

Study of the Stability of Beef Tallow at High Temperatures and Comparison with Other Fatty Materials

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Abstract: Beef tallow is a byproduct of the slaughter industry. As a consequence, meat producer countries obtain a high amount of this low value-added fatty material. In Uruguay, it is generally used for food purposes or for biodiesel production. Globally, around half of the beef tallow produced worldwide is used for the manufacturing of food. To the best of our knowledge there are no published studies concerning the stability of beef tallow when exposed to high temperatures. The aim of this work was to study some Uruguayan beef tallow brands and compare its stability with that of the most frequently used frying oils in Uruguay (sunflower high oleic, rice bran and sunflower oil) to assess its suitability for frying. Stability was assessed by the oxidative stability index and thermoxidation in absence of food. Even though beef tallow's inherent stability indicated that it should be highly stable to oxidation, the majority of the analyzed samples exhibited a similar or lower stability than sunflower high oleic. This might be explained by a different composition in pro-oxidants and/or antioxidants between the beef tallows and the oils. According to the thermoxidation assays, which are carried out in similar conditions to those of a frying process, three of the beef tallow samples, sunflower high oleic and rice bran oil would be similarly suitable for frying, while sunflower oil and the other two samples of beef tallow evidenced a lower thermoxidative stability, thus not being recommended for this use.

Key words: Beef tallow, stability, thermoxidation, high temperatures, frying, oil.

1. Introduction

In Uruguay, in 2005, beef tallow represented 73% of the fats and oils production [1]. This fatty material is a byproduct of the slaughter industry. As a consequence, a high amount of low value-added beef tallow is obtained, which is used for food purposes or biodiesel production. Globally, around half of the beef tallow produced worldwide is used for the manufacturing of food [1].

In most countries, the use of beef tallow as a frying medium is not usual, as the majority of the frying operations are performed with vegetable oils. However, given its fatty acid composition (high content of saturated and low content of polyunsaturated fatty acids) [1], it should have good stability at high temperatures. Therefore, it would be,

from this point of view, a good choice as frying medium. Besides, from a sensory point of view, it provides a very different flavor from that of vegetable oils.

To the best of our knowledge, there are no published studies concerning the stability of beef tallow when exposed to high temperatures. The aim of this work was to study some Uruguayan beef tallow brands and compare its stability with that of the most frequently used frying oils in Uruguay, to assess its suitability for this operation.

2. Materials and Methods

Five samples of different commercial brands of beef tallow (BT1, BT2, BT3, BT4 and BT5) and three samples of different vegetable oils (sunflower (S), rice bran (RB) and sunflower high oleic (SHO)) were studied. The chosen oils are the most frequently used

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in Uruguay for food frying.

Stability was assessed by the Oxidative Stability Index (OSI) at 110.0 ± 1.0 °C (OSI time) [2] and thermoxidation in absence of food. The latter studies were also carried out in a OSI equipment (OSI-8, Omnion) but at 180.0 ± 1.0 °C and leaving the tubes opened without bubbling. Conditions of strict control of temperature, time and rate surface/volume were employed. Given the high thermoxidative stability expected for some of the fatty materials, samples were taken at 0, 10, 20, 30 and 40 h of thermoxidation. These samples were stocked at freezing temperatures until the performance of the analyses. Both initial and thermoxidized samples were analyzed for total polar compounds' content [3].

The composition in fatty acids of the initial samples was determined by column gas chromatography [2], being the oil previously derivatized to methyl esters of the fatty acids [2]. These samples were also analyzed for peroxide value [2], *p*-anisidine value [2] and free fatty acids [3].

3. Results and Discussion

The results from the analysis of composition in fatty acids that are shown in Fig. 1 are in accordance with bibliography [1, 4]. All beef tallow samples present very similar amounts of saturated, monounsaturated and polyunsaturated fatty acids. On

the other hand, Fig. 2 evinces that the studied oils do present important differences between each other and with the beef tallow samples. This gives rise to considerably different inherent stability values (Table 1). Even though the performance of a fatty material at high temperatures depends on various factors, taking into account only the inherent stability, beef tallow is expected to be the most stable material, followed by sunflower high oleic oil, rice bran oil and finally sunflower oil.

Uruguayan regulation parameters and threshold values to assess fitness for human consumption of fatty materials are peroxide value (maximum 10 meq/kg of sample) and free fatty acids (maximum 0.5% for refined beef tallow, 1.0% for virgin beef tallow and 0.3% for the refined vegetable oils employed in this study). The fatty materials' initial quality analysis, presented in Table 2, reveals that all the parameters included in the current Uruguayan regulation were within the established thresholds, except for the free fatty acids' values of samples BT1 and BT3. These samples also showed comparatively higher *p*-anisidine and total polar compounds' values than the other samples of beef tallow. Even though the high value of total polar compounds is probably, at least partly, owing to the high amount of free fatty acids, all these results indicate a low initial quality of these two brands. This could be attributed to failures

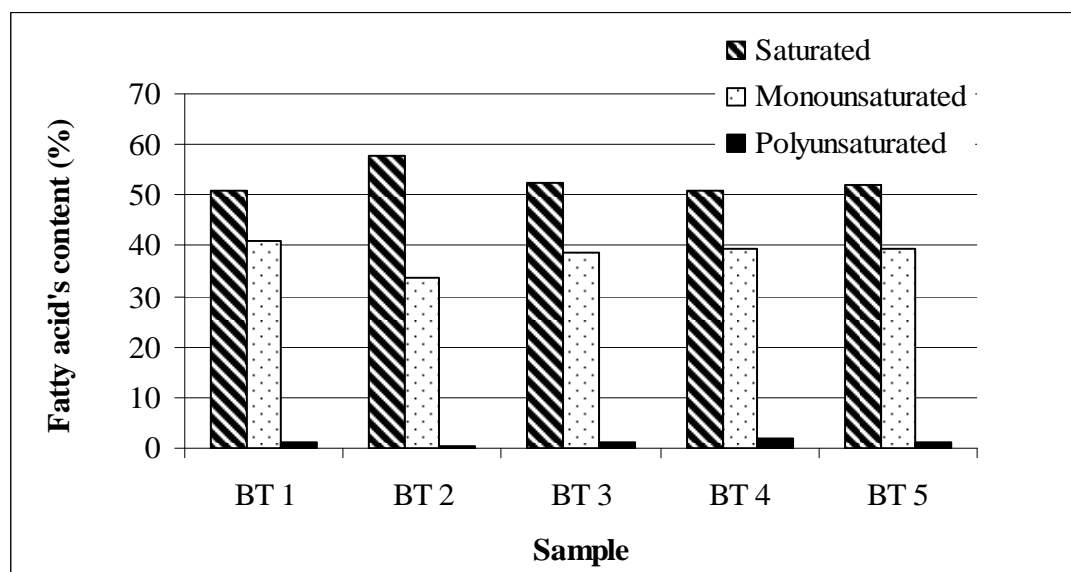


Fig. 1 Approximate composition in saturated, monounsaturated and polyunsaturated fatty acids of the different commercial brands of beef tallow.

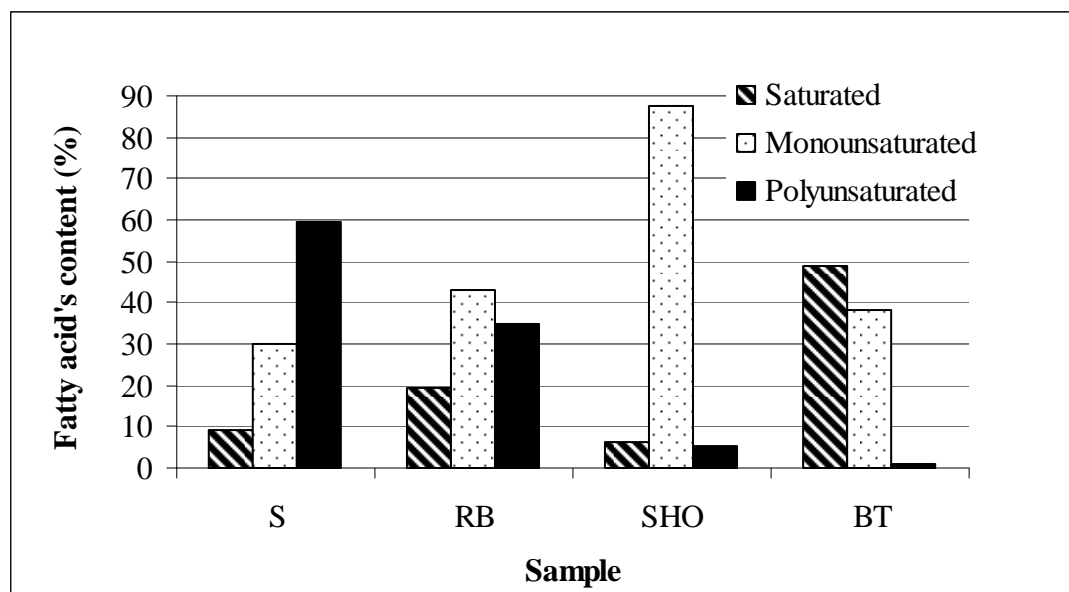


Fig. 2 Approximate composition in saturated, monounsaturated and polyunsaturated fatty acids of the different fatty materials. The composition in fatty acids labeled as "BT" is a mean of the values shown in Fig. 1.

Table 1 Inherent stability, OSI time and rate of deterioration during thermoxidation.

Fatty material	Inherent stability	OSI time (h, 110.0 °C)	Rate of deterioration (% total polar compounds/h)
S	6.3	4.0	0.85
RB	3.9	5.6	0.54
SHO	1.4	20.0	0.63
BT 1	0.5	6.0	1.12
BT 2	0.4	11.9	0.61
BT 3	0.5	5.0	0.69
BT 4	0.6	16.0	0.65
BT 5	0.5	38.3	0.65

S: sunflower oil; RB: rice bran oil; SHO: sunflower high oleic oil; BT1-5: beef tallows.

Table 2 Samples' initial quality.

Fatty material	Peroxide value (meq O ₂ /kg)	<i>p</i> -Anisidine value	Free fatty acids (%)	Total polar compounds (%)
S	4.7	6.7	0.1	4.1
RB	1.3	9.7	0.1	7.2
SHO	1.7	1.7	< 0.1	3.1
BT 1	1.3	3.3	2.7	4.9
BT 2	5.1	0.7	0.3	2.0
BT 3	1.1	5.6	2.0	4.1
BT 4	0.6	1.3	0.3	3.4
BT 5	0.5	1.1	0.3	1.6

S: sunflower oil; RB: rice bran oil; SHO: sunflower high oleic oil; BT1-5: beef tallows.

in their manufacturing process, maybe due to an excessive exposure of the fatty material to oxygen, light, high temperatures and/or other factors that may

have caused its oxidative and hydrolytic alteration.

Total polar compounds of SHO, S and RB agreed with the scientific bibliography for fresh oils [5, 6].

OSI times are presented in Table 1. Samples of beef tallow in general evidenced lower values than expected. With the exception of BT5, all samples of this fatty material presented lower values than SHO, which was not to be expected on the basis of the inherent stability of these materials (SHO almost three times higher than BT) nor considering the initial quality parameters. This suggests that they have pro-oxidant compounds that affect the OSI stability which are not present in the oils or that the latter contain antioxidants that are not found in the beef tallows.

Among the samples of beef tallow, the lower OSI times corresponded to BT1 and BT3 that showed similar values to those of S and RB. OSI times of BT5, SHO, RB and S agreed with the expected stability order.

Monitoring of the evolution of total polar compounds with thermoxidation time led to the results shown in Table 1, Figs. 3 and 4.

Regarding beef tallow samples, Fig. 3 reveals that BT1 required the lowest thermoxidation time to exceed 25% of total polar compounds (threshold established by Uruguayan regulation for used frying oils), followed by

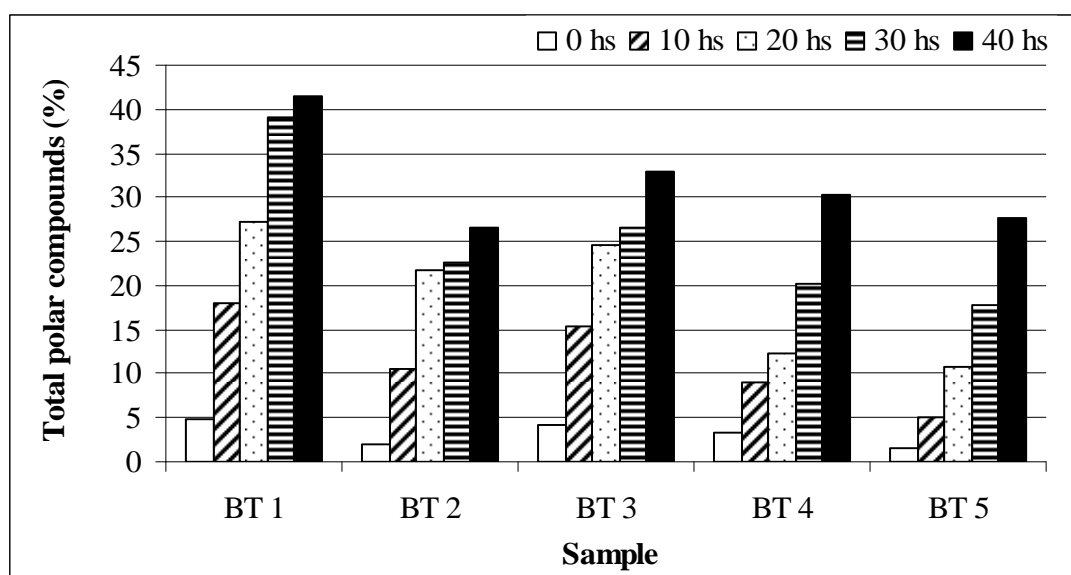


Fig. 3 Evolution of total polar compounds with thermoxidation time in the beef tallows.

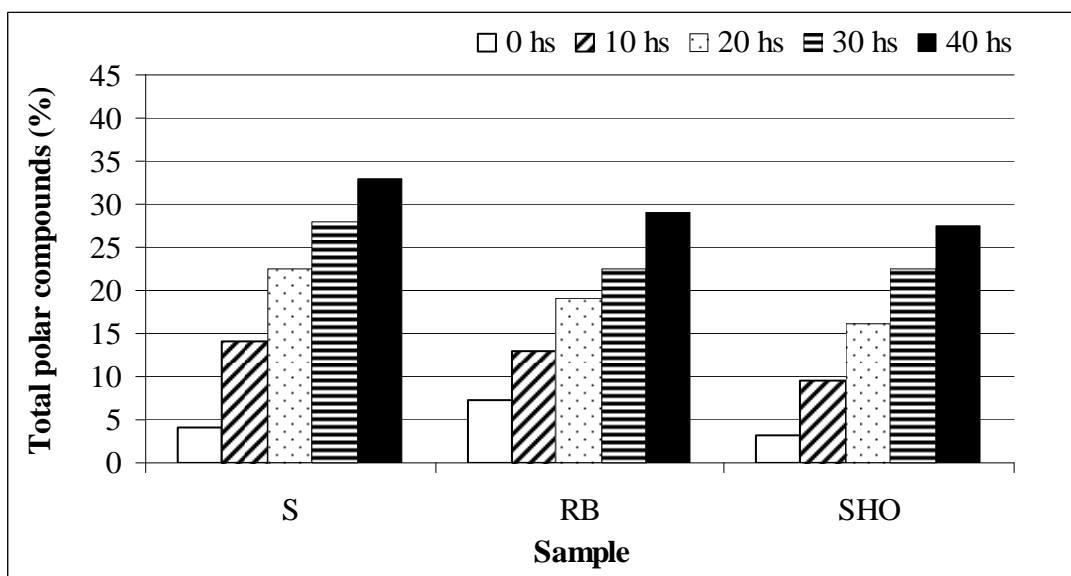


Fig. 4 Evolution of total polar compounds with thermoxidation time for the oils.

BT3. The other samples had to be exposed to 40 h of thermoxidation to rise above this value. The considerable difference in time between samples to reach this level of deterioration could be attributed to the disparity of its initial quality, as their inherent stabilities were similar. The samples that achieved the threshold value in less time were the ones which showed a lower initial quality (Table 2).

As it can be seen in Fig. 4, the time that took SHO and RB to reach 25% of total polar compounds was also 40 h; S required a similar time to that of BT3. This evidences a greater thermoxidative stability of RB than the expected according to the inherent

stability and the OSI time. This could be due to the presence of oryzanols: natural antioxidants with antipolymerization activity that are characteristic of this kind of oil [5, 7].

In general, the thermoxidation time required by beef tallows was low. Among all the samples of this fatty material, 40% required the same or less thermoxidation time than S (oil with the greatest inherent stability), while the other 60% had to be subjected to this process for a similar amount of hours to SHO (that also had a greater inherent stability than BT, though to a lower extent than S). This could also be explained by differences in the content of

pro-oxidant and/or antioxidant compounds in the fats and oils.

The deterioration rates (deduced from the chart total polar compound vs. thermoxidation time) are shown in Table 1. S presented higher deterioration rate than the other samples with the exception of BT1, and RB showed the lower one. All the other samples had deterioration rates of the same order of magnitude. These results were not expected in the basis of their inherent stabilities, but are in accordance with the former paragraphs with reference to the thermoxidative stability of BT1 and RB (the first one lower and the second one greater than expected). This also demonstrates that a high initial content of polar compounds does not necessarily lead to a high degradation rate. When the high value of this parameter does not imply a hydrolytic, oxidative or thermal degradation (that is, a low initial quality of the material) but is due to an intrinsic characteristic of it, this is to be expected.

In spite of the fact that BT3 required less thermoxidation time than the other beef tallows to exceed the threshold value of total polar compounds, it turns out to have a similar deterioration rate during thermoxidation. This means that, in this case, the relatively high initial content of total polar compounds did not result in a raise of the deterioration rate even though it did contribute to reach the 25% threshold earlier in comparison with the other beef tallows.

It is worth mentioning that the results of the thermoxidation assays are not comparable to the OSI times, as the differences in the operation condition of both assays give rise to different oxidation mechanisms with different resulting products.

4. Conclusions

Even though beef tallow's inherent stability indicated that it should be highly stable to oxidation, the majority of these samples exhibited a comparable or lower stability than SHO and several even lower than S. This would be explained by possible

differences in the amounts of pro-oxidant and/or antioxidant compounds present in the beef tallow and these oils.

According to the thermoxidation assays, which are carried out in similar conditions to those of a frying process, BT2, BT4, BT5, SHO and RB would be similarly suitable for frying, while S, BT1 and BT3 evidenced a lower thermoxidative stability, thus not being recommended for this use. This may be attributed to the low initial quality of the samples in the case of the beef tallows and to the low inherent stability in the case of S.

Future studies should include the analysis of pro-oxidant and antioxidant compounds in the fatty materials to enable a better understanding of the results. Increasing the number of analyzed samples and carrying out frying studies would also be desirable.

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