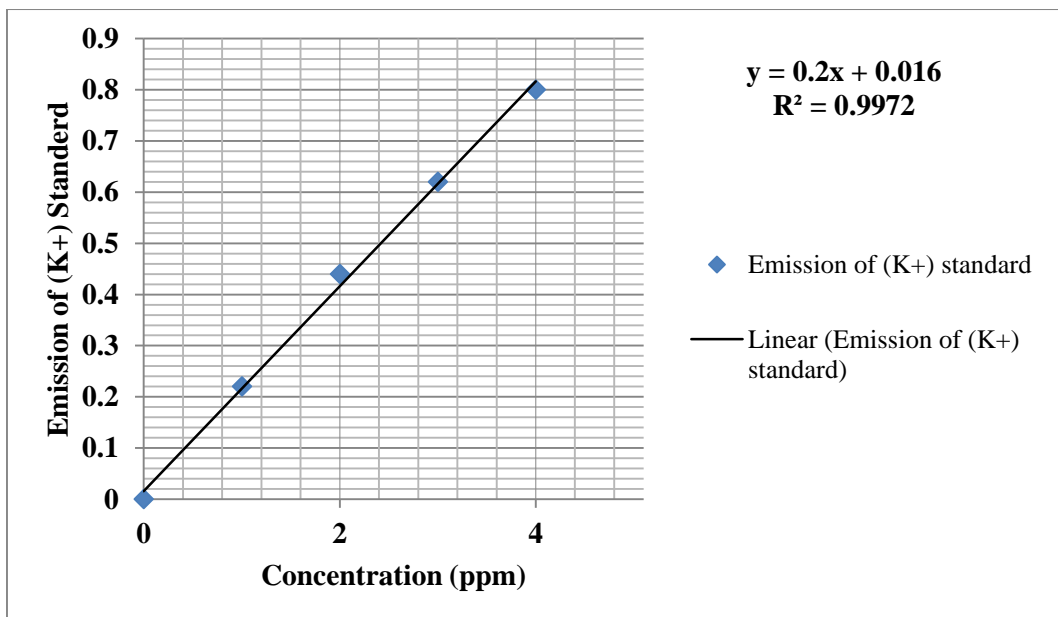
$$x = \frac{4.19 - 0.034}{0.058} = 71.65$$

(Na⁺) in sample (B) = 71.65 × 10 = 716.5 ppm = 14.33%

Table (3.1.2.2) shows the emission and concentration of (K⁺) standards

Concentration (ppm)	0	1	2	3	4
Emission	0	0.22	0.44	0.62	0.80

Fig .5. emission and concentration of (K⁺) standards:



Determination of (K⁺) by calibration curve:

Calculation (K⁺) from equation:

Sample (A) :

Reading Sample = 0.47

$$y = 0.2x + 0.016$$

$$x = \frac{y - 0.016}{0.2}$$

$$0.2$$

$$x = \frac{0.47 - 0.016}{0.2} = 2.27$$

$$0.2$$

(K⁺) in sample (A) = 2.27 × 10 = 22.7 ppm = 0.45%

Sample (B) :

Reading Sample = 2.05

$$y = 0.2x + 0.016$$

$$x = \frac{y - 0.016}{0.2}$$

$$0.2$$

$$x = \frac{2.05 - 0.016}{0.2} = 10.17$$

$$0.2$$

(K⁺) in sample (B) = 10.17 × 10 = 101.7 ppm = 2.03%

Table (3.1.3) shows the concentration of (SiO₂) in the natron samples:-

Sample	A	B
SiO ₂	53.20%	36.87%

$$\% \text{ SiO}_2 = \frac{\text{weight of SiO}_2 \times 100}{\text{weight of sample}}$$

Table (3.1.4) shows the concentration of phenolphthalein alkalinity in the one sample of natron (sample from Omdurman market used for toombak preparation) :-

Sample	A
Phenolphthalein alkalinity (0.1M)	2800
Phenolphthalein alkalinity(0.05M)	3037.5

Phenolphthalein alkalinity = amount of acid used to reach

$$\text{pH (8.3) ml} \times \text{M} \times 100.000(\text{mg CaCO}_3 / \text{eq}) / \text{sample volume (cm}^3)$$

M= molarity of acid (HCl).

Table (3.1.5) shows the concentration of matter insoluble in water and in acid in the one sample of natron (sample A):-

Sample	A
Matter insoluble in water	60.07 %
Matter insoluble in acid	63.55 %

$$\% \text{ matter insoluble} = \frac{\text{weight of matter insoluble} \times 100}{\text{weight of sample}}$$

Table (3.1.6) shows the pH of two natron solution and three toombak samples.

Sample	pH value
Natron solution	9.8
Natron solution prepared (1:4) (water and natron)	9.9
Toombak(Omdurman)	5.6
Toombak(Khartoum North)	5.7
Toombak (Khartoum)	5.6



Fig. 6. Photograph of dry snuf



Fig. 7. Photograph of addition of natron to dry snuff



Fig. 8. Photograph of moist snuff

3.2 Discussion:

- Usually it is use the local natron in toombak because low cost and high percentage of carbonate from other materials, different concentration of carbonate and bicarbonate in two samples of natron result of different chemical structure and harvest of natron.

Natron plays an important role in nicotine absorption to blood stream by increasing the pH. The processing of toombak is not hygienic leads to bacterial contamination. The fermentation process of toombak may increase the growth of many types of bacteria, but the drying of the leaves, and addition of natron may kill the vegetative cells.

- Concentration of Sodium and potassium are different in two natron sample result of type of soil and weathering, and harvesting of natron.
- Different percentage of silica of two natron samples due to different configuration, and modes of harvesting of natron.
- Alkalinity is useful that it provides buffering to resist changes in pH, due to presence of carbonate (CO_3^{2-}), bicarbonate(HCO_3^-).
- The concentration of matter insoluble in acid and insoluble in water are different in two natron samples because most of matter soluble in water insoluble in acid, in natron sample insoluble matter represent silica.

- pH values of the natron sample equal (9.8) [$\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$] it is alkaline soils when the moist toombak equal (5.6), alkaline pH in toombak due to addition of natron.

3.3 Conclusion:

Analytical results obtained conclude the following observation:

The analysis show general suitability of the analyzed natron samples from the measured chemical composition and the concentration of each component are different due to mode of harvest of natron by toombak vendors.

pH is an important determinant of buccal absorption of nicotine, thus pH value in tobacco products can influence the absorption and thereby the extent of pharmacological activity of nicotine.

3.4 Summary of the Results:

The results of the chemical and physical analysis of the two samples of natron and three sample of toombak can be summarized in the following table:

Table (3:4) summary of the results of chemical and physical analysis of the natron and toombak samples

Sample	A	B	C
CO_3^{-2}	8.70 %	22.5 %	
HCO_3^-	6.25 %	10.67 %	
Na^+	8.4%	14.33%	
K^+	0.45%	2.03%	
SiO_2	53.20%	36.87%	
Matter insoluble in acid	63.55%	-	
Matter insoluble in water	60.07%	-	
Phenolphthalein alkalinity (0.1M)	2800	-	
Phenolphthalein alkalinity(0.05M)	3037.5	-	
pH of natron	9.8	-	
pH of toombak	5.6	5.7	5.6

pH of toombak :((A) Omdurman,(B) Khartoum North,(C) Khartoum).

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