Porcine Research

Old and new perspectives of using pork fat

[1]F. Camelia Oroian, [2,3,4]I. Valentin Petrescu-Mag

[1] University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Faculty of Horticulture, Romania; [2] SC Bioflux SRL, Cluj-Napoca, Romania; [3] University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Faculty of Agriculture; [4] University of Oradea, Oradea, Romania.
Corresponding author: I. V. Petrescu-Mag, zoobiomag2004@yahoo.com

Abstract. In some countries, pork fat production is sometimes much higher than the market demand. Therefore, another use of this product is mandatory in order to maximize the profit of the pig farming. This paper aims to summarize the most important alternatives to use of the pork fat for human consumption: soap production and fuel production.
Key Words: pork lard, fat use, soap, biodiesel, cooking.

Introduction. Lard is pork fat in both its rendered and unrendered forms. It is obtained from any part of the pig where there is a large proportion of adipose tissue. It can be then transformed by thermal treatment to fats with various aspects.

In some countries such as West- and Central European countries, United States of America (USA) etc, pork fat production is sometimes much higher than the market demand. Therefore, another use of this product is mandatory in order to maximize the profit of the pig farming. This paper aims to summarize the most important alternatives to use of the pork fat for human consumption: soap production and biodiesel production.

Soap Production from Pork Fat. Lard makes a very mild, conditioning soap that is good for human skin. Compared to commercial soaps, where the glycerin is removed and sold as a separate by-product, homemade soap retains the glycerine, which is very moisturizing (Figure 1).

Figure 1. Homemade soap
(http://jurnalulph.ro/images/stories/2014/septembrie/26/reteta4.jpg).

Home made soap production from pork fat involves the use of three basic compounds: pork fat, water, and caustic soda. In addition to pork fats, another type of fats can be added, including vegetal oils. Perfume addition is not mandatory; nevertheless, some people do not tolerate well perfumes or other odorizing substances. Some manufacturers add to the mixture some natural pigments or dyes, and botanicals for specialty soaps.

Soap can be made by using either the cold or hot process. There is very little difference between the two processes except that the soap is cooked after the combining fat with caustic soda in the hot process, whereas in the cold process, the fat is heated initially, but then there is no further cooking. Different soap making recipes can be found on the internet.

Biodiesel Production. Animal fat as a source for biodiesel production is a recent trend in countries such as the USA, but also in other parts of the world. About 1/3 of the oils and fats produced in the USA are fats of animal sources, including pork lard, beef tallow, and hen fat. Fats of animal sources are attractive feedstocks for biodiesel due to the fact their cost is considerably lower than the cost of vegetable fats and oils. This is mainly due to the fact the market for animal fat is incomparably more limited than the market for vegetable oil since much of the animal fat produced in the USA isn't considered edible by people (Extension.org 2014).

Animal fat is currently added to pet food and animal feed, and used for industrial purposes such as soap production for instance. From the same reasons, another large part of the domestic animal fat supply is exported by the USA.

Animal fat feedstocks can be made into high-quality biodiesel that meets the ASTM specifications for biodiesel. However, as we shall see, there are several challenges and drawbacks to using animal fat feedstocks (Extension.org 2014).

Fatty Acid Content of Fats of Animal Origin. Animal fat is generally highly saturated, which means that the animal fat solidifies at a relatively high temperature (Yori et al 2006; Kazancev et al 2006; Demirbas & Karslioglu 2007). For this reason, biodiesel made from animal fat has a high cloud point. For instance, biodiesel made from pork lard and beef tallow have a cloud point in the range of 12.78°C to 15.56°C. Pure biodiesel, B100, made from animal fat should only be used in a hot climate. However, animal fat biodiesel can be mixed with petrodiesel. At lower blends such as B5 (a blend of 95% petrodiesel and 5% biodiesel), the high cloud point of the animal fat biodiesel does not have much effect on the cloud point of the mixture (Extension.org 2014).

The fatty acid profile of various animal fats is indicated in Table 1. Data presented in the table show the saturation degree of the fat, which in turn determines how readily it will solidify as the temperature decreases (Extension.org 2014).

Table 1

Fatty acid percentages in beef tallow, pork lard and chicken fat (Extension.org 2014)

Fatty acid	*Beef tallow*	*Pork lard**	*Chicken fat*
Myristic 14:0	1.4 - 6.3	0.5 – 2.5	1
Palmitic 16:0	20 - 37	20 – 32	25
Palmitoleic 16:1	0.7 – 8.8	1.7 – 5	8
Stearic 18:0	6 – 40	5 – 24	6
Oleic 18:1	26 – 50	35 – 62	41
Linoleic 18:2	0.5 - 5	3 – 16	18

*There are some exceptions. Several rustic swine breeds show a slightly different fatty acid profile (Botha et al 2014).

Pork lard and beef tallow are typically about 40% saturated (sum of myristic, palmitic and stearic acids more exactly). Chicken fat is lower, at about 32% saturated fat. For comparison, soybean oil is about 14% saturated and canola oil is only 6%. There are many vegetal oils which have less than 5% saturated fat, but they are expensive and consequently not suitable for biodiesel production. Thus, lard and tallow are solid at room temperature and chicken fat, while usually still liquid, is rather viscous and nearly solid (Extension.org 2014).

The methyl esters of the saturated fatty acids, mainly methyl stearate and methyl palmitate, have high melting points and therefore the whole compound has a high melting point. When the animal fat is transformed into biodiesel, the concern about solidification at lower temperatures continues (Extension.org 2014). In fact, this is the most important drawback of animal fat biodiesel production.

Animal Fats Processing*.* Fat processing is approached differently, but it is generally based on the same principles. Raw fat and waste fat from animal carcasses are removed and then made into oil using a rendering process. Rendering consists of grinding the animal by-products to a fine texture and heating them until the liquid fat separates from solids and pathogens are killed. The solid matter is usually passed through a screw press to complete the removal of the fat from the solid residue. The heating process also eliminates water, which makes the fat and solid material stable against rancidity. The final products are fat, and a high-protein feed additive known as "meat and bone meal" (Extension.org 2014).

Cetane Number*.* Cetane number (CN) or cetane rating is an indicator of the speed of combustion of diesel fuel and compression needed for ignition. The CN is an important factor in determining the quality of diesel fuel. It is an inverse of the similar octane rating for gasoline (Dabelstein et al 2007). Feedstocks of animal fat result in biodiesel with a high CN, which is a very important parameter of quality for diesel fuels. This is an advantage in favor of using animal fat for biodiesel fuel production. The saturated fatty acids are the source of this high CN and values of more than 60 are common for this type of oil. The other categories, soybean oil based biodiesel usually has a CN of around 50 and petroleum-based diesel fuel is usually 40-44. When animal fat biodiesel is blended with petrodiesel, the high CN can help the engine start more rapidly and run more quietly (Extension.org 2014).

Oxidative Stability of Biodiesel of Animal Origin. According to scientific evidence, the saturated fatty acids we have in animal fats should contribute to better oxidative stability for biodiesel. Theoretically, the alteration of fat is directly correlated with the content of unsaturated fatty acids. Animal fats contain very little of the polyunsaturated fatty acids, such as linolenic acid and linoleic acid, that make the most vegetable fats such as soybean oil and linseed oil so prone to rancidity (Extension.org 2014).

However, the practice shows that animal fat is not always more stable than vegetable oil, and this because vegetable oils often contain natural antioxidants. For example, a test of the peroxide content of lard and vegetable oil made by Stuckey (1972) showed that the pork lard experienced oxidation at higher a rate than the vegetable oil.

Animal fat contains very little of the natural antioxidants such as vitamin E that protect vegetable oils against oxidation. In some situations, used cooking oils may also contain artificial antioxidants that are added to oil to expand their life, and these artificial anti-oxidants can, in turn, expand the life of biodiesel made from used cooking oil (Extension.org 2014).

Lower NOx Emissions. One of the important attributes of biodiesel *lato sensu* is that it decreases the levels of harmful pollutants in the exhaust of diesel engines. One exception to this is oxides of nitrogen (NOx), substances which are involved in ozone and smog creation. Biodiesel tends to emit slightly more NOx than petrodiesel. Many reasons have been given by various authors for such an increase in NOx (see especially the paper of Tat et al 2007) and there is still considerable controversy on this topic (Extension.org 2014).

However, it has been indicated that biodiesel from animal fats tends to produce a smaller pollution with NOx and in some situations no increase of NOx (McCormick et al 2001). The most important reason for this fact, as we already discussed above, is probably that animal fat biodiesel has a high cetane number (>60) compared with vegetable oil biodiesel, which has a cetane number of 48-55. Higher cetane number is believed to decrease the NOx by lowering temperatures during the critical early part of the process of combustion (Extension.org 2014).

High Sulfur Content. Besides the advantages, in any case, there are also disadvantages. A notable drawback of animal fat biodiesel is the sulfur content, which can sometimes be a problem. Biodiesel sold for on-highway use is only allowed to contain maximum 15 ppm of sulfur. Some animal biodiesel of beef tallow have been shown to contain more than 100 ppm of sulfur and chicken fat biodiesel frequently contains a similar level. The sulfur seems to originate from sulfur-containing amino acids associated with proteins that carry over from the rendering process (Extension.org 2014).

Measurements of the sulfur levels in biodiesel produced from animal fats have shown that the sulfur level usually decreases by about half when the conversion takes place. However, the remaining sulfur can be difficult to eliminate. Vacuum distillation is about the only reliable technique for eliminating this sulfur (Extension.org 2014).

As an alternative measure of marketing, biodiesel high in sulfur can be sold for non-highway utilization, such as fuel for boilers or heaters (Extension.org 2014).

In-situ Pyrogenic Production of Biodiesel from Swine Fat. Obtaining homogeneous and purified fatty raw pig fat for the production of biodiesel involves a number of industrial processes. Over time, these have evolved considerably.

In-situ production of fatty acid methyl esters from swine fat via thermally induced pseudo-catalytic transesterification on silica was investigated by Lee et al (2006). Their research is synthetically presented below.

Instead of methanol, DMC (dimethyl carbonate) was used as acyl acceptor to achieve environmental benefits and economic viability. A thermogravimetric analysis of swine fat indicated that it contained 19.57 wt% of water and as well other impurities. Moreover, the fatty acid profiles obtained under various conditions (extracted swine oil+DMC+pseudo-catalytic, extracted swine oil+methanol+NaOH, and swine fat+DMC+pseudo-catalytic) were compared. These profiles were identical, showing that the introduced in-situ transesterification is technically feasible. This fact also suggests that in-situ pseudo-catalytic transesterification has a high tolerance against various impurities. This study also shows that FAME yield via in-situ pseudo-catalytic transesterification of swine fat reached up to 97.2% at a temperature of 380°C (Lee et al 2016).

As science evolves, more and more efficient techniques for producing biodiesel from pork lard will be available.

Using Pork Lard for Cooking. The case of Romania. In some countries, unlike the United States, pork bacon or even pork lard is consumed intensely by the population (Figure 2). In such countries, pork lard is used sometimes as a substitute for butter, oil, or margarine in cooking (see the cookies called "cornuleţe", Figure 3). This is the case of Romania, for example. Moreover, there is in Romania a traditional food that consists of rustic bread, pork lard, and onion (Figure 4). Another well known Romanian traditional food produced from pork fat is "jumări" (pieces of fried pork fat) (Figure 5) (Nedita et al 2017). For this reason, in such countries we can still find many fat swine breeds (Oroian & Petrescu-Mag 2014; Suteu 2011). On the other hand, besides using pork fat as food, or for cooking, the surplus of pork fat can be a good source of fat for soap production or biodiesel production.

Figure 2. Two sorts of bacon: "slănină cu boia" (chili bacon – left), and "slănină afumată" (smoked bacon – right).

Figure 3. Cookies with marmelade ("cornuleţe") (www.gustos.ro/assets/recipes_images/2013/11/27/201421/tn4_591352108203_1_1.jpg).

Figure 4. A well known Romanian traditional food: rustic bread, pork lard, and onion (http://assets.sport.ro/assets/foodstory/2015/12/01/image_galleries/6254/de-1-decembrie-gatim-romaneste-meniu-complet-ca-n-ardeal-oltenia-si-moldova_2_1_size1.jpg).

Figure 5. "Jumări" (pieces of fried pork fat) (http://4.bp.blogspot.com/-GtrLwCwb76g/TuOfXI3z00I/AAAAAAAAABYM/YEI8uhZf6r4/s1600/jumari+005.jpg).

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Authors:

Firuţa Camelia Oroian, University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Faculty of Horticulture, 3-5 Calea Mănăştur Street, Cluj-Napoca 400372, Romania, e-mail: camtod@yahoo.com

Ioan Valentin Petrescu-Mag, University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Faculty of Agriculture, 3-5 Calea Mănăştur Street, Cluj-Napoca 400372, Romania, e-mail: zoobiomag2004@yahoo.com

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