Ohmic heating

1 – Main objectives

Ohmic heating is an innovative thermal technology based on High Temperature Short Time treatment (HTST), which reduces thermal damage of the product, has low residence time dispersion, improved preservation of sensory characteristics (colour, texture etc.) of the ingredients and preserves nutritional compounds (vitamins, polyphenols, carotenoids etc.) (Novel Q, 2009).

Unlike conventional treatments, ohmic processing heats products internally by passing an electric current through the product, rather than relying on heat transfer from a heated vessel. Ohmic heating was applied to baby puree to reduce the PCs that are formed during sterilization.

Ohmic heating was chosen because it was expected to reduce PC formation on account that:

- Ohmic heating is well known to reduce the Cook Value (used to compare cooking procedures) with respect to microbiological safety. This means that for the same sterilization value (Fo value), products processed with a retort system are “overcooked” (de Alwys A.A.P. et Fryer P.J., 1990; Godereaux S., 2000).
- Ohmic heating is also known to avoid fouling and reduce deposits formed in vessels compared to traditional technologies such as heat exchangers and the retort system (Ayadi M.A. et al., 2003).

The following pages present the main results obtained on PCs, sugars, and micro-nutrients of baby purees. All the sterilized purees presented in this deliverable are shelf-stable at room temperature according to the Standard NF V 08-408.

2 – Processing contaminants

Firstly, we compared the evolution of furan in purees sterilized in a retort and by ohmic heating for a range of sterilization values (Fo) (Figure 1) .

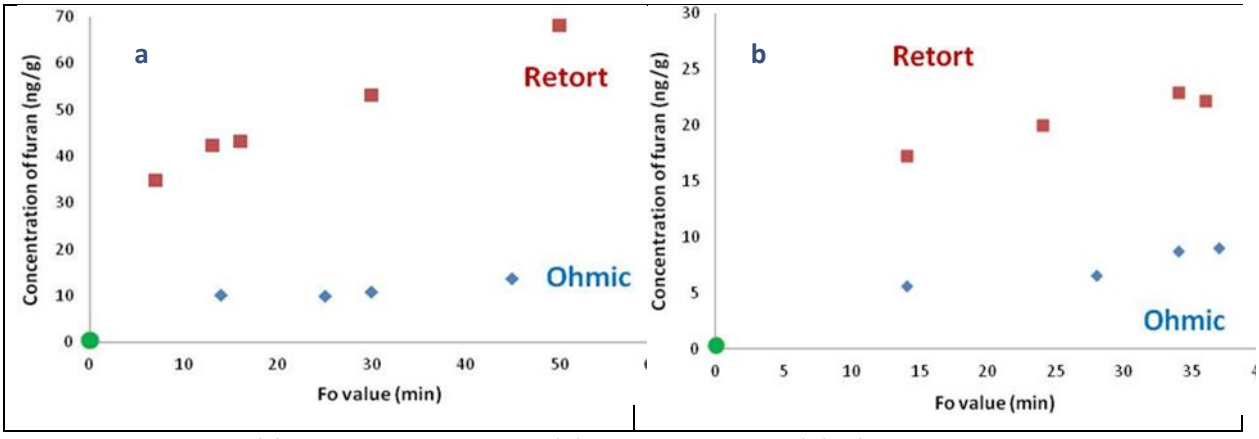

Figure 1. Amount of furan in vegetable mix (a) and chicken mix (b) after sterilization in retort or by ohmic heating for different Fo values

The most important finding was, as expected, that for all the recipes tested **the products sterilized by ohmic heating had a lower furan (3-7 times less) content than those sterilized in retorts** . We also demonstrated that agitation during retorting had a low impact (<5%) on reducing the level of furan in the purees, especially for high viscosity foods which reduced the effectiveness of the convection.

We also saw that for the products sterilized in retorts, the furan content increased when the Fo value increased. On the other hand, for the products sterilized by ohmic heating, there was no significant

increase when the Fo value increased. **This result is interesting because it confirms the value of alternative heating methods such as ohmic heating.**

For the products sterilized by ohmic heating, the temperature had no impact on the furan content. For the retorted products, the furan content was slightly higher at 123°C than at 129°C and the 129°C was slightly greater than 135°C. The results tend to confirm that the formation of furan depends more on the time (longer at 129°C than at 135°C) than the temperature.

The differences in the level of furan observed in various tested recipes were related to amount of sugar content in these recipes (see paragraph C). Vitamin C and sugar are the two known precursors of the Maillard reaction in the baby purees. To learn more about their influence on the rate of PCs formed during sterilization, we added sugar and/or vitamin C. We observed that an increase in the two precursors was necessary to obtain a significant increase of the level of furan, HMF, and furfural.

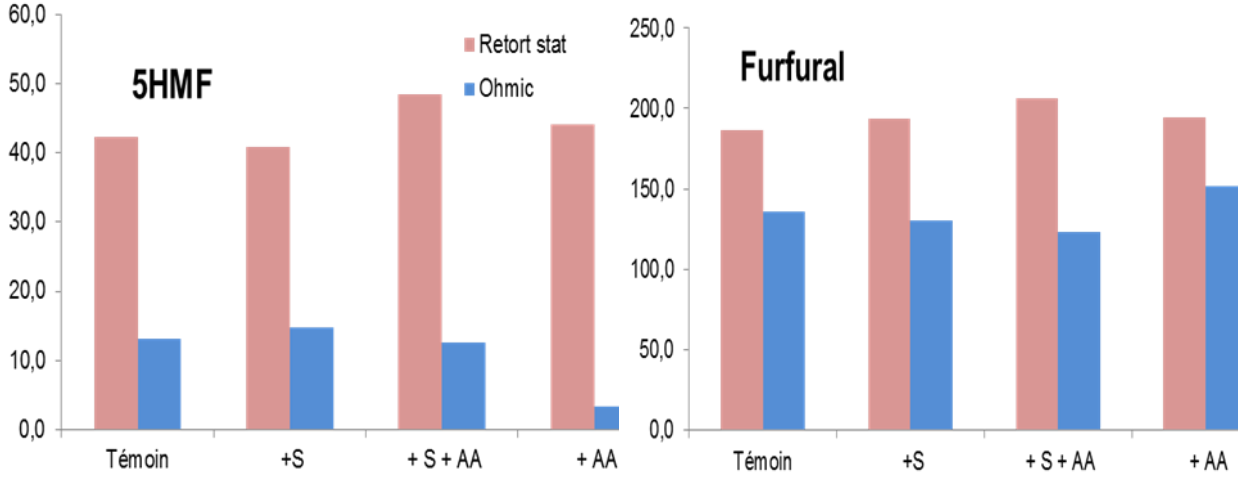

Figure 2. Amount of HMF (a) and furfural (b) in chicken mix with and without different supplementation after sterilization at 129°C for the same Fo value

Levels of all the PCs (furan, HMF, furfural) were higher in retorted puree than in ohmic sterilized product. **These results confirm that the ohmic heating reduced the volatile and non-volatile PCs formed in baby puree during sterilization.**
We studied the evolution of the PCs in purees sterilized in retorts and by ohmic heating. The few variations observed were not significant. The level of PCs in baby puree did not change during the storage at room temperature.

3 – Sugar

The total sugar content (Figure 3) did not depend on the heat treatment in either type of process, nor the intensity, in any recipe. There was twice the amount of sugar in the vegetable mix than in the chicken mix. This probably explains the higher amount of PCs measured in vegetable mix than in chicken mix (sugars are precursors of furan in the Maillard reaction). There was no impact of temperature or storage on the sugar level.

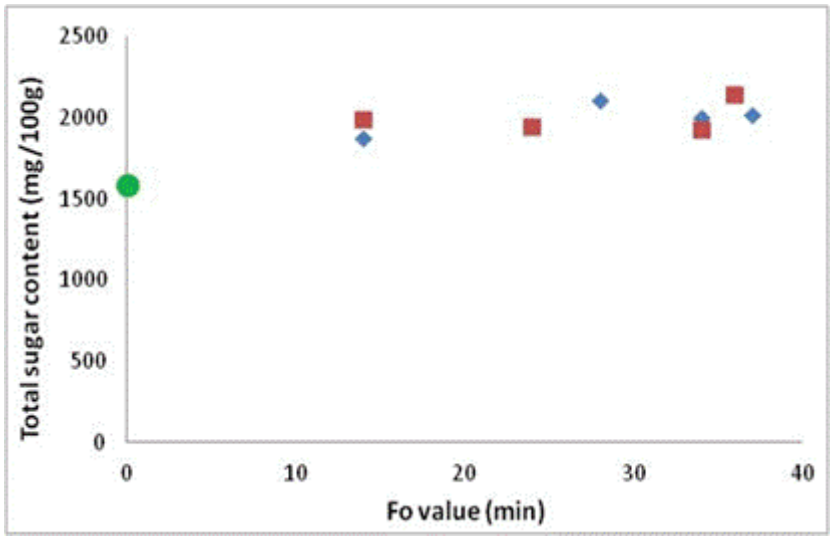

Figure 3.Total content of sugar in vegetable mix after sterilization in retort or by ohmic heating for different Fo value

4 – Nutritional compounds

The amount of vitamin C was very low in all recipes even before sterilization; it was completely destroyed by sterilization. The carotenoids and polyphenolic compounds in all puree recipes were not affected by the manufacturing process. There was also no impact of the intensity of sterilization on the amount of carotenoids content in purees for two technologies. We observed the same effects for different polyphenolic compounds. Therefore **ohmic heating provides a very much better means of preservation of carotenoids than retorting.**

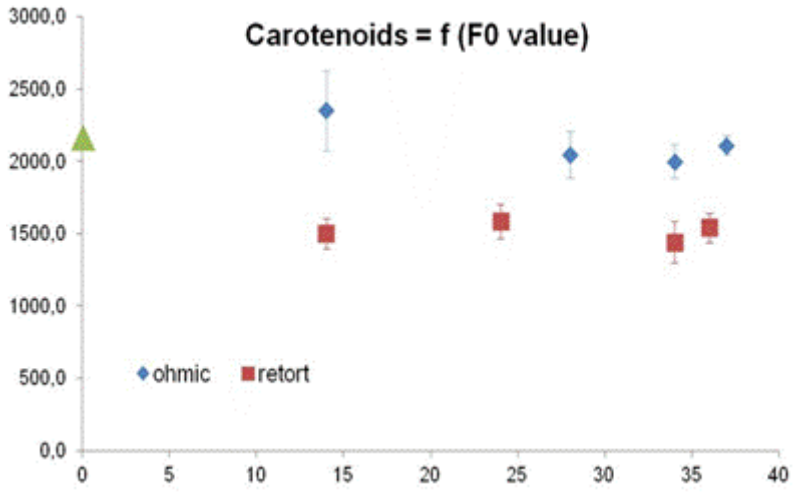

Figure 4. Total content of carotenoids in chicken mix after sterilization in retort or by ohmic heating for different Fo values

There was no impact of the storage on carotenoids or polyphenolic compounds whatever the process of sterilization used for all recipes tested.

5 – Conclusion

The most important result was that whatever the matrix, the products sterilized by ohmic heating had a lower furan (2-7 times less) content than those sterilized in retorts. **This result demonstrates that the use of an alternative technology such as ohmic heating greatly reduces the amount of PCs (furan, HMF, furfural) produced during a heat treatment for microbiological decontamination to obtain a shelf-stable product.**

We also found that the amount of furan formed was greater for the vegetable mix than for the chicken mix. We can relate this information to the higher level of sugars, phenolic compounds and carotenoids in the vegetable mix. This is consistent with their role as precursors of furan in the Maillard reaction.

In the case of products sterilized by heating ohmic, we did not observe the impact of treatment intensity or temperature on the formation of PCs for two recipes. This is consistent with the same behaviour observed for sugars and carotenoids and phenolic compounds. In contrast, in the case of products sterilized in retorts, we observed a significant impact of treatment intensity and temperature on the formation of PCs for two recipes, while we did not find a decrease in the amount of precursors in these purees. A higher temperature, allowed a shorter sterilization duration and so a lower furan content for the same Fo.

We observed that an increase of the two precursors of Maillard reaction in baby puree (sugar and vitamin C) induces an increase of different PCs.

The study of purees during storage of 6 months demonstrated no chemical evolution. The products are very stable.

All these tests have shown the relevance of alternative technology (ohmic heating) to significantly reduce the formation of PCs (volatile and non-volatile) such as furan, HMF and furfural and to preserve the nutritional compounds (carotenoids, polyphenols etc.) in purees for baby food.

These results were obtained with semi-industrial line of ohmic heating in CTCPA (200 to 1000 l/h). The maturity of the technology ohmic heating is excellent. There is no technical difficulty in deployment of ohmic lines in industry plants for baby puree aseptically filled into glass jars.

For a company that manufactures small volumes of puree, a continuous line of heat treatment has a higher initial cost than a retort process. However, when the output of the company is high the continuous heat treatment becomes more competitive financially. The cost of a thermal treatment by ohmic heating also depends on the price of electricity in each country.

Current major industrial applications for the stabilization of food by ohmic heating are:

- HT-ST flash sterilization of low acid foods: prepared meals (i.e. pasta with sauce, chili con carne etc.); baby foods, vegetables with sauce; soups with particles; chestnut cream.
- HT-ST flash pasteurization of acid foods: fruit based products, tomato sauces.

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