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Studies on Jurak Smoke:
II The Metallic Constituents of Jurak Paste and Jurak Smoke

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ABSTRACT. The concentration of 16 metals in jurak paste and jurak smoke condensate has been determined by atomic absorption. In jurak paste the main metallic constituents are Ca, Si, Fe, Al and K which represent 98.39%. Trace amounts of Sr, Ti, Mn, Zn, Cu, Pb, Ni, Cr, Co, As and Cd are present and represent only 1.61%. In the inhalant smoke Ca, Si, Fe, K and Zn are the major elements and represent 99.22% and the remaining 0.78% comprise traces of the other metals. Out of 14.685 mg metals present in one gram jurak paste only 3.075 μg are transferred to the inhalant smoke. It appears that water in the shisha reservoir retain some metallic inhalants by acting as a condensation medium, and thus reduce the carcinogenic effect of the metallic components in jurak smoke.

Introduction

Metal ions play a vital role in a vast number of widely different biological processes. However, the presence of excessive concentration or unsuitable metals in biological systems may induce toxicity manifestation[1]. Elevated level of metals in human may be attributed to; excessive uptake or metabolic disorders[2].

The respiratory tract provides an entry into the lungs for several metals from the enviroment. Tobacco smoke, environmental pollution by car exhaust emission and other fossil fuel combustion as well as the occupational hazard contribute to human exposure[3].

Within the last 30 years, and as a result of increased emphasis on the physiological and carcinogenic aspects of tobacco smoking, there have been a developing interest in the metallic constituents of tobacco and tobacco smoke. During combustion the bulk of metallic constituents remain in the ashes, but some compounds are vaporized or transferred into the smoke stream. Among the 76 metals detected in cigarettes, 30 have been identified in the smoke including Pb, Ni, Al, Cd, As, Bi, Si, and Se[4].

With respect to tobacco carcinogenesis, special interest has been focused on As, Ni, and Cd. The presence of arsenic in tobacco smoke may be a contributing factor in the tumorigenic effect of smoke condensate in laboratory animals[5]. Arsenic content in U.S. tobacco ranges between 5.0 to 10.0 $\mu g \cdot g^{-1}$ and between 7 to 18 percent of this amount reappears in the mainstream smoke of cigarettes[6].

Nickel in all forms (metal, oxide, sulfide, salts and carbonyl) is carcinogenic in experimental animals[7]. In cigarette tobacco, 2.0 to 6.0 μg per cigarette were reported. During smoking 10 to 20 percent of the nickle content in tobacco is transferred into the mainstream smoke mostly in the form of nickel carbonyl $[Ni(CO)_4]$[8] which is a potent carcinogen in rats. It induces lung epidermoid carcinomas and adenocarcinomas[9].

Several forms of cadmium are carcinogenic in the experimental animals. Occupational exposure to cadmium oxide increases the risk of prostate cancer[10]. In mainstream smoke Cd concentration is 9-70 μg per cigarette. It has been suggested that a heavy smoker retains about 1.5 μg Cd per day.

In the Kingdom of Saudi Arabia smoking of jurak is very common. However, determination of the metallic constituents of jurak smoke has not been investigated yet. The aim of the present study is to determine the main metallic constituents of jurak paste and jurak smoke condensate, to determine the rate of transfer of these metallic constituents from jurak paste to the mainstream smoke, and to estimate the impact of such transfer on jurak smokers.

Material and Methods

Preparation of Jurak Smoke condensate

Jurak smoke condensate was prepared following the same procedure previously described by El-Aaser *et al.*[15].

Sample Digestion

The wet ashing method[11] was used for determination of the metals. Jurak paste 4.0-5.0 g or jurak smoke condensate were digested with 50 ml. Concentrated HNO_3. Samples were first boiled gently for 50 minutes to get rid of all easily oxidizable matter. The temperature was then increased and boiling was continued for 3 hr until a white residue was obtained. The white residue was dissolved in 0.4 M HNO_3 and quantitatively transferred to polyethylene bottle, and completed to 100 ml.

Sample Analysis

The metals were determined with a Perkin-Elmer Model, 500 atomic absorption spectrophotometer equipped with an HGA-500 graphite furnace and an AS-40 Autosampler, with blanks carried throughout the entire procedure. Peak areas were measured with continual source backgoing correction. Samples content were analyzed calibration using acid-matched standard. The graphite furnace system was used for the determination of Al, Mn, Cr, Ti, As and Co. The other metals were determined by the flame system.

Results

The concentration of the 16 metals determined in jurak paste and jurak smoke condensate together with the precentage of the transfer of these metals from jurak paste to the smoke condensate are presented in table 1.

TABLE 1. Metal contents of jurak paste and jurak smoke condensate*

Metal	Jurak paste		Smoke condensate		μg in smoke/g jurak paste	% Transfered to inhalant smoke
	μg/g	%	μg/g	%		
Calcium	11260.0	76.67	213.60	69.95	2.136	1.9×10^{-2}
Silicon	1194.4	8.13	75.60	24.46	0.756	6.3×10^{-2}
Iron	1174.8	8.00	5.60	1.82	0.056	4.8×10^{-3}
Aluminum	640.0	4.36	0.24	0.08	0.002	3.8×10^{-4}
Potassium	180.2	1.23	4.40	1.43	0.044	2.4×10^{-2}
Strontium	93.8	0.64	0.18	0.59	0.002	1.9×10^{-3}
Titanium	48.0	0.33	0.02	0.007	0.0002	4.2×10^{-4}
Manganese	29.4	0.20	0.08	0.026	0.0008	2.7×10^{-3}
Zinc	24.4	0.17	4.80	1.56	0.0480	2.0×10^{-1}
Copper	22.8	0.16	0.40	0.13	0.0040	1.8×10^{-2}
Lead	8.4	0.06	1.20	0.39	0.0120	1.4×10^{-1}
Nickel	5.0	0.03	0.80	0.26	0.0080	1.6×10^{-1}
Chromium	1.6	0.01	0.18	0.59	0.0018	1.1×10^{-1}
Cobalt	1.6	0.01	0.16	0.052	0.0016	1.0×10^{-1}
Arsenic	1.0	0.006	0.15	0.049	0.0015	1.5×10^{-1}
Cadmium	0.5	0.003	0.06	0.02	0.006	1.2×10^{-1}
Total	14685.53		307.47		3.075	

Calcium, Si, Fe, Al and K are the main metals present in jurak paste. These metals represent 76.67, 8.13, 8.0, 4.36 and 1.23 percent respectively of the total metals determined. The remaining eleven metals Sr, Ti, Mn, Zn, Cu, Pb, Ni, Cr, Co, As and Cd are present in trace amounts and represent only 1.61 percent of the total metals determined.

*The listed values are averages of triplet samples.

In the jurak smoke condensate the 16 metals are also present but with different percentage distribution. The main metals are Ca, Si, Fe, Zn and K. These metals represent 69.95, 24.46, 1.82, 1.56 and 1.43 percent respectively of the total metals determined. The remanining eleven metals represent only 0.78%.

From the total amount of 16 metals present in jurak paste (14.685 $\mu g.g^{-1}$) only $2.09 \times 10^{-2}\%$ ($3.075 \mu g$) were transferred to the smoke condensate. The rate of transfer of these metals differs greatly and the maximum rate never exceed 1.096×10^{-1} for Zn.

Discussion

Metal ions play an important role in metabolism, however severe toxic manifestations may develop when these metals are present in excess[1]. Recently, clinical and experimental evidences are being accumulated on the carcinogenic effects of some metals specially As and Ni[5,7,9,10].

Although, the metal constituents of tobacco are thorougly investigated[4,6,9] the metallic constituents of jurak paste and the rate of their transfer to the main stream smoke is compeletely lacking. In this study 16 selected metals were determined in jurak paste and jurak smoke condensate, they include the main metals in cigarette together with those suspected to be carcinogenic[4].

Metal contents of jurak smoke condensate amounted only to 3.075 $\mu g.g^{-1}$paste. This figure is very low when compared with cigarette smoke, 150 $\mu g.g^{-1}$, [12]. The main reason for this low value is no doubt due to the water in the shisha reservoir which solubilise and condense a large portion of the volatile metals. Also the difference in nature of the matrix burnt must be taken into consideration.

The Ni content of one cigarette weighing approximately 1 g is 2 to 6 μg. Out of this amount only 10-20% ($\sim 0.37\ \mu g$) is transferred to the mainstream smoke [8]. On this approximate calculation, a person smoking 2 packs daily will inhale 5.4 mg Ni per year which is three times the carcinogenic dose in rats[13]. In jurak paste Ni concentration is 5 $\mu g.\ g^{-1}$ which is higher than that detected in cigarettes. However, only 0.008 $\mu g.g^{-1}$ is transferred to the inhalant smoke. On this bases to reach the carcinogenic dose in rats a person should smoke 660 g jurak daily which can not be reached even for heavy jurak users.

Arsenic is accepted to be a contributing factor in the carcinogenicity of cigarette smoke[14]. Replacement of arsenical insecticides with non-arsenical ones reduced As content in American tobacco to 10 $\mu g.g^{-1}$. In the main stream smoke arsenic concentration amounted to $0.3 \sim 1.4\ \mu g.g^{-1}$[6]. In jurak paste as concentration is very low (1 $\mu g.\ g^{-1}$) and only negligible amount detected in the inhalant smoke.

The data of this study indicates that water in the shisha reservoir acts as a good filtration medium for metals and organometallic compounds. This result also confirms previous finding that water acts as a good solvent and condensating medium for many organic inhalants[15].

Our data could explain the reported low incidence of tumour of upper respiratory tract in the western region where jurak smoking is common[16,17].

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References

[1] **Ulmer, D.D.**, Trace Elements, *N. Engl. J. Med.* **297:** 318-322 (1977).

[2] **Delves, H.T.**, The clinical value of trace-metal measurement. *Essays Med. Biochem.* **2:** 37-42 (1976).

[3] **Brune, D., Nordberg, G.F., Wester, P.O.** and **Bivered, B.**, *Accumulation of heavy metals in tissues of industrially exposed worker; in Nuclear Activation Techniques in the Life Sciences,* International Atomic Energy Agency, Vienna, 643 (1979).

[4] **Norman, V.**, *An overview of the vapor phase, semivolatile and nonvolatile components of cigarette smoke, Recent Advances in Tobacco Science* **3:** 28-51 (1977).

[5] **Holland, R.H.** and **Acevedo, A.R.**, Current status of arsenic in american cigarettes, *Cancer* **19:** 1248-1250 (1966).

[6] **Griffin, H.R., Hocking, M.B. and Lowery, D.G.**, Arsenic determination in tobacco by atomic absorption spectrometry. *Ana. Chem.* **47**(2): 229-233 (1975).

[7] *A report of the surgeon general. Smoking and Health* **14:** 58-60 (1979).

[8] **Szadkowski, D., Schultze, H., Schaller, K.H.** and **Lehnert, G.Z.**, On the ecological importance of the content in heavy metals of cigarette smoke, lead, cadmium, and nickel analysis of tobacco and its gas and particulate phases. *Archivfuer Hygiene* **153:** 1-8 (1969).

[9] **Synderman, F.W. Donnelly, A.J.**, Studies of nickel carcinogenesis, metastasizing pulmonary tumors in rats induced by the inhalation of nickel carbonyl. *Am. J. of Pathol.* **46**(6): 1027-1041 (1965).

[10] **International Agency for Research in Cancer**, Cadmium and inorganic cadmium compounds. *In: World Health Organization.* IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, volume 2; Some Inorganic and Organometallic Compounds. Lyon, International Agency for Research in Cancer, 74-94 (1973).

[11] **Williams, S. (editor)**, *Official Methods of Analysis of the Association of Official Analytical Chemist.* 14*th* ed., Association of Official Analytical Chemist, Inc., Virginia, 164 p. (1984).

[12] **Stedman, R.L.**, The chemical composition of tobacco and tobacco smoke. *Chem. Rev.* **96:** 153-207 (1968).

[13] **Sunderman, F.W.** and **Sunderman, Jr., F.W.**, Nickel poisoning; XI. Implication of Nickel as a Pulmonary Carcinogen in Tobacco Smoke, *Am. J. Clin. Pathol.* **35:** 203-209 (1961).

[14] **Guther, F.E. Bowery, T.G.**, Pesticide residues on tobacco, *Residue Reviews* **19:** 31-56 (1967).

[15] **El-Aaser, A.M.** and **El-Marzabani, M.M.**, Studies on jurak smoke: I. The organic constituents of jurak smoke, *JKAU: Sci.* **3:** 169-181 (1991).

[16] **Sterling, G., Khalil, A.M., Nada, G.N., Saad, A.A.** and **Raheem, M.A.**, Malignant Neoplasms in Saudi Arabia. *Cancer* **44:** 1543-1548 (1979).

[17] **Yousif, A.**, *Incidence of laryngeal and lung cancer in Saudi Arabia, Benzo[a] pyren in jurak smoke and shisha water, 8th Saudi Medical Conference,* Riyadh Oct. 30 - Nov. 3 (1983).

دراسة علي دخان الجيراك

٢ - المكونات المعدنية في الجيراك ودخان الجيراك

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المستخلص . تم في هذه الدراسة تقدير ١٦ من العناصر المعدنية في عجينة الجيراك (ماركة جنة الفواكة) وفي مكثف دخان الجيراك بوساطة الامتصاص الذري . ولقد اختيرت هذه العناصر نظرًا لوجودها في السجائر ودخان السجائر ، كما أن بعض هذه العناصر مثل النيكل والزرنيخ يعتقد أنهما من العوامل المسببة للسرطان في دخان السجائر في الجهاز التنفسي .

وتشير النتائج إلى أن :

١ - الكالسيوم ، السليكون ، الحديد ، الألومنيوم والبوتاسيوم تشكل ٩٨,٣٩٪ من المكونات المعدنية للعناصر الـ ١٦ التي تم تقديرها . أما العناصر الأخرى وهي الاسترنشيوم ، التيتانيوم ، المنجنيز ، الزنك ، النحاس ، الرصاص ، النيكل ، الكروميوم ، الكوبلت ، الزرنيخ والكاديوم فتشكل فقط ١,٦١٪ .

٢ - هذه العناصر الـ ١٦ توجد بكميات ضئيلة جدًا في مكثّف دخان الجيراك (وهو جزء الدخان الذي يستنشقه مدخن الجيراك) بالمقارنة بتركيزها في دخان السجائر .

٣ - انخفاض تركيز هذه المعادن في مكثّف دخان الجيراك ربما يرجع أساسًا إلى مياه الشيشة التي تحتجز جزءًا كبيرًا من هذه المكونات المعدنية وكذلك انخفاض درجة حرارة احتراق الجيراك التي تبلغ حوالي ٤٥٠°م والتي لا تكون كافية لتطاير نسبة كبيرة من المعادن وانتقالها إلى الدخان .

٤ - انخفاض مستوى هذه المكونات المعدنية خاصة المعادن المسرطنة مثل النيكل والزرنيخ ربما يكون من العوامل المؤدية إلى انخفاض التأثير السرطاني لدخان الجيراك بالمقارنة بدخان السجائر والذي تم توضيحه في دراسات إحصائية وبائية سابقة .