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Full Length Research Paper

Comparative analyses of phytochemicals and antimicrobial properties of extracts of wild *Tamarindus indica* pulps

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***Tamarindus indica* L. (Tamarind), an underutilised fruit tree which belongs to the Leguminosae family, grows wild in the savannah region of Nigeria. *T. indica* pulp was obtained from 19 towns of the 20 savannah states of Nigeria. The methanol and hexane crude extracts obtained from it pulps were evaluated *in vitro* to determine their inhibition activities on human pathogenic microorganisms made up of five bacteria and three fungi. All the bacterial strains were sensitive to both extracts at concentrations ranging from 25 to 125 mg/ml, using the agar broth cup diffusion procedure. Only the hexane extract exhibited intrinsic antifungal properties on *Penicillium* species. Preliminary phytochemical screening of both extracts indicated the presence of alkaloids and tannins. Both the antimicrobial and phytochemical properties of the extracts of the pulp varied for locations of the tamarind. Natural products present in tamarind pulp have potential of being used as agents for animals and/or plants protector against pathogenic microorganisms.**

Key words: Tamarind, phytochemical, antimicrobial, underutilised fruit, saponins.

INTRODUCTION

Tamarindus indica L. (Tamarind) belongs to the dicotyledonous family Leguminosae, and sub-family Caesalpiniaceae, which is the third largest family of flowering plants with a total of 727 genera and 19.327 species (Martinello et al., 2006; Khanzada et al., 2008). It is indigenous to tropical and subtropical Africa (Gunasena and Hughes, 2000; BAIF, 2002; Martinello et al., 2006; Sudjaroen et al., 2005). *T. indica* tree is well known for its fruit, which initially shows a reddish-brown colour that turns black or black-brown, aromatic and sour on ripening. *T. indica* fruit is very rich in minerals, potassium, phosphorus, calcium and magnesium. It has one of the highest levels of protein and carbohydrate of any fruit (BAIF, 2002), though it contains smaller amounts of iron and vitamin A (Khanzada et al., 2008). *T. indica* fruit pulp, a dessert fruit, is often eaten directly from the pod and also used for the preparation of beverages, jam, syrup, candy, curries, chutneys, sauces and ice cream in different regions of the world (Gunasena and Hughes, 2000; Khanzada et al., 2008) . A bitter infusion of *T. indica* pods is used in pickles to preserve fish, for cooking cereals and to detoxify poisonous yam tubers (Gunasena and Hughes, 2000).

Many parts of tamarind plant have long been used in traditional medicines for the treatment of a wide variety of ailments and diseases such as jaundice, gonococci and gastrointestinal disorders (Morton, 1987; Gunasena and Hughes, 2000; BAIF, 2002; Martinello et al., 2006). Extract from the pulp is used as a therapeutic drink in febrile conditions, convalescence, bowel complaints, bilious disorders, dysentery and rheumatism (Morton, 1987; Kobayashi et al., 1996; Coutino-Rodriguez et al., 2001; Souza and Aka, 2007). *T. indica* pulp extract is also administered to alleviate sunstroke, Datura poisoning and alcoholic intoxication (Morton, 1987). Tamarind preparations are used as aid in the restoration

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of sensation in cases of paralysis, reduction of body temperature in fevers, and as laxatives, expectorant and blood tonic (Morton, 1987; Komutarin et al., 2004). Other parts of the plant possess antibacterial, antifungal, hypoglycaemic, cholesterolemic (Khanzada et al., 2008), hypolipomic, antioxidant (Tsuda et al., 1994; Martinello et al., 2006), antihepatotoxic (Joyeux et al., 1995), anti-inflammatory (Rimbau et al., 1999), antimutagenic (Ramos et al., 2003) and antidiabetic (Maiti et al., 2004) properties. Shehla Imam et al. (2007) isolated two triterpenes, lupanone and lupeol, from methanolic extract of the leaves of *T. indica*. Ingestion of *T. indica* fruit has been reported to have an additional beneficial effect on the mobilisation of deposited fluoride from bone, by enhancing urinary excretion of fluoride (Khandare et al., 2004).

T. indica plant is found in the savannah region of Nigeria where it grows wild in backyards, roadsides or wastelands. Despite the use of the plants and its fruits for various purposes by the rural people in Nigeria, *T. indica* is yet to be given the focused research attention it deserves. The research on *T. indica* has been on diverse topics but scattered and unconnected that the impact has been unimpressive. There is no information on the comparative analyses of phytochemicals and antimicrobial properties of tamarind fruits grown in different parts of Nigeria. The comparative analyses of *T. indica* found in different parts of Nigeria become pertinent considering the fact that climatic and environmental factors affect the chemical composition of plants and fruits (Klein and Perry, 1982; Farinu, 1986; Staroscik and Wilson, 1982; Mercadante and Rodriguez-Amaya, 1998). This paper reports on the phytochemical and antimicrobial properties of extracts of tamarind pulp obtained from different parts of Nigeria.

MATERIALS AND METHODS

Collection and preparation of samples

Mature tamarind fruits were collected between March and May 2008 from nineteen randomly selected major towns of the twenty savannah states of Nigeria. The pulp was hand-scrapped from the seeds and shell of tamarind fruits. Non-plant materials, visible dirt and insect-infested parts were removed from the pulp prior to analyses.

Extraction of tamarind pulp

10. 0 g of tamarind pulp was extracted in hot hexane and methanol for 8 h successively. The extracts were concentrated under vacuum and stored in the refrigerator until analysis.

Phytochemical screening

The extracts of tamarind pulp were prepared in suitable forms for the screening of alkaloid, saponin, tannin, glycoside, flavonoid, phlobatannin and reducing sugar using the standard laboratory procedures (Harbone, 1991).

Antimicrobial studies

Mircroorganisms and medium

Cultures of four human pathogenic bacteria made up of two gram negative (*Escherichia coli, Klebsiella pneuomoniae*) and two gram positive (*Staphylococcus aureus, Bacillus subtillis*) bacteria were used for the *in vitro* antibacterial assay. For the antifungal assay, three fungi (*Aspegillus niger, Candida albicans* and *Penicillum species*) were used. All the microorganisms were laboratory strains obtained from the laboratory stock of the Department of Pharmaceutical Microbiology, University of Ibadan, Nigeria.

Nutrient agar (Oxiod Laboratories, U.K.) and potato dextrose agar (Oxiod Laboratories, U.K.) were the media used. Hexane and methanol (Merck) were the solvents used in dissolving the extracts and as negative control in the assay.

Drug

Ampicillin (Beecham) and tioconazole (Pfizer) were used as reference drugs in the assay.

Microorganism assay

The agar disc diffusion technique described by Bauer et al. (1966) and Drouhet et al., (1986) were employed. 1 ml of each test organism obtained from a 24 h broth culture was aseptically added into labeled sterilized petri dishes. Sterilised, cooled nutrient agar and potato dextrose agar were poured into dishes containing the broth culture and immediately swirled for even distribution of organisms. About 6 mm diameter sterilized cork borer was used to make wells on the plates and 0.2 ml of different concentrations of the extract was aseptically introduced into the wells. The diameter of the clear zone of inhibition around the wells containing the extracts were determined after incubating plates at 37°C for 24 h for bacteria and at 25°C for 72 h for fungi.

Diameters of clear zone were taken as an index of the degree of sensitivity of the test organism to the extract. Control dishes which contained no extract of the tamarind pulp samples were similarly set alongside and subjected to the same treatment.

Statistics

Means and standard deviations of the diameter of zones of growth inhibition around the wells containing the extracts for the five treatments were determined. Tests were done in triplicates and diameters zone of inhibition (mm) were expressed as the mean and standard errors of the means.

RESULTS AND DISCUSSION

Phytochemical screening of the hexane and methanol extracts of the tamarind pulp samples revealed the presence of only alkaloids and tannins (Table 1). This result shows that only these two secondary metabolites are present in the pulp samples from all the locations. Climatic variations have in no way affected the chemical composition of the pulps and the two metabolites are soluble in both non-polar and polar organic solvents, n-hexane and methanol. Presence of tannins is most likely to be responsible for the antioxidant and anti-inflammatory properties recorded for this plant pulps

Table 1. Phytochemical screening of n-hexane and methanol extracts of Nigerian tamarind (*T. indica* L.) pulp.

Sample source	Extracts											
	Alkaloids		Tannins		Glycoside		Saponins		Flavonoids		Phlobatannins	
	MeOH	Hexane	MeOH	Hexane	MeOH	Hexane	MeOH	Hexane	MeOH	Hexane	MeOH	
Abuja	+	+	+	+	-	-	-	-	-	-	-	-
Jos	+	+	+	+	-	-	-	-	-	-	-	-
Langtang	+	+	+	+	-	-	-	-	-	-	-	-
Kano	+	+	+	+	-	-	-	-	-	-	-	-
Gwarzo	+	+	+	+	-	-	-	-	-	-	-	-
Bichi	+	+	+	+	-	-	-	-	-	-	-	-
Bauchi	+	+	+	+	-	-	-	-	-	-	-	-
Azare	+	+	+	+	-	-	-	-	-	-	-	-
Gombe	+	+	+	+	-	-	-	-	-	-	-	-
Mallam-Sidi	+	+	+	+	-	-	-	-	-	-	-	-
Katsina	+	+	+	+	-	-	-	-	-	-	-	-
Funtua	+	+	+	+	-	-	-	-	-	-	-	-
Birnin-Kebbi	+	+	+	+	-	-	-	-	-	-	-	-
Jega	+	+	+	+	-	-	-	-	-	-	-	-
Kaduna	+	+	+	+	-	-	-	-	-	-	-	-
Maiduguri	+	+	+	+	-	-	-	-	-	-	-	-
Minna	+	+	+	+	-	-	-	-	-	-	-	-
Shaki	+	+	+	+	-	-	-	-	-	-	-	-
Sokoto	+	+	+	+	-	-	-	-	-	-	-	-

+ = Present,- = Absent.

(Tsuda et al., 1994; Martinello et al., 2006; Rimbau et al., 1999). The alkaloids are responsible for other medicinal properties of this pulp as employed in folk, though it could work synergetically with the tannins (Martinello et al., 2006; Souza and Aka, 2007; Odebode et al, 2004)

In Table 2, the antimicrobial activities of the extracts varied with the concentration of extracts, as the concentration of the extract increases, the more effect it has on the microorganism activity and the larger the zone of inhibition ($p < 0.05$). The pulp extract effect on the microorganisms varied differently. The effect was more pronounced on *K. pneuomoniae* (gram negative bacteria) and *B. subtillis* (gram positive bacteria) which lead credence to the use of the plant for the treatment of respiratory and urinary related problems by the natives. Extracts of tamarind pulp had previously been reported to possess potent fungicidal, molluscicidal and bactericidal properties (BAIF, 2002). Several authors had also reported antimicrobial activities on the other plants of the family (Nuhu et al, 2002; Ejimadu and Ogbeide, 2001; Okerulu and Chinwe, 2001; Kubmarawa et al., 2003; Odebode et al., 2004). The extracts were only effective on the other bacteria at very high concentration, *S. aureus* (125 mg/ml) and *E. coli* (100 mg/ml). It is only extract obtained from Birnin-Kebbi pulp that was active at 75 mg/ml. *A. niger* and *C. albicans* were resistant to all the extracts from all the locations except the methanol extract of the pulp from Jega that showed activity on *A. niger.* The two extracts particularly, the methanol extract from the pulp of all the locations showed very weak activities on *Penicillium* sp.

The minimum inhibition concentration of the extract on *K. pneumoniae* was 25 and 50 mg/ml in methanol and hexane extracts

Table 2. *In vitro* growth inhibition zones of some microorganisms in crude extracts of tamarind pulp.

Sample source	Extract	Concentration (mg/ml)	Diameters of zones of inhibition of microorganisms (mm)						
			S. aureus	***E. coil***	***B. subtilis***	***K. pneumoniae***	***A. niger***	***C. albican***	***Penicillium sp***
Abuja	Hexane	25	-	-	-	-	-	-	-
		50	-	-	5.8 ± 0.2	-	-	-	-
		75	-	-	6.2 ± 0.3	10.4 ± 0.3	-	-	-
		100	-	3.3 ± 0.2	7.5 ± 0.4	12.7 ± 0.3	-	-	4.6 ±0.2
		125	8.4 ± 0.3	8.8 ± 0.5	11.2 ± 0.2	17.1 ± 0.2	-	-	7.6 ± 0.3
	Methanol	25	-	-	-	9.3 ± 0.2	-	-	-
		50	-	-	-	10.6 ± 0.2	-	-	-
		75	-	-	6.5 ± 0.2	12.4 ± 0.3	-	-	7.5 ± 0.2
		100	-	5.3 ± 0.3	8.6 ± 0.2	13.2 ± 0.2	-	-	8.6 ± 0.3
		125	10.2 ± 0.1	12.5 ± 0.2	12.4 ± 0.3	16.2 ± 0.2	-	-	12.6 ± 0.2
Azare	Hexane	25	-	-	-	-	-	-	-
		50	-	-	-	-	-	-	-
		75	-	-	-	8.1 ± 0.1	-	-	-
		100	-	5.7 ± 0.2	5.3 ± 0.1	10.2 ± 0.2	-	-	-
		125	6.3 ± 0.2	8.1 ± 0.1	10.3 ± 0.2	14.3 ± 0.2	6.8 ± 0.1	-	-
	Methanol	25	-	-	-	8.6 ± 0.2	-	-	-
		50	-	-	-	13.5 ± 0.2	-	-	-
		75	-	-	6.3 ± 0.2	16.3 ± 0.2	-	-	5.3 ± 0.7
		100	-	6.1 ± 0.1	10.4 ± 0.2	21.3 ± 0.7	-	-	8.0 ± 0.0
		125	-	10.2 ± 0.2	13.2 ± 0.1	24.0 ± 0.0	-	-	11.3 ± 0.7
Bauchi	Hexane	25	-	-	-	-	-	-	-
		50	-			-	-	-	
		75	-		4.3 ± 0.2	7.7 ± 0.3	-	-	5.7 ± 0.2
		100	-	4.2 ± 0.1	7.3 ± 0.2	12.0 ± 0.0	-	-	-
		125	6.1 ± 0.1	8.3 ± 0.1	10.5 ± 0.2	13.7 ± 0.7	10.3 ± 0.1	-	-
	Methanol	25	-		-	8.3 ± 0.7	-	-	6.3 ± 0.7
		50	-		-	9.7 ± 0.7	-	-	9.3 ± 0.2
		75	-		5.4 ±0.2	15.0 ± 0.0	-	-	12.3 ± 0.2
		100	-	8.3 ± 0.2	8.3 ± 0.1	20.0 ± 0.0	-	-	-
		125	7.3 ± 0.1	12.2 ± 0.2	13.3 ± 0.2	24.0 ± 0.0	-	-	-

Table 2. Contd.

		25	-	-	-	-	-	-	-
		50	-	-	-	8.3 ± 0.1	-	-	-
	Hexane	75	-	-	6.3 ± 0.2	11.4 ± 0.3	-	-	7.7 ± 0.2
		100	-	5.4 ± 0.3	9.4 ±0.3	14.5 ± 0.2	-	-	11.3 ± 0.1
		125	10.0 ± 0.0	11.0 ± 0.0	12.3 ± 0.2	18.2 ± 0.2	-	-	15.3 ± 0.2
Bichi									
		25	-	-	-	11.8 ± 0.4	-	-	-
		50	-	-	-	12.3 ± 0.7	-	-	-
	Methanol	75	-	-	10.5 ± 0.2	14.4 ± 0.4	-	-	12.5 ± 0.2
		100	-	12.4 ± 0.4	12.7 ± 0.4	18.5 ± 0.3	-	-	14.5 ± 0.2
		125	12.4 ± 0.3	14.5 ± 0.4	14.7 ± 0.4	22.2 ± 0.2	-	-	18.5 ± 0.2
		25	-	-	-	-	-	-	-
		50	-	-	-	-	-	-	-
	Hexane	75	-	-	6.2 ± 0.2	9.4 ± 0.1	-	-	-
		100	-	-	9.3 ± 0.7	12.1 ± 0.1	-	-	-
		125	-	6.3 ± 0.2	12.3 ± 0.3	17.0 ± 0.0	7.4 ± 0.2	-	5.7 ± 0.4
Birnin-Kebbi									
		25	-	10.1 ± 0.1	-	8.2 ± 0.2	-	-	7.6 ± 0.1
		50	-	-	10.3 ± 0.7	11.0 ± 0.2	-	-	14.0 ± 1.0
	Methanol	75	10.3 ± 0.7	10.3 ± 0.7	12.3 ± 0.7	12.7 ± 0.7	-	-	18.3 ± 0.7
		100	10.7 ± 1.3	12.7 ± 0.7	14.7 ± 1.3	14.0 ± 1.0	-	-	20.3 ± 0.7
		125	13.7 ± 0.7	14.3 ± 0.7	16.4 ± 0.6	15.7 ± 0.7	-	-	25.0 ± 1.0
		25	-	-	-	-	-	-	-
		50	-	-	-	8.2 ± 0.2	-	-	-
	Hexane	75	-	-	6.2 ± 0.2	11.3 ± 0.2	-	-	-
		100	-	-	9.3 ± 0.2	13.3 ± 0.3	-	-	6.3 ± 0.2
		125	10.3 ± 0.1	8.0 ± 0.0	11.3 ± 0.2	16.6 ± 0.1	-	-	10.3 ± 0.2
Funtua									
		25	-	-	-	10.1 ± 0.2	-	-	-
		50	-	-	8.2 ± 0.1	12.4 ± 0.2	-	-	-
	Methanol	75	-	-	10.0 ± 0.0	14.2 ± 0.2	-	-	8.3 ± 0.2
		100	-	10.1± 0.1	13.0 ± 0.1	16.1 ± 0.2	-	-	11.2 ± 0.1
		125	8.5 ± 0.5	12.2 ± 0.1	-	19.3 ± 0.2	-	-	14.0 ± 0.0

Table 2. Contd.

	Hexane	25	-	-	-	-	-	-	-
		50	-	-	-	-	-	-	-
		75	-	-	8.7± 0.1	10.0 ± 0.0	-	-	5.3 ± 0.7
		100	-	-	9.2 ± 0.1	12.7 ± 0.7	-	-	8.0 ± 0.0
		125	-	-	11.2± 0.2	13.7 ± 0.7	-	-	14.3 ± 0.7
Gombe									
		25	-	-	-	11.0 ± 1.0	-	-	-
		50	-	-	-	13.7 ± 0.7	-	-	14.3 ± 0.7
	Methanol	75	-	-	11.0 ±1.0	17.0 ± 1.0	-	-	15.7 ± 1.7
		100	10.3 ± 0.7	-	12.3 ± 0.7	19.0 ± 1.0	-	-	18.3 ± 0.7
		125	12.0 ± 0.1	10.3 ±0.7	15.0 ± 1.0	21.0 ± 1.0	-	-	20.3 ± 1.7
		25	-	-	-		-	-	-
		50	-	-	-	5.0 ± 0.0	-	-	-
	Hexane	75	-	-	2.2 ± 0.2	10.3 ± 0.3	-	-	-
		100	-	4.0 ± 0.0	6.3 ± 0.7	13.3 ± 0.3	-	-	5.0 ± 0.0
		125	8.3 ± 0.1	8.4 ± 0.3	10.4 ± 0.3	16.1 ± 0.2	-	-	8.3 ± 0.2
Gwarzo									
		25	-	-	-	10.0 ± 0.0	-	-	-
		50	-	-	-	11.3 ± 0.7	-	-	-
	Methanol	75	-	-	8.3 ± 0.2	13.0 ± 0.0	-	-	8.5 ± 0.3
		100	-	5.3 ±0.1	10.6 ± 0.1	15.1 ± 0.2	-	-	10.3 ± 0.2
		125	10.2 ±0.1	12.3 ±0.2	13.3 ± 0.2	17.4 ± 0.2	-	-	11.3 ± 0.2
		25	-	-	-	-	-	-	-
		50	-	-	-	6.9 ± 0.1	-	-	-
	Hexane	75	-	-	-	10.7 ± 0.2	-	-	-
		100	-	5.2 ± 0.2	5.2 ± 0.1	13.4 ± 0.2	-	-	-
		125	7.0 ± 0.0	8.3 ± 0.1	10.2 ± 0.2	15.4 ± 0.2	5.8 ± 0.2	-	-
Jega									
		25	-	-	-	5.3 ± 0.3	8.6 ± 0.2	-	-
		50	-	-	-	12.3 ± 0.3	10.2 ± 0.2	-	-
	Methanol	75	-	-	6.3 ± 0.7	15.6 ± 0.2	15.6 ± 0.3	-	-
		100	-	8.2± 0.2	11.1 ± 0.2	18.6 ± 0.3	18.3 ± 0.2	-	5.7 ± 0.2
		125	7.1 ± 0.1	11.3 ± 0.2	15.2 ± 0.2	22.7 ± 0.1	11.5 ± 0.2	-	10.0 ± 0.0

Table 2. Contd.

		25	-	-	-	-	-	-	-
		50	-	-	-	8.3 ± 0.2	-	-	-
	Hexane	75	-	-	6.2 ± 0.2	11.3 ± 0.2	-	-	-
		100	-	6.3 ± 0.7	7.8 ± 0.4	13.1 ± 0.3	-	-	6.4 ± 0.3
		125	10.1 ± 0.2	8.5 ± 0.2	11.0 ± 0.0	15.4 ± 0.4	-	-	9.4 ± 0.3
Jos									
		25	-	-	-	10.5 ± 0.2	-	-	-
		50	-	-	-	12.3 ± 0.2	-	-	-
	Methanol	75	-	-	8.3 ± 0.2	14.4 ± 0.2	-	-	8.1 ± 0.1
		100	-	10.4 ± 0.2	10.4 ± 0.3	16.0 ± 0.1	-	-	11.4 ±0.3
		125	8.3 ± 0.2	12.4 ± 0.3	13.2 ± 0.3	19.0 ± 0.0	-	-	14.5 ± 0.2
		25	-	-	-	-	-	-	-
		50	-	-	-	-	-	-	-
	Hexane	75	-	-	4.4 ± 0.1	7.2 ± 0.1	--	-	-
		100	-	-	8.3 ± 0.2	12.3 ± 0.2		-	3.2 ± 0.1
		125	6.7 ± 0.7	8.0 ± 0.0	10.4 ± 0.2	15.4 ± 0.2	7.3 ± 0.2	-	8.3 ± 0.2
Kaduna									
		25	-	-	-	9.2 ± 0.1	-	-	-
		50	-	-	-	12.2 ± 0.1	-	-	5.3 ± 0.2
	Methanol	75	-	-	5.6 ± 0.2	16.6 ± 0.1	-	-	8.3 ± 0.2
		100	-	7.6 ± 0.3	10.0 ± 0.0	19.0 ± 0.0	-	-	11.3 ± 0.2
		125	8.0 ± 0.0	10.3 ± 0.2	12.7 ± 0.7	23.2 ±0.2	-	-	14.4 ± 0.3
		25	-	-	-	-	-	-	-
		50	-	-	-	12.4 ± 0.3	-	-	-
	Hexane	75	-	-	12.3 ± 0.2	16.4 ± 0.3	-	-	8.1 ± 0.2
		100	-	8.6 ± 0.1	16.4 ± 0.3	19.3 ± 0.2	-	-	14.6 ± 0.3
		125	10.3 ± 0.2	11.3 ± 0.2	18.7 ± 0.2	21.5 ± 0.2	-	-	18.3 ± 0.7
Kano									
		25	-	-	-	10.4 ±0.3	-		-
		50	-	-	-	12.5 ± 0.2	-	-	-
	Methanol	75	-	-	11.3 ± 0.2	14.4 ± 0.3	-	-	8.0 ± 0.0
		100	-	10.1 ± 0.2	13.7 ± 0.7	17.6 ± 0.1	-	-	11.3 ± 0.3
		125	10.7 ± 0.2	13.1 ± 0.0	17.4 ± 0.1	22.4 ± 0.3	-	-	13.3 ± 0.3

Table 2. Contd.

		25	-	-	-	-	-	-	-
		50	-	-	5.2 ± 0.1	-	-	-	-
	Hexane	75	-	-	4.3 ± 0.1	12.2 ± 0.2	-	-	-
		100	-	5.6 ± 0.2	8.5 ± 0.2	14.2 ± 0.2	14.2 ± 0.2	-	4.3 ± 0.1
		125	10.7 ± 0.2	8.3 ± 0.1	11.4 ± 0.2	17.5 ± 0.2	17.5 ± 0.2	-	7.4 ± 0.2
Katsina									
		25	-	-	-	9.4 ± 0.2	9.4 ± 0.2	-	-
		50	-	-	-	10.2 ± 0.1	10.2 ± 0.1	-	-
	Methanol	75	-	-	6.3 ± 0.2	12.2 ± 0.1	12.2 ± 0.1	-	7.4 ± 0.1
		100	-	5.1 ± 0.0	8.3 ± 0.2	13.3 ± 0.1	13.3 ± 0.1	-	8.3 ± 0.1
		125	10.2 ± 0.1	12.1 ± 0.0	12.4 ± 0.1	16.7 ± 0.2	16.7 ± 0.2	-	12.1 ± 0.1
		25	-	-	-	-	-	-	-
		50	-	-	-	-	-	-	-
	Hexane	75	-	-	4.3 ± 0.2	10.3 ± 0.2	-	-	8.3 ± 0.3
		100	-	7.4 ± 0.2	8.3 ± 0.1	13.4 ± 0.3	-	-	10.1 ± 0.2
		125	-	12.2 ± 0.1	10.3 ± 0.1	16.3 ±0.3	-	-	14.3 ± 0.1
Langtang									
		25	-	-	-	-	-	-	-
		50	-	-	-	8.4 ± 0.3	-	-	-
	Methanol	75	-	-	-	12.4 ± 0.3	-	-	-
		100	-		6.5 ± 0.2	16.4 ± 0.3	-	-	5.3 ± 0.2
		125	-	6.2 ± 0.2	9.4 ± 0.2	18.4 ± 0.3	-	-	7.0 ± 0.6
		25	-	-	-	-	-	-	-
		50	-	-	-	8.3 ± 0.2	-	-	-
	Hexane	75	-	-	7.3 ± 0.7	11.2 ±0.2	3.2 ± 0.1	-	3.3 ± 0.2
		100	-	-	10.7± 0.3	14.4 ± 0.3	7.2 ± 0.2	-	8.4 ± 0.2
		125	8.0± 0.0	5.3 ± 0.2	13.3 ± 0.5	17.0 ± 0.0	9.3 ± 0.2	-	12.5 ± 0.2
Maiduguri									
		25	-	-	-	12.3 ±0.7	-	-	-
		50	-	-	-	13.7 ± 0.3	-	-	-
	Methanol	75	-	-	-	16.0 ± 1.0	-	-	-
		100	-	10.3 ± 0.7	12. ± 0.0	18.3 ± 0.7	-	-	-
		125		11.7 ± 0.7	13.3 ± 1.0	21.0 ± 1.0	-	-	-

Table 2. Contd.

		25	-	-	-	-	-	-	-
		50	-	-	-	6.3 ± 0.3	-	-	-
	Hexane	75	-	-	8.3 ± 0.4	10.4 ± 0.4	-	-	6.8 ± 0.2
		100	-	-	11.9 ± 0.1	14.6 ± 0.1	-	-	9.3 ± 0.1
		125	5.3 ± 0.7	7.4 ± 0.1	14.0 ± 0.0	18.4 ±0.3	-	-	12.5 ± 0.2
Mallam Sidi									
		25	-	-	-	10.2 ±0.2	-	-	-
		50	-	-	-	13.0 ± 0.0	-	-	10.6 ± 0.3
	Methanol	75	-	-	-	18.3 ± 0.3	-	-	13.3 0.3
		100	8.4 ± 0.3	8.0 ± 0.0	8.0 ± 0.0	23.4 ± 0.3	-	-	17.5 ± 0.2
		125	11.5 ± 0.3	12.7 ± 0.7	12.7 ± 0.7	27.3 ± 0.2	-	-	19.3 ± 0.1
		25	-	-	-	-	-	-	-
		50	-	-	5.3 ± 0.2	-	-	-	-
	Hexane	75	-	-	6.2 ± 0.1	10.4 ± 0.1	-	-	-
		100	-	3.2 ± 0.1	7.2 ± 0.2	13.4 ± 0.1	-	-	-
		125	8.0 ± 0.0	8.1 ± 0.1	11.5 ± 0.3	17.4 ± 0.2	-	-	-
Minna									
		25	-	-	-	9.4 ± 0.2	-	-	-
		50	-	-	-	11.4 ± 0.1	-	-	-
	Methanol	70	-	-	6.4 ± 0.2	15.6 ± 0.1	-	-	8.7 ± 0.1
		100	-	5.3 ± 0.2	9.4 ± 0.1	17.4 ± 0.1	-	-	12.0 ± 0.2
		125	11.0 ± 0.8	12.3 ± 0.1	12.4 ± 0.2	19.3 ± 0.2	-	-	13.7 ± 0.7
		25	-	-	-	-	-	-	-
		50	-	-	-	-	-	-	-
	Hexane	75	-	-	4.1 ± 0.1	7.3 ± 0.1	-	-	-
		100	-	4.1 ± 0.1	7.1 ± 0.2	12.3 ± 0.2	-	-	-
		125	6.5 ± 0.1	8.3 ± 0.1	10.5 ± 0.2	14.2 ± 0.1	10.0 ± 0.0	-	-
Shaki									
		25	-	-	-	8.3 ± 0.2	-	-	-
		50	-	-	-	11.3 ± 0.2	-	-	
	Methanol	75	-	-	5.5 ± 0.2	15.2 ± 0.1	-	-	6.8 ± 0.2
		100	-	8.3 ± 0.2	8.3 ± 0.2	20.3 ± 0.2	-	-	9.3 ± 0.2
		125	7.4 ±0.2	12.3 ± 0.1	13.3 ± 0.1	23.3 ±0.2	-	-	13. 3± 0.2

Table 2. Contd.

		25	-	-	-	-	-	-	-
		50	-	-	5.5 ± 0.1	-	-	-	-
	Hexane	75	-	-	6.3 ± 0.2	10.3 ± 0.3	-	-	-
		100	-	3.5 ± 0.1	7.3 ± 0.2	13.3 ± 0.2	-	-	4.1 ± 0.1
		125	8.2 ±0.2	8.3 ± 0.2	11.3 ± 0.2	17.3 ± 0.2	-	-	7.3 ± 0.1
Sokoto									
		25	-	-	-	9.3 ± 0.2	-	-	-
		50	-	-	-	10.4 ± 0.3	-	-	-
	Methanol	75	-	-	6.5 ± 0.2	12.3 ± 0.3	-	-	7.3 ± 0.1
		100	-	5.6 ± 0.2	8.3 ± 0.1	13.4 ± 0.2	-	-	8.2 ± 0.1
		125	10.0 ± 0.0	12.3 ± 0.2	12.2 ± 0.1	16.3 ± 0.2	-	-	12.3 ± 0.7

respectively. *Penicillium* sp. on the other hand, had a minimum inhibition concentration of 25 and 75 mg/ml respectively in methanol and hexane extracts. *B. subtilis* was next to *K. pneumoniae* in terms of sensitivity to the extracts, with a minimum inhibition concentration of 50 mg/ml in both the hexane and methanolic extracts. Generally, methanol extract exhibited higher antimicrobial activity than hexane extract while the bacterial pathogens were more sensitive to the crude extracts than fungal pathogens.

CONCLUSION

Hexane and methanolic extracts of *T. indica* L. fruits are sources of bioactive naturally occurring compounds that have antimicrobial properties. There are also no differences in the chemical composition of *T. indica* fruits harvested from the different locations. From the results of this research work, natural products from tamarind fruits have shown potential capability of being used as animal and/or plant protection agents against pathogens. The unorthodox practice by Nigerians peasant of using extracts of *T. indica* L. fruits in the treatment of various human ailments has thus been collaborated.

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