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Full Length Research Paper

Production, analysis and uses of cotton oil in tropical Africa: A review

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Abstract

The value of cotton oil is considerably increasing as food or fuel for diesel engines whether they are intended for agriculture or transport, as well in the countries of the South as in those of the North. In Africa particularly, government actions should appear in order to boost the production of oil upstream. Equipments and machines should also be designed and adapted for a better use of co-products in animal feed and in the craft sector. In a context of high and increasing price in oil, one can wonder about the energetic opportunities of cotton oil whose production in hectare varies from 100 to 300 Liters according to places. Previous works and some uses that began since the years 1980 showed that cotton oil presents the same behavior as biofuel and as diesel combustibles. The technical constraints of use are good for engines as burners. If equipments are adapted, the performances and the yield are very close, sometimes better than those obtained with petroleum products. This work will help to ease the orientation of research in the domain of cotton oil.

Key words: cotton, Africa, cotton oil, feeding, crafts, biofuel.

Introduction

Cotton oil is part of the most conveyed products of the oilseeds system in the world, particularly in tropical zones. In Africa, it is the most consumed edible oil in C-4 countries (Mali, Chad, Burkina Faso and Benin) and an important proportion in Ivory Coast, Togo and Cameroon. As far as Cameroon is concerned, which represents one of the countries of French speaking Africa having the most important processing industry of cotton seeds, cotton oil constitutes a main source of lipids for the populations (Kapseu, 2009).

Averagely, 100 kg of cotton seed produce 10 liters of oil. So, in Africa, 100 liters are usually obtained per hectare. Considering its yields in cotton seed, China can produce 300 liters of oil per hectare (Vaitilingom, 2006). Compared to the colza or to the sunflower, which are only cultivated for their oil, by producing 1000 to 1200 liters per hectare, the importance to grind the cotton seeds is noticed which is just one co-product of the fiber. This fiber represents 85% of the market value of cotton seed. Approximately, two third of seeds are used in this purpose worldwide. In a context of increasing kerosene price, joint efforts are actually led on the energetic opportunities of this oil.

With regard to what precedes, the necessity of reviewing the production and the values of use of this oil in tropical Africa comes up. From this perspective, the objective of this work is to establish a review on the production, the analysis of the chemical composition and food and/or non food uses (energetic) of cotton oil in tropical Africa.

Production of the cotton oil

More than 90% of the world's production of oil for human consumption is assured by six botanical species. These six species supply a greater part of lipid consumed by the world's population. These six are soya beans oil, palm oil, groundnut oil, sunflower oil, colza oil and cotton oil.

Table 1 represents the production in tons of the cotton oil for the African countries. It is observed that the first producer country is Burkina Faso followed by Nigeria, then by Egypt and by Mali. The production of the cotton oil in these countries represents 3.5% of the world's production.

Table 1: Countries producing cotton oil in Africa (in tons) (FAO, 2012)

Countries	2005	2006	2007	2008	2009	2010
World	69 446 228	71 455 708	72 504 406	-	-	5 000 000
Burkina Faso	712 707	725 000	690 000	55 000	45 000	42 000
Nigeria	521 000	563 000	570 000	-	-	-
Egypt	560 000	560 000	560 000	-	-	-
Mali	534 143	432 466	414 965	-	-	-
Cameroon	-	-	-	-	-	20 000
Chad	-	-	-	-	-	-
DR Congo	-	-	-	-	-	-

Analysis of the cotton oil

Oil and cake constitute the essential by-products of cotton seeds. According to Jones (1981), the kneading of ground seeds would give 45% of cake, 25% of hulls and 16% of oil. Sauvant *et al*. (1994) have reported that one ton of cotton seeds supplies approximately 200 kg of oil, 300 kg of hulls and 500 kg of cake. The chemical composition of the by-products of the cotton seeds varies as it is the whole seed, the cotton nut, or the cake. The nutritive content depend more on the extraction method of the oil (Nagalakshmi *et al.*, 2007), on the proportion of downs and linters (Lennerts, 1988) and on the level of dehulling of the seeds (Balogun *et al.*, 1990).

Chemical composition

Cotton oil is the reference standard mostly used in tests evaluating the taste and the odor of other edible oils. According to nutritionists, dietetically ideal oil is constituted of one third of saturated fatty acids, one third of monounsaturated fatty acids and one third of polyunsaturated fatty acids (Pascal, 1996). The cotton oil is closest to this composition (table 2).

Table 2: Fatty acid composition of different edible oils of common use (Pascal, 1996)

Oils	SFA (%)	MFA (%)	PFA (%)
Cotton	22	23	55
Palm	50	40	10
Soya	15	25	60
Colza	8	62	30
Groundnut	20	59	21

SFA: Saturated Fatty Acids; MFA: Monounsaturated Fatty Acids; PFA: Polyunsaturated fatty acids

On the other hand, the high proportion of oleic acid, palmitic acid and stearic acid give the cotton oil certain stability (Pascal, 1996). It should also be noticed that the cotton oil without gossypol presented after refining a pleasant taste and a satisfactory polyunsaturated fatty acids composition on the nutritional aspect (Ketekou, 1985). It is particularly rich in linoleic acid (figure 1).

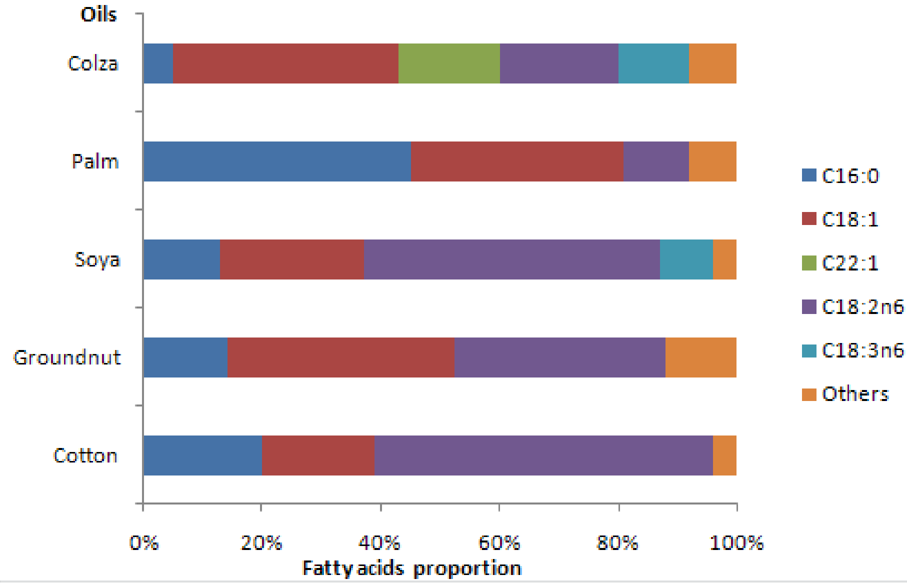

Figure 1: Fatty acids composition of main edible oils (Sontag, 1979)

Finally, cotton oil is rich in tocopherols which are natural antioxidants assuring its stability and its long term preservation. This high vitamin E content (α-tocopherol) made this oil a potential dietary asset.

The gossypol

Gossypol ($C_{30}H_{30}O_8$) is a product of the metabolism of the plants of the kind Gossipium which possesses an intrinsic toxicity and decreases the biological value of proteins (Ojewola *et al.*, 2005). It is also obtained from the bark of *Thephesia populnea* which, as the cotton plant, is a shrub of the family of malvaceae (Dao *et al.*, 2002).

From a chemical point of view, gossypol is a low and easily oxidable acid (Botsoglou and Spais, 1992), liposoluble and of chemical formula 1,1', 6,6'7,7'-hexahydroxy-5,5'-diisopropry 1-3,3'-diméthyl- [2,2' – binaphtalène] -8,8'-dicarboxaldéhyde (figure 2).

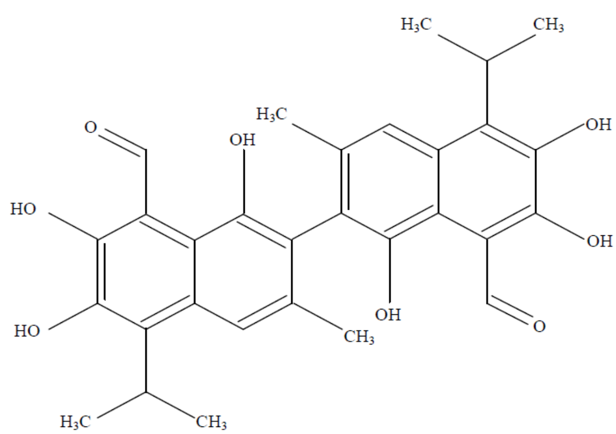

Figure 2: Flat structure of the molecule of gossypol (Dao *et al*., 2002)

Gossypol is contained in the glands present in all the parts of the cotton plant (leaves, stalks, roots and seeds) and enables to distinguish the varieties with glands (glanded) from varieties without glands (glandless). During the extraction of oil, the break of glands permit the aldehydes groups of the gossypol to form stables imines links (bases of Schiff) with the free amine groups of proteins and specially those of the lysine, as such giving a bound gossypol which is not absorbed in the digestive tract (Wen-ju *et al*., 2006).

The works that have been conducted to eliminate the « free-gossypol » and improve the nutritional value of the rations were based on diverse physical, chemical or biological treatments such as solvent extraction processes of oil during mixing, the supplementation in amino acids or in vitamins and vegetable improvement for the obtaining of varieties « glandless ».

Uses

In human and animal feeding

From a food point of view, cotton oil is used in culinary recipes, in deep frying (doughnuts, croquettes) and in traditional pastry. From the mixing of the cotton seed, emerged 17% of edible oil, 55% of coproducts (residues of the cotton seed for cattle food, essentially used for the production for food proteins for cattle) and 1% of waste. These cotton cakes take on a major importance in the zone where conflicts between shepherds and breeders are aggravated by the lack of pasture.

In the craft sector

At the craft level, cotton fibers enter the making of fabrics (leppi) and household furniture (tapestry, pillows) by weavers. At the industrial level, cotton fibers are used in the manufacturing of fabrics (Wax) in the brilliant designs and colors which remind us of the African tradition. The by-products of the cotton factory enter the manufacturing of soap (soapstock) and cosmetics. The rest is consumed in the form of energy during the process of kneading (Kapseu, 2009).

As biofuel

Beside its food and craft uses, two major ways can be considered by the producing countries:

- the use in the short circuit of auto-consumption;
- the use as « national » fuel, notably for transport

The short circuit of auto-consumption concerns small producers and cotton companies: the first ones to have access to a substitute of the fuel, the second to relieve an increasing oil bill (table 3). The natural cotton oil stemming from traditional extraction processes is directly usable pure or in mixture with some fuel in certain diesel engines covering the range of power from 5 to 100 kW.

As « national » fuel, that is to say, a biofuel used pure or in mixture, in a way trivialized by users « non captives », cotton oil must be adapted to the technical constraints of market diesel engines. Indeed, straight vegetable oil should respect some specifications in order not to damage the diesel engines (Blin *et al.*, 2013).

Direct fuel injection engines do not accept natural vegetable oil. It is generally by etherification that vegetable oils are transformed into fuels, collectively called Biodiesel, respecting the specifications of fuels and gasoline.

Table 3: Cotton oil uses as fuel (Vaitilingom, 2006)

Utilizations	Users	Characteristics	Types of engines
Short circuit of auto-consumption	-Small producers -Cotton companies	Pure or in mixture with fuel	Power from 5 to 100 kW
National fuel (for transport)	-Non captives -Transporters	-Etherification to obtain biodiesel -Mixtures of biodiesels/diesels	Technical constraints of the market diesel engines
Combustible	Burners	Less constrainable	Less constrainable

Cotton oil can be etherified thanks to some imported methanol or ethanol of sugar cane. It is possible to produce a « national » biofuel usable in mixture or pure, in substitution of petroleum products for diesels given that the zones of sugar cane and cotton zones are close. This is more interesting due to the fact that carbon dioxide (CO_2) emissions decreased at all loads for fuel blends (Senthilraja *et al.*, 2016).

Added to its use in engines, it is also necessary to note the possibility of use as combustible for burners. This use is being developed in Europe for drying of agricultural products or for collective and domestic heating thanks to the appearance of adapted burners because of the fact that it is less constrainable in terms of adaptation equipment.

Natural vegetable oils are fuel and gasoline substitutes provided that engines or burners are specially adapted (Vaitilingom, 2006). However, it is important to underline that it can be done in any reversible way. The modifications always allow the use of the pure petroleum products as well as in mixture with vegetable oil.

Table 4 compares diesel « fuel » characteristics with those of cotton oil. A more elevated viscosity for oil is noticed whereas its calorific power is slightly lower. However, the density that is lightly higher corrects the energetic deficit of the volume of the injected fuel and may enable the cotton oil to attain the equivalent performances to that of diesel combustible.

Table 4: Energetic characteristics of cotton oil (Vaitilingom, 2006; Chirat (2007)

Designation	Element	Cotton oil	Diesel
Fuel characteristics	Density at 20^{o}C	0,921	0,836
	Viscosity at 20 ^{o}C (mm^2/s)	73	3 to 7,5
	Flowing point (^{o}C)	– 2	–18
	Trouble point (^{o}C)	– 1	< – 5
	Flash point (^{o}C)	243	93
	Cetane degree	34	50

Calorific power (MJ/kg)	36,8	43,8

Conclusion

The bibliographical review on the production, analysis and uses of cotton oil in tropical Africa is very diversified. Cotton oil is essentially produced in C-4 countries. It is used for human and animal consumption in almost all the producing countries, and like fuel in West Africa. It could be noticed that much work still has to be done in Africa to ameliorate the production of vegetable oils in terms of quantity and quality. Many difficulties contribute to retard the advancement of research on cotton oil, which are, the lack of collaboration among researchers, the lack of funds, the lack of a real government policy on the research in most African countries. It should be noted that these difficulties are found in whatever the using conditions of this vegetable oil.

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