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ERGOGENIC CONTROVERSIES OF SOCIO-CULTURAL AFRICAN HERBS: A REVIEW STUDY ON KHAT (CATHA EDULIS) AND KOLA NUT (COLA *SPP*).

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ABSTRACT

Khat and kola nut, are highly controversial ergogenic herbs indigenous to Africa and in the countries around the Red Sea. The spectrum of khat actions has been postulated to lie between amphetamines and caffeine while kola nut active chemical is caffeine. Therefore, khat and kola nuts and their principal active constituents (cathinone, cathine and caffeine respectively) are categorized as stimulants. The chewing of khat leaves and kola nuts has a deep rooted religious and socio- cultural tradition in Africa. Ironically, the World Antidoping Agency and the International Olympic Committee have placed a limit to cathine usage in sports. Caffeine, though not presently in the list of banned substances, but was previously banned, unbanned and restricted before 2004. Reasons for the partial ban and unban of cathine and caffeine respectively seem unclear and ambiguous. It is also confusing and worrisome if, the ethical line of cheating in sport is being scrutinized more carefully, or weather a cultural incident of khat and kola nut chewing is being handled appropriately. Before a conclusive statement could be made on the ergogenic status of both herbs, there is a need for joint extensive studies and international conference of stake holders.

Keywords: khat; kola nut; Africa herbs; cathine; caffeine; cathinone; ergogenic.

INTRODUCTION

Herbs are defined as plants or plant extracts ingested for other than caloric or culinary benefit (Bucci, 2000). Despite their long tradition of use by physically active persons, herbs have seldom been studied scientifically as a possible aid to physical performance. Humans consume herbs to enhance their long-term endurance performance (e.g., in running, cycling, rowing, swimming, walking, dancing, aerobics, cross-country skiing, and mountain climbing), to induce muscular hypertrophy and strength (e.g., for bodybuilding, weight lifting, wrestling, strength sports, and track and field events), or to enhance performance in sport events, both skill sports and those that are recreational. Tradition, identity of ingredients, advertisements, personal endorsements, use by other athletes, and the desire to succeed represent the extent of validation for most herbs used for physical performance (Bucci, 2000).

Herbs are used most commonly at present to enhance physical performance (both endurance and strength), improve recovery, maintain health during intense periods of exercise, build muscle mass, and reduce body fat (Kleijnen & knipschild, 1992; Bucci, 2000). Drug use in sports is not a recent phenomenon. The first reported death from drug usage in sport occurred in 1890s (Cooper, 1972). It is not difficult to belief that drug have been used to gain performance benefits for many years

Over four thousand years, people have been using substances to improve their physical performance and appearance.

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Descriptions of athletes ingesting special foods or herbs to enhance their performance dated back to ancient Greek (Cooper, 1972; Noble, 1986; Devries and Housh, 1994; Eichner, 1997). International competition organizations use the term doping to identify ergogenic practices that are illegal. The use of any drug or herb to improve athletic performance is cause for disqualification by these organizations as contrary to the highest ideals of sportsmanship. Above all some of these drugs and, or herbs can be habituating and can have other harmful effects (Deuries, 1994; Eichner, 1997; Al-Motarreb, 2002; Islam, 1990). Presently cathine (khat extract) and caffeine (cola extract) are categorized as stimulants. Previously, both extracts were among the group of stimulants partially banned by sports sanctioning bodies (SAIDFS, 2007; WADA, 2003). However, in 2004 the World Anti Doping Agency (WADA) and the International Olympic Committee (IOC) removed caffeine from the list of banned substances leaving behind cathine in the list (WADA, 2004). Though, drugs and herbs use in sports have been considered as a dangerous and unethical violation of the code of fair play. However, the ethical line of cheating in sport is being scrutinized more closely than weather a cultural incident of khat and cola nut chewing is being handled appropriately. The purpose of the present review is to examine the available research evidence in this area where there have been controversies and agreement.

Historical background and Botanical specification of khat and cola nut.

Khat: Kingdom, Plantae; class, Magnoliopsida; order, Celastrales. The origins of khat are often argued, many beliefs that it originated from Ethiopia from where it spread to the hillsides of East Africa and Yemen (Peters, 1952; Cox and Rampes, 2003). Others belief that it originated in Yemen before spreading to Ethiopia and nearby countries (Al-Motarreb et al, 2002; ACMD, 2005; NDIC, 2007). From Ethiopia and Yemen the tree spread to Kenya, Somalia, Malawi, Uganda, Tanzania, Arabia, Congo, Madagascar, Zimbabwe, Zambia and South Africa. It has also been found in Afghanistan and Turkistan (Luqman & Danoskwi, 1976). Khat has been grown for use as a stimulant for centuries in the horn of Africa and Arabian Peninsula (Kennedy, 1987). The chewing of khat predates the use of coffee. The khat plant is known by a variety of names, such as qat in yemen, chat in Ethiopia, jaad in Somalia and miraa in Kenya and Tanzania (Kennedy, 1987). It is also known as marungi, flowere of paradise, catha, cat, qat, gaad, African salad, tohai, and bushman's tea, but in most western literature it is referred to as khat (Islam et al, 1990, NDIC, 2008). The earliest scientific report concerning khat was in the eighteenth century by the botanist Peter Forskal (Baasher, 1980; Al-Hebshi & Skang, 2005).

The shrub khat (Catha edulis Forsk) has a slender trunk with smooth, thin bark. The lancet shaped leaves are between 0.5 to 10cm long and 0.5 to 5cm wide. Young leaves are reddish green, later turning to yellow green (fig 1). In areas with frost, the shrub grows to higher than 1.5 meters, but in places with more rainfall like highlands of Ethiopia and areas near the equator

Fig 1. Fresh Khat leaves

Khat trees can reach 20meters (Al-Motarreb et al, 2002; Kennedy, 1987). Khat can also survive in droughts where other crops have failed. Khat is a perennial, propagated by grafting; it grows at altitude of 1500-2000 meters. Leaves are faintly aromatic with an astringent, slightly sweet taste. Trees are grown for 3-4 years before leaves are harvested. A healthy tree yields for about 50years.

Cola (or kola) nut: The use of the kola nut (fig 2), like the coffee berry and tea leaf, appears to have ancient origins. Cola nuts are the seed pods of various evergreen trees from the Kingdom, Plantae; class, Magnoliopsida; order, Celastrales; family, oplophoroidea; (sub-family, sterculioideae; tribe, sterculie; genus, *Catha*; species, *C. edulis.)* family, Oplophoroidea; subfamily, Sterculioideae; tribe, Sterculieae; genus, Cola. There are approximately 171 species in this genus, but 2 are commonly found historically to West Africa; Cola *acuminate* and Cola *nitida* (BCF, 2008; Lovejoy, 1995). The trees are native to the tropical rain forests of West and Central Africa, but are now found in the West Indies and Brazil, where they were introduced by African slaves. Kola chewing in Western Sudan dated for at least a millennium and in the Central Sudan, including modern Northern Nigeria for at least 500 years. Many kola varieties exist but historically, only C. nitida and acuminata have been important in West Africa, Nigeria (Yoruba & Igbo tribes) and Ghana (BSF, 2008). Three species (C. *vera,* C. *nitida* & C. *acuminata*) are used as a stimulant and are prepared in the same manner. The kola tree grows to approximately 40 ft (12 m) in height, and has white to yellow flowers with spots that range from red to purple. The kola tree's leaves are 6–8 inches long (15–20 cm) and the tree bears fruit that is shaped like a star. Inside the fruit, about a dozen round or square seeds can be found in a white seed shell, kola nut, which contains high amounts of caffeine (Jayeola & Akinwale, 2002; Leakey & Simons, 1998; Ibu et al, 1986).

There are several kinds of cola seeds derived from different species, but the *Cola vera* are most generally used and preferred for medicinal purposes. Those from West Africa and West Indies supply the commercial drug. *C. acuminata*, or Gurru nuts, is employed in the same way as *C. vera*; they are from a tree growing in Cameron and Congo, not esteemed so highly, but much in use as a caffeine. The Kola of commerce (C.*vera*) consists of the separated cotyledons of the kernel of the seed; when fresh it is nearly white, on drying it undergoes a fermentative change, turning reddish brown and losing much of its astringency. The dried cotyledons vary in size from 1 to 2 inches, are irregular in shape but roughly plano-convex, exterior reddy brown, interior paler, easily cut, showing a uniform section, odourless and almost tasteless. Large quantities of the fresh seeds are employed in Africa on account of their sustaining properties, where they form an important article of inland commerce (*Cola nitida* is characterized by nuts of two cotyledons and they appear in red, pink and white), while *Cola acuminata* is characterized by four to six cotyledons and mainly used to fulfill traditional roles (Jayeola & Akinwale, 2002).

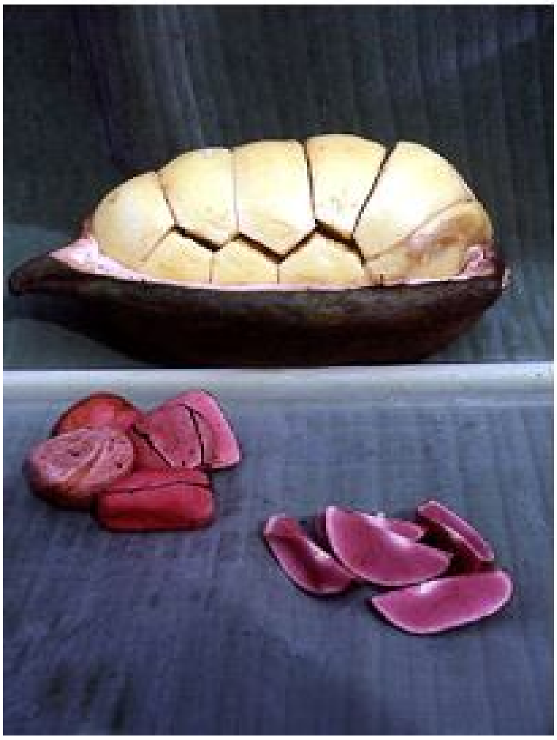

Fig 2: Cola acuminata

In 1911, kola became the focus of one of the earliest documented health scares when the US government seized 40 barrels and 20 kegs of Coca-Cola syrup in Chattanooga, Tennessee, alleging that the caffeine in its drink was "injurious to health" (Benjamin et al, 1991).

Socio-cultural and religion aspect of khat and cola chewing

Khat chewing has a deep rooted socio-cultural tradition, its pleasure inducing and stimulation effects seem to have a strong influence on the social and cultural life of the communities who indulge in it. Khat is predominantly consumed in a social setting (Kalix & Braenden, 1985; Dhaifalah & Santavy, 2004). Muslim religion, smoking and low income and high educational level showed strong association with daily khat consumption (Alem et al, 1999; Awas et al,1999). The Moslem faith of the Yemenites forbids intoxicants other than those prescribed for medical reasons.

To some Muslims, Khat is known as "the flower of paradise". Other countries in the Middle East impose heavy penalties equivalent to those for opium or cannabis on anyone who carries or uses khat. This is not so in Yemen, where even religious leaders may practice the habit. This may be because, in contrast to opium and cannabis, khat produces milder antisocial behavior and is more akin to amphetamine- or caffeine-type substances. In the town of Bohmensaka, South Africa the consumption of this product has been noted to date back as late as the 1500's. Tribes would chew on these at festivals and large gatherings. Khat was a delicacy to the natives and was customary to their nature.

In some parts of Africa, kola nuts are given as gifts to visitors entering a home, usually with some formal ceremony. Offering the kola nut is a gesture of friendship and hospitality. Kola nut has long been reported as the Igbo (Ibo) ethnic group of Eastern Nigeria medium of welcoming a guest and establishing or reinforcing their interaction rate (Uchendu, 1964). The kola nut ceremony is similar to the traditional American Indian peace pipe or breaking bread in a religious context. Elsewhere, before a marriage, a bag of kola nuts are often given by a groom to the parents of the bride. Kola nuts are a used in rituals performed by religious healers. Besides the ceremonial uses, many Africans consume kola nuts regularly, even daily, for the medicinal effects. Kola nuts are a common sight in African markets in cities and villages. They are often sold by street vendors at bus and train depots. On a train or bus, a traveler with a kola nut will often offer a piece to the others nearby, whether he knows them or not. It is preferred among West African Muslims, who are forbidden to drink alcohol (Jayeola & Akinwale, 2002). Coffee and cola nuts are most frequently used by university students in Nigeria as stimulants, mainly during examinations. The stimulants keep them alert while they are studying (Nevadomsky, 1985).

Chemistry and Pharmacokinetics of khat and cola nut

Khat: The environment and climate conditions determine the chemical profile of khat leave. In the Yemen Arab republic, about 44 different types of khat exist, originating from different geographic area of the country (Geisshusler & Brenneisen, 1987). Its taste varies from one kind to another and depends on the tannic acid content. Khat leaves have an astringent taste and aromatic odour. The young leaves are slightly sweet (WHO, 2006). Many different compounds are found in khat, including alkaloids, terpenoids, flavonoids, sterols, glycosides, tannins, amino acids, vitamins and minerals (Kalix & Braenden, 1985).

The phenylalkylamines and the cathedulins are the major alkaloids. The cathedulins are based on a poly-hydroxylated sesquiterpene skeleton and are basically polyester of euonyminol. Recently 62 different cathedulins were characterized from fresh khat leaves (Kite et al, 2003). The khat phenylalkylamines comprise cathinone [s-(-) cathinone] which is considered as the primary constituent of khat. And two diastereoisomers cathine [1S, 2S –(+) – norpseudo-ephedrine or (+) norseudoephedrine] and norephedrine [1R,2S –(-)-norephedrine] which are the secondary constituents. These compounds are structurally related to amphetamine and noradrenaline. Cathinone is mainly found in the young leaves and shoots. During maturation, cathinone is metabolised to cathine [(+)-norpseudoephedine in a ratio approximately 4:1)] (WHO, 2006; UNDCPC, 2008). Other phenylalkylamine alkaloids in khat leaves are the phenylpentanylamines meru cathimone, pseudomerucathine and merucathine. These seam to contribute less to the stimulant effect of khat (Nencini & Ahmed, 1989; Kalix, 1987).

Cathinone is unstable and undergoes decomposition reactions after harvesting and during drying or extraction of the plant (Nencini & Ahmed, 1989; Kalix, et al, 1987). Decomposition leads to a “dimmer” (3,6-dimethyl-2,5-diphenylpyrazine) and possibly to small fragments. Both the dimmer and phenyl propanedione have been isolated from khat extracts (WHO, 1980). As cathinone is presumably the main psychoactive component of khat, this explain why fresh leaves are preferred and why khat is wrapped up in banana leaves(Fig 3) to preserve freshness (WHO, 2006).

Fig 3. A bundle of khat wrapped up in banana leaves.

The pleasure deriveds from khat chewing is attributed to the euphoric actions of s-(-) - cathinone, a sympathomimetic amine with properties similar to amphetamine (Kalix, 1992).The euphoric effect of khat start after about 1hour of chewing. Blood levels of cathinone start to rise with in 1 hour and peak plasma levels are obtained within 1.5-3.5 hour after the onset of chewing (Halket et al, 1995).

During khat chewing most of the alkaloids were extracted in to the saliva, since only 10% of the original content was found in the leaf residues. It is concluded that the buccal mucosa plays a major role in the absorption of all the three alkaloids. The stomach and/or the small intestine receive the swallowed juice and are probably the second phase of absorption. Chewing the material effectively liberates the alkaloids from the leaves and allows rapid absorption in to the systemic circulation. On average, peak plasma levels are obtained after 2.3 hours for cathinone, 2.6 hours for cathine and 2.8 hours for norephedrine (Toennes et al, 2003).

Cola nut: Cola nuts are reported to contain stimulants (Jayeola & Akinwale, 2002; Toennes et al, 2003; Van Handel, 1983; Oludemokun, 1982) as well as substances that induce neurotoxicological effects in animals (Ikegwuonu et al,1981).Analyzed the chemical content of varieties of kola nuts (Cola nitida *alba*, Cola nitida *rubra* A. Chev, and Cola acuminate. Schott & Endl found in Nigeria and West African for their content of secondary plant metabolites (Atawodi et al, 2007). The three varieties of the kola nuts contained appreciable levels of (+)-catechin (27-37 g/kg), caffeine (18-24 g/kg), (-)-epicatechin (20-21 g/kg), procyanidin B 1 [epicatechin-(4beta)-catechin] (15-19 g/kg), and procyanidin B2 [epicatechin-(4beta)-epicatechin] (7-10 g/kg). Antioxidant capacity of the extracts and purified metabolites was assessed to reflect in situ generation of free radicals (e.g., Hydroxide), as to indicate the major secondary plant metabolites present in kola nut extracts. They also reported that caffeine is potentially the more effective cancer chemo preventive metabolite in terms of its antioxidant capacity. Other chemicals found in kola nut include tannin, kolatin, betaine, theobromine and theophylline which are similar to caffeine in chemical structure and effect (Lovejoy, 1995; Morton, 1992).

The cola nut has a bitter flavor; the major and most potent chemical in it is caffeine (Lovejoy, 1995). Nuts spoil very easily and nuts must be kept damp and protected from the air, thus nut are wraps in leaves often in bundles (Lovejoy, 1995). Caffeine is one of the readily available stimulants consumed daily by more than 80% of the world's population, making it the most widely consumed drug in history (James, 1997). Caffeine (1, 3, 7- trimethyl-xanthine) with a molecular weight of 194.2, is a methyl derivative of xanthine. It is basically a Purina compound containing two condensed heterocyclic rings. It is a naturally occurring chemical found in over 60 different species of plant leaves, seeds and fruits among is cola nut. In human, caffeine is rapidly and completely absorbed after oral administration. In human, caffeine solutions empty rapidly from the stomach and absorbed from the gastrointestinal tract. Following the ingestion of caffeine, significant amounts appear in the plasma within 15 minutes and peak plasma concentrations are reached at approximately 60 minutes regardless of the dose (Robertson et al, 1981; Van Handel, 1983).

Herbs (khat & cola nut) and exercise performance

Stimulants such as amphetamine and cathine are among the categories of drug groups currently banned by sports sanctioning bodies (SAIDFS, 2006; Jacobson & Kulling, 1989). Studies (Halbach, 1972; Luqman & danowski, 1976) have postulated that the spectrum of khat actions lay between the amphetamines and caffeine. This premise was based on the predominant component identified to date, that is, (+) norpseudoephedrine rather than knowledge of all of its ingredients and their pharmacologic manifestations.

Cathine, a secondary constituents and one of the major final bye products of khat metabolism is presently banned by the International Olympic Committee (IOC) and WADA. However, the ban on cathine is not absolute as it is in amphetamine; the IOC and WADA allow urinary concentration of Cathine up to 5micrograms per milliliter (SAIDFS, 2006; WADA, 2007). Reason for this partial ban might not be unconnected to the fact that cathinone a major constituent of khat which is finally metabolized to cathine has an amphetamine like action. Cathinone was included in Schedule I of the United Nation Convention on Psychotropic Substances and cathine as schedule IV (Halbach, 1972). Also the legality of khat usage by the general populace varies from country to country (Dhaifalah & Santavy, 2004; Drake, 1988; Brenneisen et al, 1990).

Khat may be used by individuals to enhance their working capacity (Kennedy, 1987; Elmi, 1983; Kalix, 1985). It produces excitation and increased activity (Kalix & Braenden, 1985; WHO, 1980). Khat also increased metabolic rate and oxygen consumption and has analgesic effect via activation of monoaminergic between pathways mediating conception (Kalix & Braenden, 1985; WHO, 1980;Yanagita, 1979; Ahmed & El-Qirbi, 1993; Nencini et al, 1993).

Twenty four year old Kenya bantamweight boxer, David Munyasia was disqualified from the 2004 Athens Olympic (Greece), after testing positive of cathine. The boxer admitted of chewing an African weed or bangi, khat which contain the banned stimulant, nor pseudoephedrine (cathine), (Nencini et al, 1984). The team crew claimed ignorant that khat contained banned substances, cathine.

khat may influence athletic performance by reducing the perceived effort of exercise via its analgesic effect. It has been argued that moderate use improves performance and increases work output, owing to the stimulant and fatigue-postponing effects. Consequently, working hours and possibly productivity can decrease when khat is not used, because of reduced motivation (Cox & Rampes, 2003). Most of the studies (Oyungu et al, 2007; Kimani et al, 2008; Connor et al, 2000; 2002; Eiseberg et al, 1987) conducted on the role and effects of khat and extracts on performance have been conducted on animal samples. Also, their results have been subjective and unclear.

Unlike khat (cathine-cathinone) caffeine, which has been studied extensively (Bucci, 2000). Due to the controversial reports of some scientists (Perkins & William, 1975; Costil, 1978; Costil et al, 1978; Ivy et al, 19794) on the ergogenic effect of caffeine on performance, the International Olympic Committee (IOC) had a series of banned, un-banned and finally pegged the use of caffeine in sports competition to a tolerance limit of 12 $ug.ml^{-1}$ urine (Oludemokun, 1982; Pasma, et al, 1995). However, in 2004, the World Anti–Doping Agency again removed caffeine from the list of banned substances (WADA, 2007). Previous studies on the ergogenic effect of caffeine have been equivocal and mostly coffee caffeine has been used, very few studies (Ajeremi & Ahmed, 1994; Ajeremi, 1990) have been conducted using cola nut caffeine. Also their results were subjective and on animal samples.

CONCLUSION

Both khat and cola nut have a deep rooted religious and socio-cultural tradition mostly in West, East Africa and some parts of South Africa and Arabian Peninsula (particularly Yemen). Both herbs are controversial and adding to confusion is the WADA and IOC banning, pegging and unbanning of these herbs without consensus ergogenic reports. WADA and IOC have placed a limit to cathine one of the constituents of khat. Reason for this partial ban might not be unconnected to the fact that cathinone a major constituent of khat which is finally metabolized to cathine and both have an amphetamine like action. More so, caffeine has been removed from the doping list. Reason for the removal of caffeine from the list seems ambiguous and unclear, since till date studies still continue to report equivocal ergogenic findings. It is worrisome, if the ethical line of cheating in sports is being scrutinized more closely or whether a religious and socio-cultural incident of khat and kola nut chewing is being handled appropriately. Currently, there are no well-designed trials evaluating the ergogenic effect of direct khat and cola chewing on sports performance, most of the previous studies has been conducted using khat extract (cathinone) and mostly on animal samples. Coffee-caffeine on the other hand has been studied extensively, with little emphases on cola nut-caffeine. However, most of the studies on caffeine have been bisected by qualitative and quantitative research study design. In conclusion, both khat and kola should be remove from any doping list pending a global acceptable scientific evidence of dangerous and unethical effects.

RECOMMENDATION

Based on the present review, and before a conclusive statement could be made on the ergogenic effect of khat and cola nut chewing, the need clearly exist for an international conference of sports scientists, sports advocates, managers, athletes, organization and the indigenous/local people of these herbs to deliberate on a consensus, scientific, joint qualitative and quantitative study on the ergogenic effects of both herbs on human performance. Also, this study should be carried out with emphases on larger samples, type of sports and interracial differences.

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