NOTA TÉCNICA

ÓLEO DE MAMONA COMO COMBUSTÍVEL: FATOS, PERSPECTIVAS E RISCOS.

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RESUMO

O óleo de mamona é uma matéria prima de grande demanda pela indústria farmacêutica e química. Mais que isto, atualmente, em vários países do hemisfério sul, Brasil inclusive, vem sendo usado como combustível (bio-diesel) e sua produção vem ganhando espaço também em discussões concernentes aos aspectos sociais e ecológicos relacionados com sua utilização. Algumas propriedades físicas e químicas, em particular a alta viscosidade e elevado teor de água, torna complicado o uso do óleo de mamona como combustível nos motores de combustão interna. Melhores perspectivas de sua utilização estão associadas a transesterificacao dele, e adição deste bio-diesel ao diesel oriundo do petróleo. Isto, todavia, sinaliza a necessidade de se produzir o óleo de mamona a preços consideravelmente menores do que os que se praticam atualmente no mercado mundial.

Palavras-chave: óleo de mamona, bio-diesel.

ABSTRACT

CASTOR OIL AS A FUEL: FACTS, PERSPECTIVES AND RISKS

Castor oil is more than just a raw material in great demand by the pharmaceutical and chemical industries. In several southern hemisphere countries, including Brazil, it is being used as a bio-fuel. Its large scale production is being discussed in conjunction with social and ecological aspects. Some of its properties, especially extremely high viscosity and high water content, complicate use of castor oil as fuel for internal combustion engines. Better perspective of its utilization as fuel may be possible through transesterification and addition to petroleum derived diesel. This also suggests that there is demand to produce castor oil at considerably lower than the prevailing ones in the world market.

Keywords: castor oil, bio-diesel.

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INTRODUCTION

The European Union has set clear goals for renewable energy by the year 2010: 12% of renewable energy in gross domestic energy consumption, being 22% green electricity, and 6 % bio-fuels (Boxberger et al., 2006).

Brazilian government in 2004, on the other hand, approved a vegetal oil programme focusing on poverty alleviation, environmental protection, and energy from renewable sources. The program intends to encourage bio-fuel use and also considerably reduce taxes for small producers. The new program is estimated to create jobs for about 250,000 farm families. It is expected that in the near future, the cultivation of oil palms in the Northern and castor (*Ricinus communis L*), in the North-eastern regions of Brazil will be subsidised and politically encouraged. This article attempts to analyse the suitability of castor oil as a fuel and its chances of becoming a new commodity for fuel or other purposes in national and world markets.

MATERIAL AND METHODS

The paper is based on a study commissioned by the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH (Scholz, 2005). Data regarding physical and chemical properties, handling, and world market of castor oil were collected and analysed. These informations also pointed out several aspects related castor oil use as a fuel for internal combustion engines.

RESULTS AND DISCUSSIONS

Production: Castor (castor bean, castor oil plant, ricin, higuerilla, mamona, mamoeira, palma christi) is a member of the tropical spurge family (*Euphorbiaceae*) and nowadays can be found, naturalised and cultivated, in all temperate countries of the world. Seeds of this plant were found in Egyptian graves of about 4000 B.C. Originally castor is a tree or shrub that can grow to height of over 10 m in about four years. The cultivated annual varieties grow to a height of 60 to 120 cm in a year, while in perennial cultivation it grows to several meters (Figure 1).

Castor grows in the humid tropics to the sub-tropical dry zones (optimal precipitation 750 to 1000 mm, temperature 15 to 38 °C) and can be cultivated in Southern Europe (Scholz, 2005).

Harvesting castor capsules is fairly complex. In manual harvesting the ripe fruits (moisture content < 45%) are selectively cut, and the capsules are then removed by hand or by a picker. Due to the varying stages of seed maturity up to five separated harvests may be necessary. In mechanical harvesting, modified combine harvesters are normally used, which partially separate the immature capsules. In this case, the plants must be leafless, which may require the use of defoliants. Since the seeds are very poisonous, caution is needed during harvesting and processing: only 0.18 g per kg of body mass can result in death. Special attention should be given to children due to the pleasant taste of the poisonous seeds.

Castor seeds are generally cleaned and sorted by machines and the oil is extracted by pressing the seeds, one to three times. During cold pressing, which is preferred for pharmaceutical and cosmetic use, the oil yield is 30 to 36% of the seed mass. Warm pressing (> 70 °C) yields about 38 to 48%. The remaining oil, to a large extent, can be extracted by solvents. Good processing leaves behind only 1 to 2% of the oil in the pressed cake (Rehm, S. et al., 1984).

At present the castor seed yield in Brazil is about 0.9 t/ha compared to the world average of about 1.1 t/ha. Yields of 4 to 5 t/ha can be obtained under very favourable conditions (FAO, 2005). The bean shaped seeds usually contain 40 to 55% oil. With a mean oil content of 47% and mean estimated extraction efficiency of 90%, the world average oil yield is, therefore, is around 460 kg/ha, although a maximum yield of 2000 kg/ha. It may be possible (FRANKE, 1994). Thus castor is among plants with highest oil yield potential.

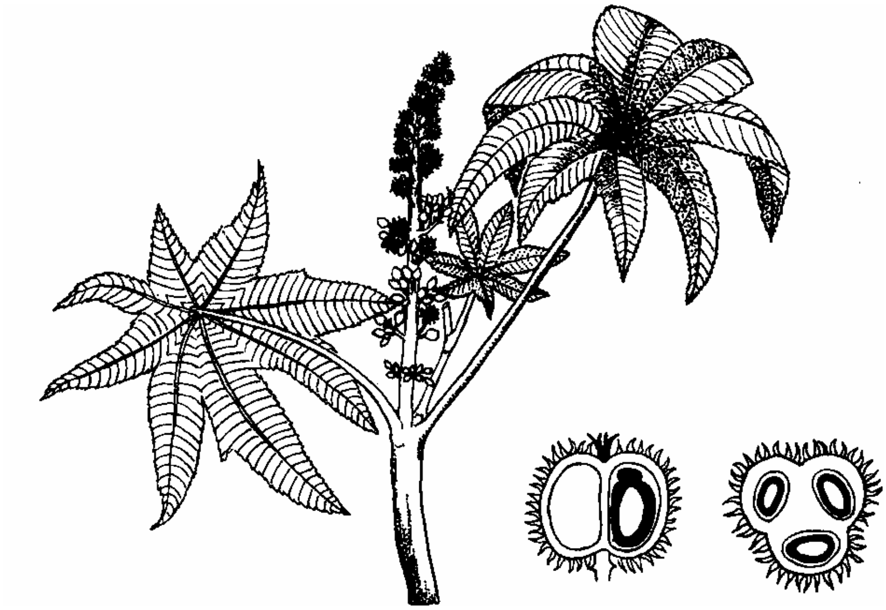

Figure 1. Castor shoot with blossom stand as well as a longitudinal and a cross section of a capsule (FRANKE, 1994).

World market: The share of castor seed is less than 0.15% of total world trade of oil seeds. For this reason, *Oil World*, a well known vegetable oil statistics journal, notify the production, trade and consumption data as foot notes (Scholz, 2005). At present, the annual world yield of castor seeds is about 1.3 million tonnes, which corresponds to about 0.55 million tonnes of castor oil. Since the beginning of the 1970's, castor oil seed production increased continuously but, in some cases, subjected to yearly fluctuations of 20%, especially due to storm damage in the main producing regions.

About half of all the castor oil produced in the world is exported, with India dominating the market with a share of 80%. Presently, India produces over 90% of the entire world castor oil. The prices of castor oil vary considerably due to fluctuations in production and also due to speculation. The average price in the last decade was about 900 US$/t, which is almost twice the price of rapeseed oil in Germany (Figure 2).

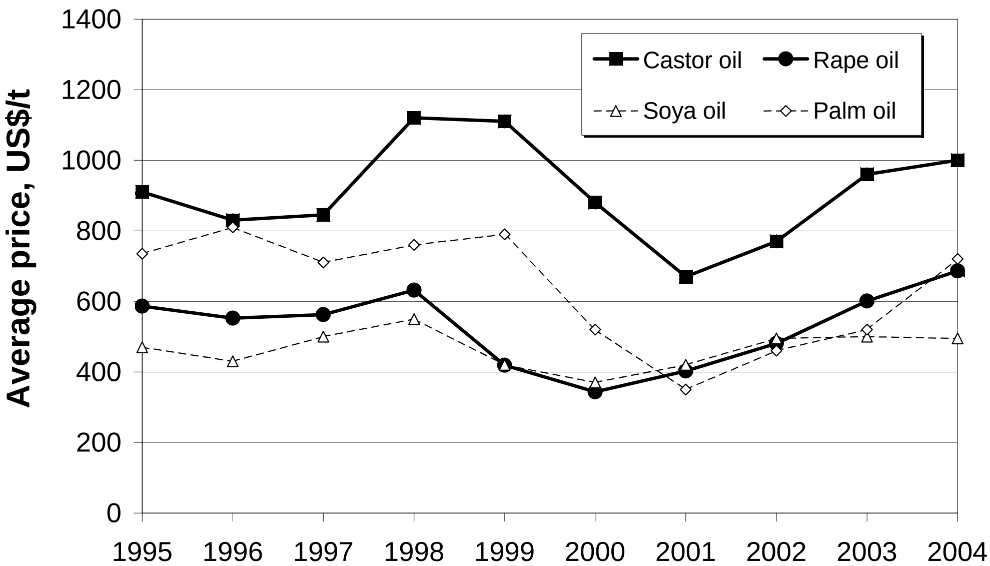

Figure 2. Price trend of castor oil and other vegetable oils in Germany.

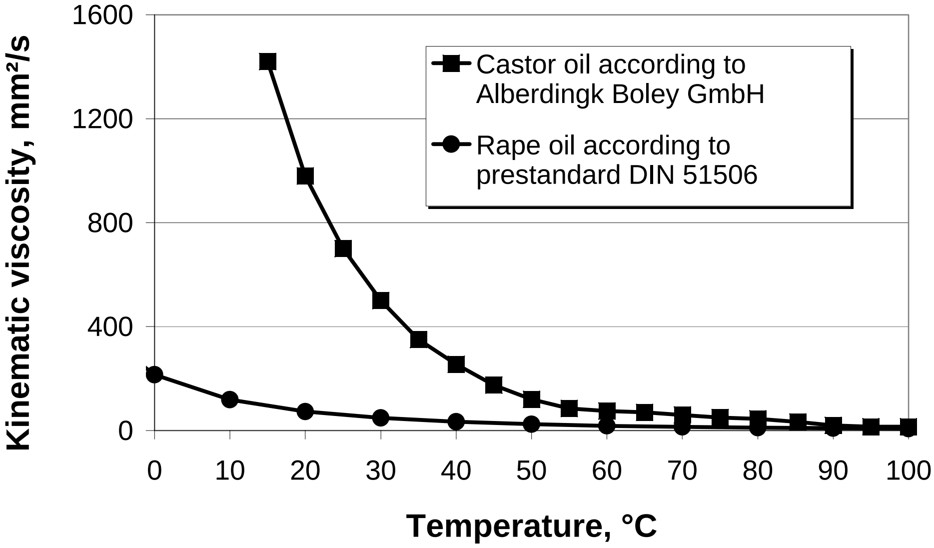

Figure 3. Kinematic viscosity of castor and rapeseed oil versus temperature.

Properties: Castor oil provides a yellow-green to yellow-brown, odourless, viscous, non drying oil which in its natural state initially has a mild but later an unpleasant taste, which can also be clear on processing. As opposed to other vegetable oils it is characterised by its indigestibility, solubility in alcohol, high hygroscopicity and extraordinarily high viscosity as well as by its high proportion of polyunsaturated fatty acids. A comparatively high proportion of unsaturated fatty acids are found only in HO (High Oleic) oil of sunflower. With an iodine number of less than 90, castor oil is a non drying oil. Airtight long storage presents no problems (SCHOLZ, 2005). The chemical-technical demands of castor oil used as a raw material in the chemical industries are defined by the ICOA standard (ICOA, 2003) and by the (DIN 55939, 1992/1999)

Regarding the fuel related properties, the high calorific value and the high cetane number are of advantage along with the low phosphorus content and carbon residues. However, a considerable higher viscosity at temperatures under 50 °C, and possibly also a higher compressibility, compared to other vegetable oils can be disadvantage (Figure 3), which may cause problems at extraction and injection. A further disadvantage is its hygroscopicity, resulting in relatively high water content and thereby resulting in algal growth, filtration and corrosion problems. Castor oil is also characterised by its extraordinary oxidative and low-temperature stability. The table 1 compares the most important fuel-related characteristic values of commercial castor oil to the limits of the pre-standard DIN 51605 for rapeseed oil fuels. This comparison is only partially admissible, since the rule, strictly speaking, applies only to rapeseed oil.

Up date only few studies have been done on the use of castor oil in diesel engines. At the beginning of the 1990's castor oil was tested for engines in a laboratory in Thuringia, Germany. But due to the cost of the oil, more precisely, the lack of cost effectiveness of castor cultivation and oil extraction, these experiments were discontinued in Germany. A careful assessment, based on these studies, suggests that castor oil may be suitable for the vegetable oil- compatible engines (KAMPMANN, 2005). Initial experiences with a CHP plant in a Brazilian rain forest village appear to confirm it (BOXBERGER, 2006). It should be, however, taken into account that sometimes even rapeseed oil causes difficulties in engines modified for vegetal oil fuel.

Table 1. Fuel specific properties of castor oil and rapeseed oil

Properties Contents	Unit	Rapeseed oil (DIN 51605, 2005)	Castor oil According to various sources (Scholz, 2005)
Density (15 °C)	$Kg.m^{-3}$	900 ... 930	950 ... 974
Ignition temperature by P.-M.	°C	> 220	229 ... 260
Kinematic viscosity (40 °C)	$mm^2.s^{-1}$	< 36	240 ... 300
Net calorific value	$MJ.kg^{-1}$	> 36.0	37.2 ... 39.5
Flammability (Cetane number)	-	> 39	42
Carbon residue	mass%	< 0.40	0.22
Iodine number	$g.100\ g^{-1}$	95 ... 125	82 ... 90
Sulphur content	$mg.kg^{-1}$	< 10	10
Overall contamination	$mg.kg^{-1}$	< 24	ca. 10
Neutralisation value	$mgKOH.g^{-1}$	< 2.0	1.0 ... 4.0
Oxidative stability (110 °C)	H	> 6.0	95
Phosphorus content	$mg.kg^{-1}$	< 12	< 4
Total content of Mg and Ca	$mg.kg^{-1}$	< 20	-
Ash content	mass%	< 0.01	< 0.01
Water content (w.b.)	mass%	< 0.075	0.15 ... 0.30

CONCLUSIONS

Castor is an undemanding oil plant which grows well in tropical climates and has high oil yields, but requires a large amount of hand labour. Therefore, it is suitable for the small scale farming structures in the north-eastern Brazil. It can help improve the living conditions of small farmers as well as supply eco-friendly energy for multiple purposes.

However, new markets or utilization strategies are not acquired. The trade and export of castor oil may cause problems because of the relative stability in the world market and also because of high price it will hardly replace other vegetable oils, such as rapeseed oil, which are also suitable as fuel. Several properties, particularly extremely high viscosity and the water content also considerably complicate the use of castor oil as fuel in engines. Without the development of special engines, a sustainable turnover is therefore hardly to be expected soon, even in Brazil.

Despite the unfavourable engine-related technical properties of castor oil, it perhaps is possible to create a methyl or ethyl ester by transesterification, which can be added to diesel fuel in small proportions. In Brazil this is being investigated on a semi technical scale and encouraged, amongst other things, by a new law which stipulates a bio-diesel admixture of 2% in 2008, and 5% by 2013.

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