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INFLUENCE OF PLASTIC PACKAGING ON THE QUALITY OF KOUTOUKOU (A TRADITIONAL SPIRIT) PRODUCED IN CÔTE D'IVOIRE

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Abstract

Objective: The aim of this study is to assess the risk associated with the use of plastic packaging on the quality of koutoukou (KTK, a traditional spirit) produced in Côte d'Ivoire. **Methods**: Samples of beverages (KTK) are collected and packed in plastic and glass bottles. Drinks so packed are kept in the laboratory at room temperature for 14 days. After this waiting period, the samples of koutoukou are removed to undergo various separation tests through the gas chromatography. **Results**: Glass bottles constituents are less likely to migrate than plastic bottles constituents, in the case of conservation of alcoholic beverages. **Conclusion**: Koutoukou packed in plastic bottles or thins is a potential hazard for consumers and these packaging contribute to the deterioration of the quality of koutoukou produced and distributed in Côte d'Ivoire.

INTRODUCTION

Packagings are ubiquitous in the consumer's life. Among them, the plastic packagings are constantly changing, giving rise to a surprising diversification. However, there are compatibility issues between the plastic packaging and food. Indeed, interactions between plastic and food are inevitable. Sometimes, they cause quality defects both at organoleptic and toxicological level. The best known of these phenomena is the migration of monomers (building blocks of plastic) or residual processing aids which may be released by the packaging and contaminate food.

Scientists are confronted to another problem. In fact, in order to avoid the waste of "disposable plastic» and under pressure from environmentalists, it is talk of "recyclable plastic." This food packaging from recycled materials poses many problems and their use is not, to date, no risk to the consumer. It is difficult to know what constituents are released by clean and new plastic, so what could be about a used material that the origin and the use by consumers are often not known.

Several recycling processes exist. They range from simple washing of bottles to a complete depolymerization of material in monomers which are then purified and repolymerization to make a new bottle. Washing processes are not very effective. But in Africa, particularly in Côte d'Ivoire, it is the most widely used methods. The reuse of single-use bottles is a common household practice. Indeed, for the preservation of different products such as koutoukou (KTK), the keepers of cabarets and bistros reuse various recycled bottles such as mineral water and some pharmaceuticals ones. These practices can significantly affect the organoleptic and toxicological qualities of KTK. Such practices pose a risk of poisoning to consumers of this basic beverage, having regard to the numerous cases of poisoning contacted within the population due to KTK consumption [1-3].

In order to remove all the ambiguities of such practices, this study aims to evaluate the risk of reusing containers like disposable plastic used for the conservation of KTK on physico-chemical properties of the latter.

MATERIALS AND METHODS

Koutoukou

Koutoukou (KTK) is a traditional spirit obtained initially by distillation of the oil palm sap fermented [4,5]. In this study, it was taken either directly from producers (Aboisso, area of high production of KTK) or from cabarets vendor (Abidjan, the economic capital of Côte d'Ivoire).

Liqueur in bag

The liqueur in bag is a liqueur brandy packed in plastic bags and usually from Ghana, a neighboring country.

Recycled packaging

The experiment was carried out with recycled bottles of mineral water (plastics) and those of pharmaceuticals (glasses). These bottles have been washed with hot soapy water and rinse several times with tap water before each use.

Experimental protocol

The aim of this research was to identify the chemical compounds other than ethanol, present in KTK and liquor stored in plastic bottles compared to those stored in glass bottles. Thus, analysis by gas chromatography was performed on the samples. Then, the alcohol strengh, the pH and the Brix degree have been determined.

For this, the collected samples of KTK were packed in plastic bottles and glass bottles. Drinks so packed were kept in the laboratory at room temperature for 14 days. After this waiting period, the samples were removed KTK to undergo various tests.

Determination of chromatographic profile of KTK contained in plastic bottles and glass

To determine the different profiles of KTK, the gas chromatography (GC) was used. It was performed on a chromatograph type SHIMADZU GCMS QP 2010 system that combines gas chromatography and mass spectrometry.

Determination of some physico-chemical properties of drinks packed in glass and plastic bottles

Determination of alcoholometric density

The alcoholometric density was determined using the hydrometer GAY-Lussac. This is repeated three times and the result is the average of the three measures.

Determination of pH

Determination of pH was done for the different beverages with a pH meter (HANNA HI 98129) previously calibrated [6]. This is repeated three times.

Determination of Brix degree

Brix measures the weight in grams of dry matter contained in 100 g of product. It is done by the means of a refractometer brand Tonick Eko. The measurement is made by transparency, with a prism having an index of refraction. A drop of the contents of each type of bottle is placed on the refractometer prism and then covered. The measurement is read directly from the scale fitted to the instrument. Between two measurements, the prism of the refractometer is rinsed with distilled water to return to zero of the apparatus. The operation is repeated also three (3) times.

Statistical analysis of results

Data obtained were processed statistically using the software STATISTICA 7.1 by analysis of variance (ANOVA). Whenever a significant difference ($p < 0.05$) was revealed, the ANOVA test is complemented by the Tukey post ANOVA, to identify the variables with very significant differences compared to controls.

RESULTS

Chromatographic profile of koutoukou taken from the producer (KTKp)

The chromatographic profile of koutoukou-producer (KTKp), taken directly from the producer. The chromatographic profile of KTKp has four peaks fully identified (Figure 1). There is also a wide disparity in the concentrations of chemical elements highlighted. In order of importance, we note: ethanol (85.80 %); 2-isopropoxyethanamine (14.20 %); 1-propanethiol (trace) and N-butane-1, 1, 1 -D3 (trace).

After conservation of KTKp in plastic packaging, the chromatographic profile obtained (Figure 2) has ten fully identified peaks. There is also a wide disparity in the concentrations of chemical elements highlighted. These are: methylsulfidtiole (681.51 mg/l); 2-methyl-1-butanol (581.01 mg/l); ethanol (507.79 mg/l); 1,1-diethoxyethane (94.06 mg/l); acetic acid (16.47 mg/l); N-ethyl-N'-nitroguanidine (9.33 mg/l); methyl cyclobutane (7.86 mg/l) Diethylenetriamine (4.00 mg/l); 1,1 '-

bibicyclo (2.2.2) octyl-4-carboxylic acid (2.29 mg/l) and beta-ionone epoxide (0.14 mg/l).

The chromatographic profile of KTKp from glass bottles (Figure 3) has four peaks fully identified. There is also a wide disparity in the concentrations of chemical elements highlighted. In order of importance, we note: ethanol (85.80 %); 2-isopropoxyethanamine (14.20 %); 1-propanethiol (trace) and N-butane-1, 1, 1-D3 (trace).

Chromatographic profile of any koutoukou whatever there was or collected from cabarets (KTKtv)

The chromatogram of KTK collected from vendors of cabarets and packed in plastic bottles (Figure 4) shows eight peaks, all of which has been identified quantitatively and qualitatively. There is a wide disparity in the concentrations of chemical compounds identified. In order of importance, we note: ethanol (958.94 mg/l); 2-mercaptoethanoic acid (796.16 mg/l); methylhydrazine hydrochloride (597.66 mg/l); acetonitrile (2.83 mg/l); 2-propanol (0.55 mg/l); hexaborane-12 (0.43 mg/l) and methanol (0.15 mg/l).

The chromatogram of KTK collected from the vendors of cabarets, but packed in glass bottles (Figure 5) reveals five peaks which have been identified quantitatively and qualitatively. There is a wide disparity in the concentrations of chemical compounds identified. In order of

importance, we note: methylsulfidtiole (59.46 %); ethanol (31.64 %); 1-Methylpentyl hydroperoxide (8.89 %); the 3-methyl butanoic acid (0.01 %) and N-butane-1, 1, 1-D3 (trace).

Chromatographic profile of the liqueur in plastic bag

The chromatographic profile of the liqueur in plastic bags (Figure 6) presents ten peaks. They are identified and each is an element constituting the liqueur sold in shops. There is a wide disparity in the concentrations of various elements detected with a high concentration of ethanol. In fact, there are: ethanol (823.43 mg/l); methylsulfidtiole (681.51 mg/l); nitrosomethane (17.75 mg/l); 2H-pyran-3, 4 dihydro-2-carboxamide (8.35 mg/l); 1-propyne (6.19 mg/l); 3-hydroxy-2- butanone (4.84 mg/l); cyano-acetic acid (3.78 mg/l); 1,2-propadiene (2.69 mg/l); methylazoxymethyl acetate

(1.82 mg/l) propyl and methyl ether (0.39 mg/l).

The chromatographic profile of the liqueur in bag, repacked in glass bottles (Figure 7) presents eleven peaks. They are identified and each is an element constitutive of the liqueur sold in shops. There is a wide disparity in the concentrations of various elements detected with a high concentration of 2, 4-thiazolidinedione (53.30 %) followed by ethanol (41.51 %), 2, 3-butylene oxide (4.59 %), 2,3-butanediol (0.23 %), toluene (0.17 %), 2-4-methyl pentanone (0.08 %), 3-hydroxy-2-butanone (0.07 %), trans-beta-IONON-5,-6-epoxide (0.03 %), acetaldehyde (0.02 %) and the hydrochloride Methylhydrazine (trace).

Physico-chemical properties of drinks packed in plastic and glass bottles

The physico-chemical of drinks is shown in Table 1. The determination of alcoholometric density of different beverages stored in plastic bottles gave 38.00 ± 0.95 for KTK taken in cabarets (KTKtv), 48.33 ± 2.94 for koutoukou coming directly from the producer (KTKp) and the liqueur (42.67 ± 0.47). Compared to beverages stored in glass bottles, KTKp, KTKtv and liqueur in bag titrate respectively 39.00 ± 0.93°, 41.67 ± 0.47° and 48.53 ± 1.94°.

The measurement of pH of the various drinks packed in plastic bottles gave for KTK provided from cabaret, KTKp and for the liqueur, respectively 3.36 ± 0.03, 3.18 ± 0.11 and 8.08 ± 0.21.

Those drinks contained in glass bottles have given for the KTKtv, KTKp and for the liqueur in bag, respectively the following values: 3.30 ± 0.03, 3.08 ± 0.11 and 3.00 ± 0.21. These results are not significantly different. Beverages packed in plastic bottles and those packed in glass bottles have very similar Brix degree. These values are not significantly different.

DISCUSSION

Packaging of drinks in plastic and glass bottles did not affect significantly their pH, strength and Brix degree.

Brix degree reflects the degree of dry matter or dry extract in a given product. When the value of Brix degree is high, the concentration of dry matter is not high in the product concerned. Statistical analysis of the results of the Brix degree indicates that there is no significant difference between the amounts of dry extract of the various beverage samples.

But the comparative study of the chromatographic profile of beverages packed in plastic and glass bottles showed a significant difference in the nature of the identified elements.

The results of the analysis by gas chromatography have some similarities with those found by Tehoua *et al*. (2012) [2]. Overall, ethanol, 2-propanol and méthylsuldtiole chemical remain the chemical elements observed in all the drink samples analyzed.

Repacked drinks in glass bottles have at least five chemical elements while the liqueur in bag has 11 chemical elements in various proportions. His profile is similar to drinks packed in plastic bottles with a variety of chemical elements (at least eight peaks). Thus, in the case of KTK, this disparity come from the non-standardized or non-approval of the manufacturing process of KTK. Manufacturing, which differs from one producer to another, influence the composition of this traditional brandy. But it also highlights the influence of the type of packaging on the quality variability of drinks so packed. These observations reveal that drinks in plastic bottles present a high risk than those packed in glass bottles for that beverages consumers regard to all chemical elements identified. These elements come from interactions between the plastic and drinks. This has led to the deterioration in the toxicological quality of these drinks through the release of some compounds in them. These interactions between packaging and drinks are inevitable but much higher in the case of plastic bottles. This phenomenon highlights the danger associated with the reuse of bottles in general and especially plastic in the case of KTK conservation. Indeed, this popular drink in people living in Côte d'Ivoire is preferentially packed in recycled plastics. This type of packaging contributes tremendously to the deterioration of the quality of KTK offered to consumers. These results corroborate the observation of several authors on the risks of poisoning related to consumption by people [1,7].

Moreover, analyzes revealed the presence of some products deemed hazardous for consumption:

- ✓ acétonitrite or methyl cyanide, noxious and flammable. It can penetrate through oral, dermal or inhalation. It is metabolized to cyanide and thiocyanate, making it a compound very dangerous to health. This product has a systemic effect and cause an increase in liver weight in male mice [8];
- ✓ propanoic acid, of formula: CH3CH2COOH, which causes vomiting, diarrhea, irritation of the mucous membranes of the mouth, throat, esophagus and intestinal tract in humans after consumption;
- ✓ dimethyldisulphide, pale yellow liquid whose odor is strong and putrid. It is a volatile organic compound, flammable (flash point 15 °C), harmful to humans by inhalation or ingestion and dangerous to the environment. The presence of this product in koutoukou could come to its accumulation in the sap of the palm tree. This compound is used as a chemical intermediate in the manufacture of pesticides [9];
- ✓ isopropanol or 2-propanol, which causes irritation, a burning sensation in the mouth and throat and abdominal pain after eating. This product may cause depression of the central nervous system (CNS), liver damage and kidney damage. Depression of the central nervous system (CNS) characterized by: headache, dizziness, drowsiness, nausea, vomiting, abdominal pain and incoordination. Severe overexposures may lead to coma and even death due to respiratory failure. Liver damage characterized by loss of appetite, jaundice and occasional pain in the upper left abdomen. Generally, the symptoms of kidney disease evolve through the event: oliguria, presence of blood in the urine and total renal failure. The presence of this compound in koutoukou could explain the observed effects among consumers, similar to those described by previous studies [7];
- ✓ 2-Mercaptoethanoic acid of molecular formula (C2H4O2S) also called thioglycolic acid is an irritant and corrosive to the digestive tract. When consumed in high doses, it causes in animals, heavy breathing, convulsions and liver damage [10].

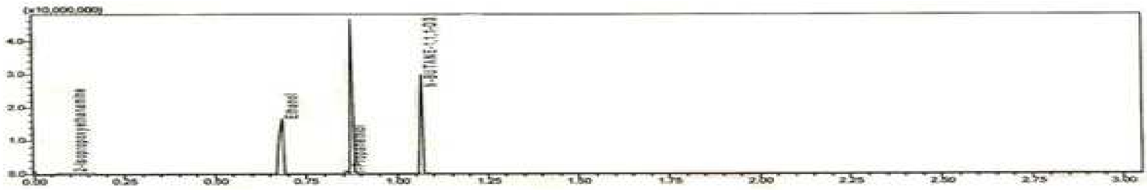
These elements found in these drinks come on the one hand from the migration of monomers (building blocks of plastic) or residual processing aids which may be released by the packaging and end up in these drinks, on the other hand, the use that has been made at a prior use (conservation of detergent, pesticide and gasoline) before ending up at the landfill and recycling. Migration of constituents of plastic materials has led to deterioration in the organoleptic properties, toxicological and possibly microbiological of drinks [11].

The presence of these elements in the samples analyzed enables to understand and assess the risk of harm that could be the drink for consumers.

Authors showed that KTK is an acid alcoholic beverage and its toxicity is not related to the presence of methanol, but lies rather in the manner of consumption [1]. However, the presence of some elements (potentially toxic) to trace or small quantities should be taken into account in the overall assessment of the quality of the drink. In view of these results, toxicity of koutoukou would it not be partly due to the presence of these components of the plastic packaging?

CONCLUSION

In light of the results, glass bottles are less likely to migrate their constituents as plastic bottles in the case of conservation of alcoholic beverages. This is why glass containers are often used for drinks. Glass bottles are generally use for alcoholic beverages packaging. Liqueurs in bags and packed koutoukou in plastic bottles or tins are a potential hazard for consumers and thereby contribute to the deterioration of the quality of koutoukou produced and distributed in Côte d'Ivoire.



Ret.Time	Search	Report	Surface	Concentration (%)	Name
0.100	Done	1	2267099	14.20	2-Isopropoxyethanamine
0.683	Done	1	13693872	85.80	Ethanol
0.867	Done	1			1-Propanethiol
1.067	Done	1			N-BUTANE-1,1,1-D3

Figure 1 Chromatographic profile of koutoukou-producer (KTKp)

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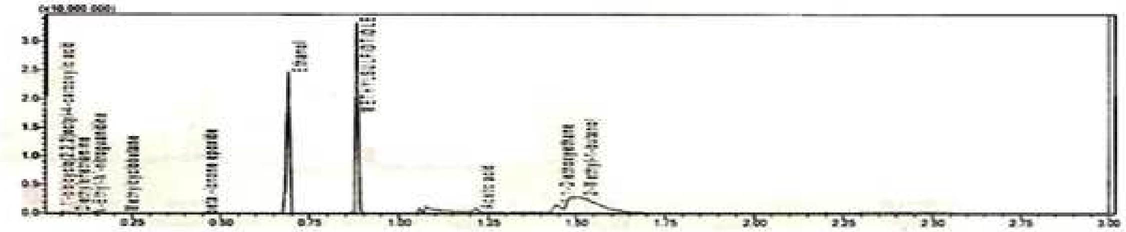
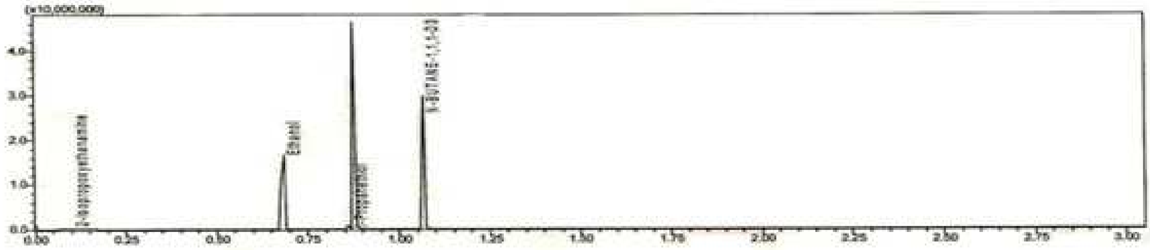


Ret.Time	Search	Report	Surface	Concentration (mg/l)	Name
0.033	Done	1	65619	2,29	1,1'-bibicyclo(2.2.2)octyl-4-carboxylic acid
0.075	Done	1	115199	4,00	Diethylenetriamine
0.125	Done	1	268589	9,33	N-Ethyl-N'-nitroguanidine
0.217	Done	1	226308	7,86	Methylcyclobutane
0.442	Done	1	3899	0,14	beta.-Ionone epoxide
0.692	Done	1	14618310	507,79	Ethanol
1.217	Done	1	474107	16,47	Acetic acid
0,882	Done	1	19619316	681,51	METHYLSULFIDTIOLE
1.442	Done	1	2707886	94,0631	1,1-Diethoxyethane
1.508	Done	1	16726362	581,0190	2-Methyl-1-butanol

Figure 2 Chromatographic profile of KTK-producer packed in plastic bottle



Ret.Time	Search	Report	Surface	Concentration (%)	Name
0.100	Done	1	2267099	14.20	2-Isopropoxyethanamine
0.683	Done	1	13693872	85.80	Ethanol
0.867	Done	1			1-Propanethiol
1.067	Done	1			N-BUTANE-1,1,1-D3

Figure 3 Chromatographic profile of KTKp packed in glass bottle

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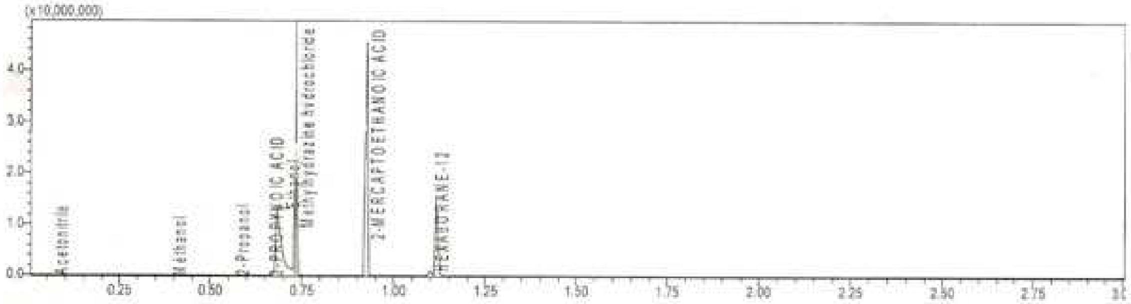
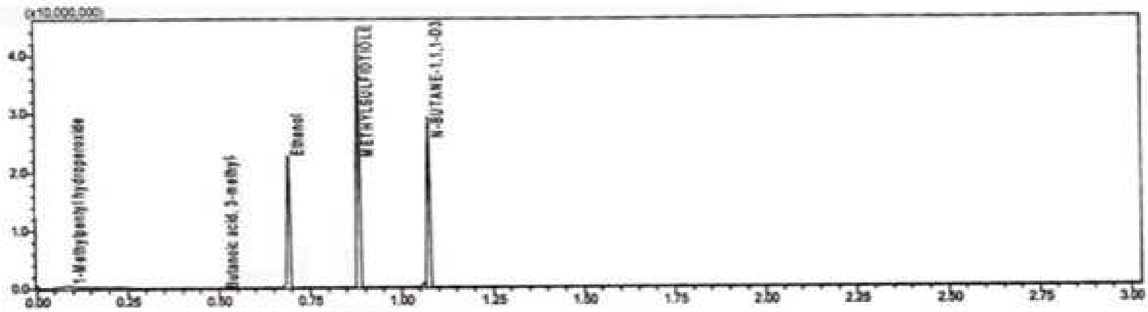


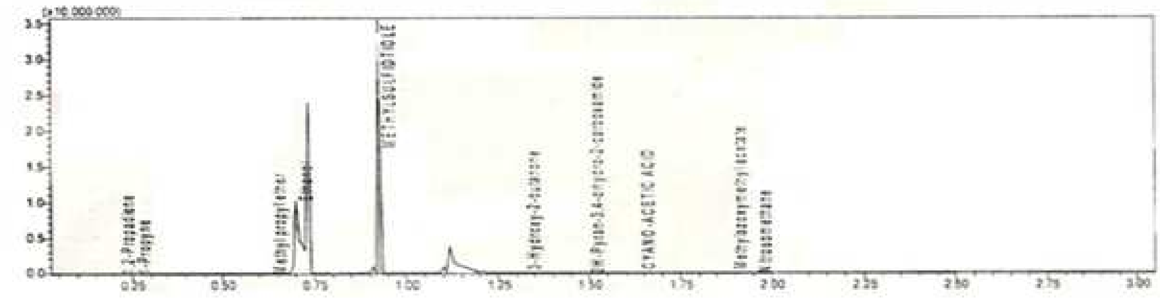
Ret.Time	Search	Report	Surface	Concentration (mg/l)	Name
0.058	Done	1	81487	2,83	Acetonitrile
0.383	Done	1	4348	0,15	Méthanol
0.558	Done	1	15974	0,55	2-Propanol
0.650	Done	1	57143	1,98	2-PROPYNOIC ACID
0.683	Done	1	27605969	958,94	Ethanol
0.733	Done	1	17205361	597,66	Methylhydrazine hydrochloride
0.925	Done	1	22919831	796,16	2-MERCAPTOETHANOIC ACID
1.100	Done	1	12356	0,43	HEXABORANE-12

Figure 4 Chromatographic profile of KTK collected from cabarets and packed in plastic bottle



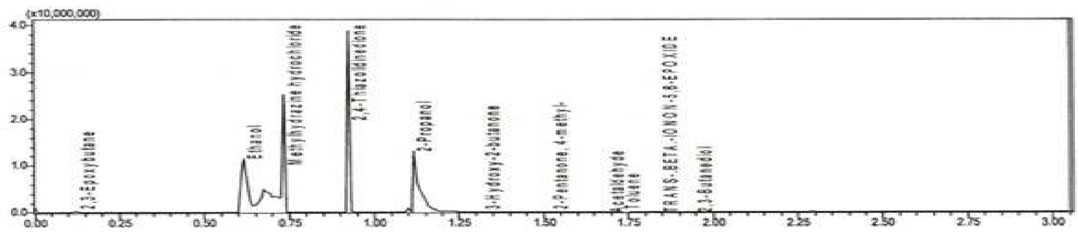
Ret.Time	Search	Report	Surface	Concentration (%)	Name
0.091	Done	1	3374916	8.89	1-Methylpentyl hydroperoxide
0.508	Done	1	5372	0.01	Butanoic acid, 3-methyl-
0.692	Done	1	12013520	31.64	Ethanol
0.883	Done	1	22577500	59.46	METHYLSULFIDTIOLE
1.075	Done	1			N-BUTANE-1,1,1-D3

Figure 5 Chromatographic profile of KTK collected from cabarets and packed in glass bottle



Ret.Time	Search	Report	Surface	Concentration (mg/l)	Name
0.208	Done	1	7742	2,69	1,2-Propadiene
0.242	Done	1	17830	6,19	1-Propyne
0.625	Done	1	1118	0,39	Methyl propyl ether
0.700	Done	1	23704872	8234,30	Ethanol
1.317	Done	1	13923	4,84	3-Hydroxy-2-butanone
1.492	Done	1	24028	8,35	2H-Pyran-3,4-dihydro-2-carboxamide
1.633	Done	1	10873	3,78	CYANO-ACETIC ACID
1.883	Done	1	5251	1,82	Methylazoxymethyl acetate
1.950	Done	1	51107	17,7529	Nitrosomethane
0,925	Done	1	19619316	681,51	METHYLSULFIDTIOLE

Figure 6 Chromatographic profile of liqueur in plastic bag



Ret.Time	Search	Report	Surface	Concentration (%)	Name
0.125	Done	1	1685437	4.59	2,3-Epoxybutane
0.617	Done	1	15254116	41.51	Ethanol
0.733	Done	1			Methylhydrazine hydrochloride
0.925	Done	1	19586081	53.30	2,4-Thiazolidinedione
1.117	Done	1			2-Propanol
1.317	Done	1	26150	0.07	3-Hydroxy-2-butanone
1.517	Done	1	29919	0.08	2-Pentanone, 4-methyl-
1.683	Done	1	8017	0.02	Acetaldehyde
1.725	Done	1	64188	0.17	Toluene
1.842	Done	1	10320	0.03	TRANS-.BETA.-IONON-5,6-EPOXIDE
1.942	Done	1	84924	0.23	2,3-Butanediol

Figure 7 Chromatographic profile of liqueur repacked in glass bag

Table 1

Physico-chemical properties of drinks packed in plastic and glass bottle

Packaging	Drinks	Alcoolimetric degree	pH	Brix degree
Plastic	KTK tv	38,00 ± 1,63 a	3,36 ± 0,03 a	11,83 ± 0,71 a
	KTK p	48,33 ± 2,94 a	3,18 ± 0,11 a	11,28 ± 2,98 a
	Liqueur	42,67 ± 0,47 a	8,08 ± 0,21 a	11,38 ± 0,19 a
Glass	KTK tv	39,00 ± 0,93 a	3,30 ± 0,03 a	11,63 ± 1,61 a
	KTK p	48,53 ± 1,94 a	3,08 ± 0,11 a	11,18 ± 1,98 a
	Liqueur in bag	41,67 ± 0,47 a	3,00 ± 0,21 b	11,38 ± 0,29 a

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