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Stabilization of Apricot Puree by Means of High Pressure Treatments

Stabilizacija kaše marelice primjenom visokog tlaka

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Summary

The possibility of obtaining an apricot puree microbiologically and enzymatically stable by applying the high-pressure technique was evaluated using a pilot isostatic press from the firm ABB (Sweden).

Samples of puree produced in the laboratory without using any heat treatments were subjected to 300–900 MPa at 20 and 50 °C for up to 10 min.

Results showed that yeasts and moulds inoculated into puree samples were completely inactivated by 400 MPa treatments at 20 °C for 1 min; however, to completely inactivate PPO activity the product must be preheated at 50 °C before applying 700 MPa for 5 min.

The high-pressure technique allows the stabilization of various products proving a viable alternative to the conventional pasteurization treatment.

Sažetak

Ispitivana je mogućnost dobivanja mikrobiološki i enzimski stabilne kaše marelice primjenjujući visoki tlak u pokusnoj izostatičkoj preši tvrtke ABB (Švedska).

Uzorci kaše proizvedene u laboratoriju bez bilo kakve toplinske obradbe podvrgnuti su tlaku od 300 do 900 MPa pri 20 do 50 °C tijekom 10 min.

Rezultati su pokazali da su kvasci i plijesni inokulirani u uzorke kaše potpuno inaktivirani djelovanjem tlaka od 400 MPa tijekom 1 minute pri 20 °C.

Ipak za potpunu inaktivaciju polifenol-oksidaza proizvod se mora predgrijati na 50 °C prije primjene tlaka od 700 MPa tijekom 5 minuta.

Postupak visokog tlaka omogućuje stabilizaciju različitih proizvoda, što je značajna alternativa konvencionalnoj pasterizaciji.

Introduction

The effects of high pressure treatment on microorganisms have been known since the last century, when in 1895 Roger described the first experiences on some strains of Staphylococci and *E. coli*.

Ever since in 1914 Hite reported about the possibility of microbiological inactivation in fruit derivatives, reports have followed on microbiological stabilization through the experimental use of high pressure.

The main limitation in the application of this technique so far has been the technology needed to produce economicaly high-pressure equipment.

The present evolution of some metallurgical industries together with a new willingness to invest on the part of the food companies, always searching for new high quality products, has renewed the interest in the use of high pressure as a food stabilization technique.

The technological transfer from other fields where high pressures are normally applied (aircraft, metallurgy, automotive, ceramics and electronics industries) allowed a quick evolution of this technology in the food area where, on the other hand, the applications have so far been tied up to the use of discontinuous equipment. In Japan, where the food culture has always been linked to products where freshness sensation should be enhanced, there are already on the market some products as fruit jellies and juices, stabilized by high-pressure treatment. The use of this new technique has required a wide basic experimentation documented by numerous articles *(1)*.

In Europe, the possibility to use hyperbaric treatment (2000–900 MPa) as an alternative technique to the traditional stabilization by thermal treatment has raised the interest of research groups that have been using pilot presses for a couple of years *(2-4)*.

Fruit derivatives, like puree and pulp, to be used for the production of fruit juices and nectars have always required the use of heat as a physical treatment for the microbiological and enzymatic inactivation of both the semifinished and the final product.

Mould and yeasts, normally ubiquitous in the environment and thus present in huge quantity on the fruit surface, are, together with the lactic acid bacteria, the usual contaminants of these »acid products« (pH < 4.5) and therefore they should undergo rather limited thermal treatments.

From the enzymatic point of view, the stabilization of these products requires a blanching treatment of the pulp during the first preparation steps. Therefore, thermal treatments are unavoidable in obtaining a product stable from the microbiological and enzymatic point of view: to get rid of or to reduce such a treatment would be interesting from the technological point of view.

To achieve commercial stability, fruit nectars undergo thermal treatments that unavoidably cause the appearance of »cooked taste« in the finished product. In spite of the fact that by now the use of flash pasteurization as well as of aseptic packing lines is widely spread, the finished products normally on sale have taste and flavor considerably different from the ones of the fresh fruits. At purchasing the consumer, who is today accustomed to standardized quality and taste, may find a better way of preserving the natural freshness of a product as a reason for preferential choice. Therefore, the possibility to obtain fruit puree stabilized with high-pressure treatments, and reducing as much as possible the thermal processing seems to be a matter of great interest.

The purpose of this work is to evaluate the possible application of high-pressure as a partial or total stabilization treatment of apricot puree.

Experimental

Preparation of apricot puree

Fruits of cultivar »CAFONA« have been used for the preparation of apricot puree following the diagram in Fig. 1.

The following pilot plants have been used:

a) cubing machine – Mod. California (Bertuzzi-Brugherio)

b) refining machine – Sieves Ø = 0.1–1 mm (REV MEC--Parma)

c) Homogenizer – 10–100 MPa (NIRO-Soavi-Parma)

The puree samples (total solids: w(T.S.) = 7.74 %; soluble solids: w(S.S.) = 7.0 %; pH = 3.4) for the pressing tests were packed under vacuum in 250 mL P.E. bags and kept at 0–1 °C while waiting for the treatment.

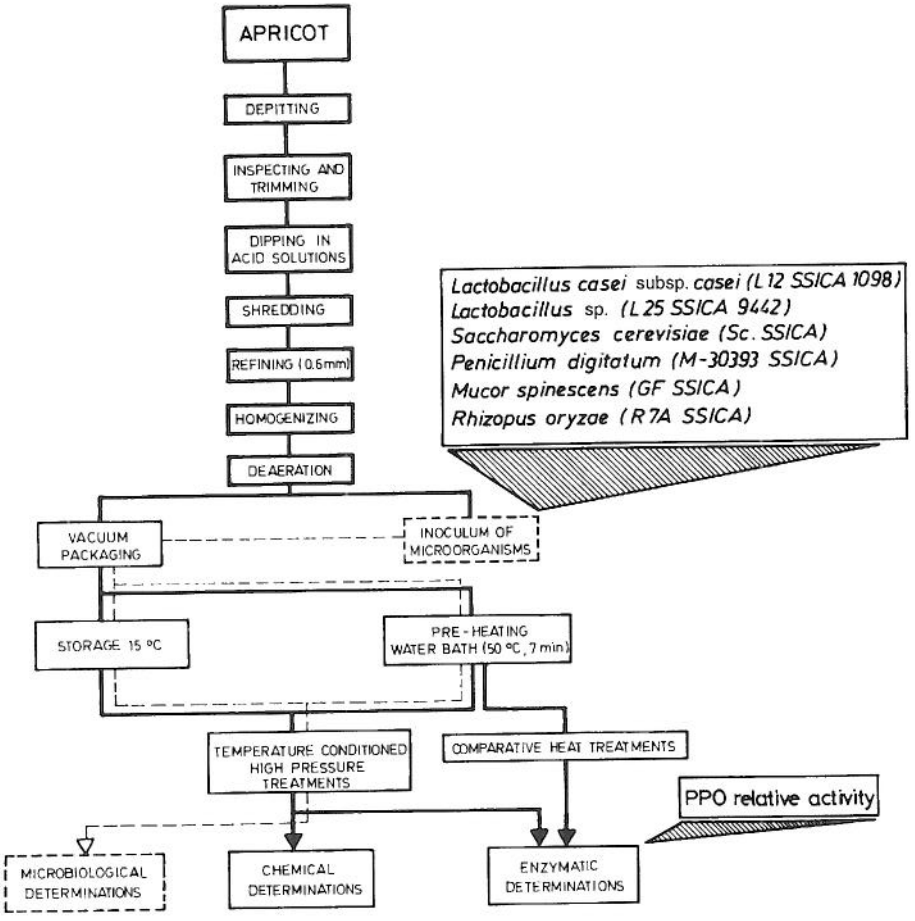

Fig. 1. Preparation steps of apricot puree
Slika 1. Faze pripreme kaše marelice

Hyperbaric treatment

The experiments were performed in a pilot isostatic press from ABB, model QFP6, capable of operating up to 900 MPa and with a useful volume of 600 mL. The sample can be pressed at various temperatures (max. 80 °C) by using a heating jacket surrounding the pressure chamber.

Treatments were performed with the equipment pre-heated to 20 °C and 40 °C, respectively. For the 50 °C treatments the packed puree was dipped into a controlled thermostatic water bath until the desired temperature was reached. This sample was then cooled for the analytical control that gave the following data:

w(T.S.) = 8.07 %; w(S.S.) = 7.1 % and pH = 5.5

Thanks to the use of a thermocouple, positioned inside the pressure chamber, the temperatures reached by the samples during the treatments were recorded (Fig. 2).

Master samples for comparison purposes were submitted to thermal treatments, always by dipping them into thermostatic baths, so they could reflect the thermal profiles of the samples submitted to the high pressure treatments.

Microbiological tests

The following strains were inoculated into apricot puree: spores of *Penicillium digitatum* (M-30393), *Mucor spinescens* (GE) and *Rhizopus oryzae* (R7A); *Lactobacillus casei* subsp. *casei* (L12, SSICA 1098 strain), *Lactobacillus* sp. (L25, SSICA 9442 strain) and *Leuconostoc mesenteroides* (LN5, SSICA 1473 strain).

Saccharomyces cerevisiae (Sc): this strain was also inoculated into apricot puree with 25 and 50 % of added sucrose that brought water activity to 0.96 and 0.86, respectively; inoculum level ranged by 10^5 to 10^6 cells per mL of substrate.

The samples (V = 20 mL) were packed in plastic pouches and treated by high-pressure.

Enzymatic tests

For the determination of the polyphenoloxidase (PPO) relative residual activity, which was performed 24 hours after the H.P. treatment directly on the treated and un-treated samples, a method based on the measuring of the substrate oxidation rate was used (0.1 M sol. catechol in phosphate buffer c = 0.1 M and pH = 5).

The variation of O_2 concetration dissolved in the liquid substrate allowed the determination of the percentage of the PPO residual activity in the puree. To perform the measurement, the O_2 residual concentration was determined at regular intervals of 15 s for 5 minutes; the values obtained with three repetitions were then statistically analyzed for the determination of the relative residual activity coefficients *(5)*.

This method permitted the operation directly on the apricot puree, and since it was quick, it also allowed the repetition of a fairly good number of determinations on significant quantities of samples (5 mL).

Analytical determinations

Before and after the pressing the pH, w(T.S.) and w(S.S.) determinations on the samples were performed according to the methods used for vegetable preserves *(6)*.

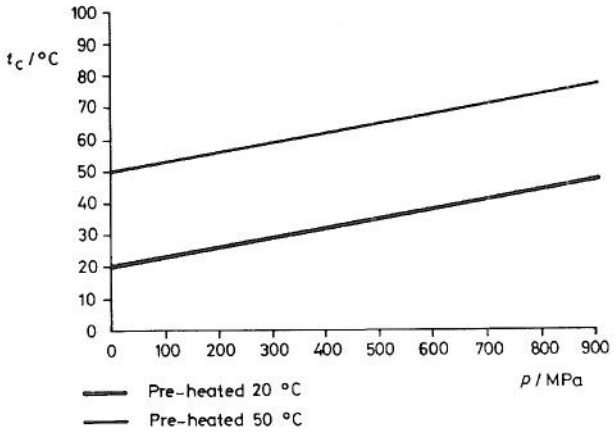

Fig. 2. Temperature variation during the pressing of apricot puree
Slika 2. Promjena temperature za vrijeme tlačenja kaše marelice

Results and Discussion

Microbiological tests

The three strains of mould were inactivated by a treatment of 400 MPa for 1 min (Fig. 3); Counts of viable cells are expressed as cfu/mL; *P. digitatum* proved to be the most resistant. The lactic acid bacteria were inactivated at different pressure values: *L. mesenteroides* and gas forming *Lactobacillus* (L25) were inactivated at 300 MPa for 9 min and 400 MPa for 1 min, respectively. A treatment at 500 MPa for 1 min was necessary for the inactivation of a not-gas-forming Lactobacillus (L12) (Fig. 4).

S. cerevisiae was normally destroyed at 300 MPa for 1 min. The inactivation of *S. cerevisiae* inoculated into apricot puree with 25 % of added sucrose (a_w = 0.96) was obtained by a treatment of 300 MPa for 7 min (Fig. 5).

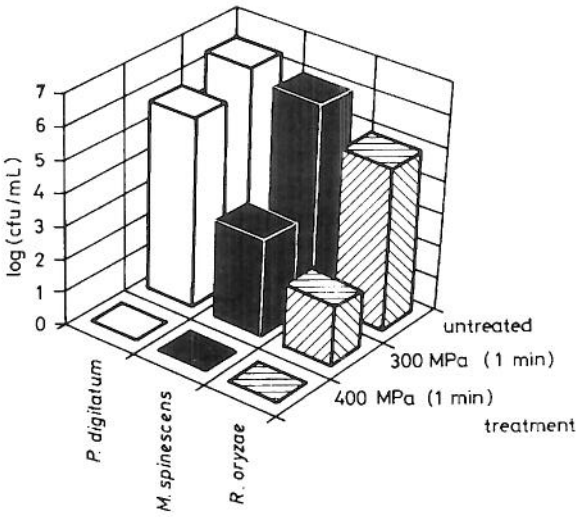

Fig. 3. Pressure resistance of spores of three mould strains in apricot puree. Counts of viable cells are expressed as cfu (colony forming units) per milliliter
Slika 3. Otpornost spora triju vrsta plijesni u kaši marelice prema tlaku. Broj izraslih kolonija (cfu/mL)

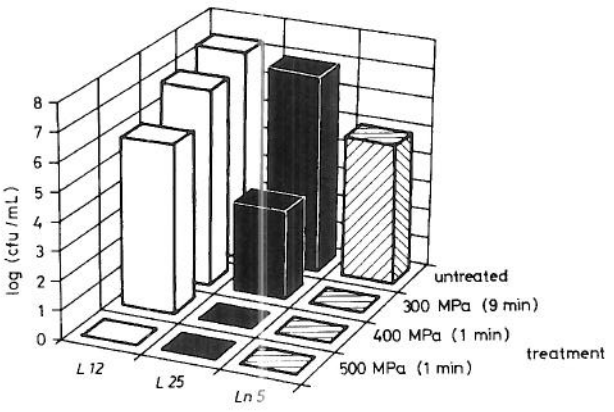

Fig 4. Pressure resistance of two Lactobacillus strains (L12 and L25) and of *Leuconostoc mesenteroides* (Ln5) in apricot puree
Slika 4. Otpornost dviju vrsta Lactobacillus (L12 i L25) te *Leuconostoc mesenteroides* (Ln5) u kaši marelice prema tlaku

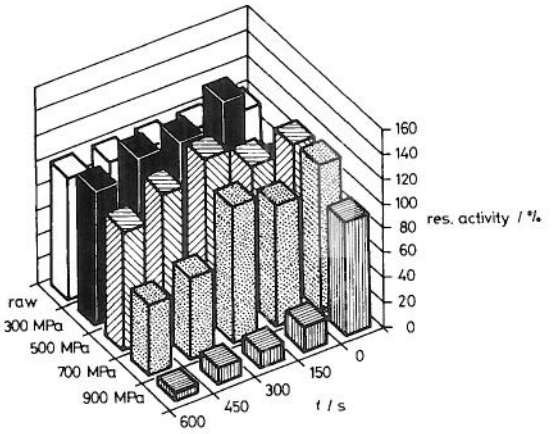

Fig. 6. Relative residual PPO activity after H.P. treatments at 20 °C
Slika 6. Relativni ostatak PPO aktivnosti nakon obradbe visokim tlakom pri 20 °C

A treatment at 800 MPa for 5 min to destroy the yeast in apricot puree with 50 % of added sucrose ($a_w = 0.86$) proved necessary.

Enzymatic tests

In agreement with what has been seen for other plant products *(5)* the pressure treatments performed on the puree at 20 °C have given very interesting results.

Fig. 6. shows that pressure treatments from 300 to 500 MPa for different times do not allow the enzymatic inactivation as far as the PPO is concerned. Instead, in this range there have been some cases of enzymatic activation.

For instance, in the samples treated at 300 MPa for 150 s and 500 MPa for 300 s, one can notice relative residual activities of 142.1 and 129.5 %, respectively. A partial inactivation of the relative residual PPO can be noted only after treatments higher than 700 MPa.

Pressure of 900 MPa has led to residual percentage of activity lower than 20 % only after the threshold of 150 s.

When looking at Fig. 6. one can note a fairly good nonuniformity in the isochronals and isobars trend except for the set of treatments for 600 s and those at 900 MPa.

Instead, the treatments performed with both the samples and the equipment preheated to 50 °C gave the results shown in Fig. 7; one can note that although after the preheating there is an increase of the PPO activity (8 %) the following H.P. treatments lead to evident enzymatic inactivations. By treatments at 300 MPa for 600 s an inactivation of about 25 % is achieved while at 500 MPa for 300 s 65 % inactivation is achieved. At 700 MPa for times longer than 300 s and at 900 MPa for times longer than 150 s one can see that almost complete inactivation of the PPO is achieved.

Comparative thermal treatments

The PPO residual activity values of the H.P. treated samples at different pressures are compared in Figs. 8 and 9 with the PPO residual activity values determined

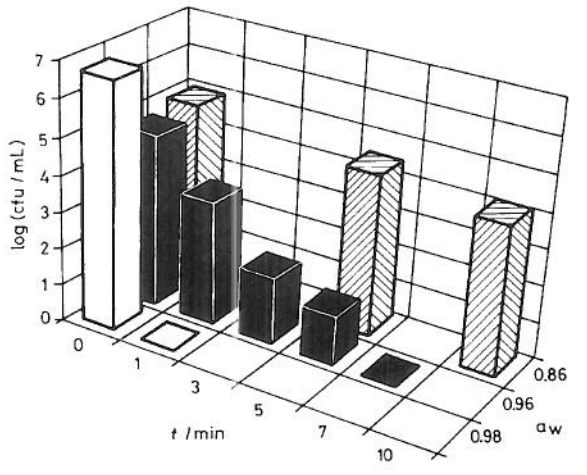

Fig. 5. Pressure resistance (300 MPa) of *Saccharomyces cerevisiae* in apricot puree
Slika 5. Otpornost *Saccharomyces cerevisiae* u kaši marelice prema tlaku (300 MPa)

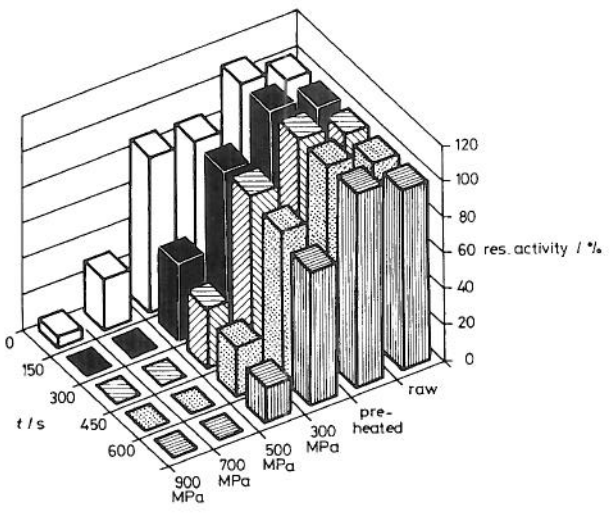

Fig. 7. PPO relative residual activity after pressing at 50 °C
Slika 7. Relativni ostatak PPO aktivnosti nakon obradbe tlakom pri 50 °C

Table 1. Mass fraction of soluble solids in apricot puree at various treatment conditions
Tablica 1. Topljiva suha tvar kaše marelice pri različitim uvjetima obradbe

Treatments:	0 s	150 s	300 s	450 s	600 s	0 s	150 s	300 s	450 s	600 s
	[20 °C]					[50 °C]				
300 MPa	7.04	7.04	7.08	7.06	7.04	6.98	7.13	7.15	7.12	7.09
500 MPa	7.00	7.02	7.06	7.02	7.04	7.09	7.13	7.12	7.02	7.12
700 MPa	6.98	7.04	6.94	7.02	7.04	7.10	7.08	7.13	7.16	7.14
900 MPa	7.02	7.08	7.04	7.08	7.08	7.12	7.14	7.15	7.16	7.15

Table 2. Mass fraction of total solids in apricot puree at various treatment conditions
Tablica 2. Ukupna suha tvar kaše marelice pri različitim uvjetima obradbe

Treatments:	0 s	150 s	300 s	450 s	600 s	0 s	150 s	300 s	450 s	600 s
	[20 °C]					[50 °C]				
300 MPa	7.76	7.76	7.67	7.63	7.65	8.05	8.18	8.19	8.00	8.20
500 MPa	7.73	7.83	7.79	7.82	7.76	8.30	8.10	8.20	8.11	8.11
700 MPa	7.74	7.85	7.86	7.76	7.74	8.02	7.93	8.26	8.07	8.06
900 MPa	7.73	7.77	7.69	7.74	7.91	8.15	8.09	7.98	8.17	8.05

Table 3. pH of apricot puree at various treatment conditions
Tablica 3. pH-vrijednosti kaše marelice pri različitim uvjetima obradbe

Treatments:	0 s	150 s	300 s	450 s	600 s	0 s	150 s	300 s	450 s	600 s
	[20 °C]					[50 °C]				
300 MPa	3.42	3.45	3.45	3.46	3.45	3.37	3.44	3.37	3.46	3.46
500 MPa	3.46	3.41	3.41	3.43	3.43	3.41	3.35	3.42	3.43	3.44
700 MPa	3.46	3.40	3.44	3.42	3.43	3.41	3.39	3.40	3.36	3.45
900 MPa	3.47	3.43	3.45	3.43	3.41	3.40	3.36	3.44	3.44	3.43

in the samples submitted to the same thermal treatment undergone by the pressed samples.

As one can see, the protective effect exhibited by the high pressures on the thermal degradation of the enzymatic activity is evident, but only up to 700 MPa, where instead, the synergic effect of pressure and temperature in the achievement of the inactivation of this enzymatic activity occurs.

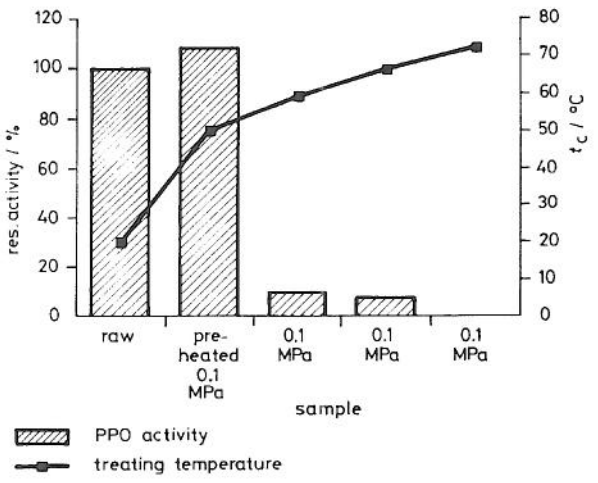

Fig. 8. PPO relative residual activity after thermal treatment
Slika 8. Relativni ostatak PPO aktivnosti nakon toplinske obradbe

Chemical determinations

The chemical data obtained on the puree after the treatments and listed in Tables 1–3 allow the statement that the high pressure does not affect pH, dry residual or optical residual substantially.

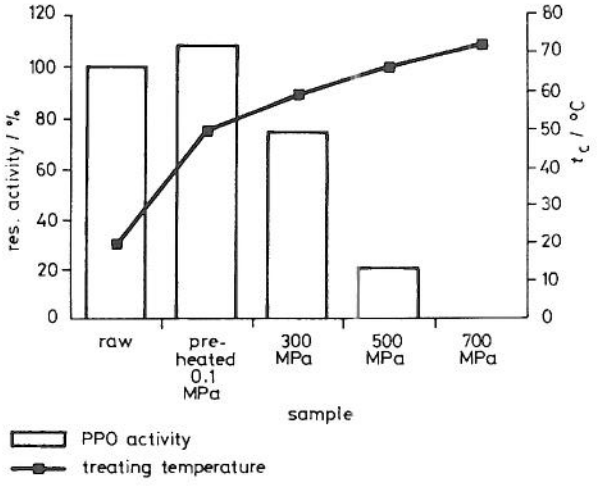

Fig. 9. PPO relative residual activity after H.P. treatment at 50 °C
Slika 9. Relativni ostatak PPO aktivnosti nakon obradbe visokim tlakom pri 50 °C

The only noteworthy variations that cannot be attributed to the sample variability but to the puree preheating process are the product change of pH, total solids and soluble solids.

Conclusions

On the basis of the results achieved one can state that while the sanitization of apricot puree can be obtained through pressure treatments at relatively low pressures (400 MPa) and for short times (<60 s) the PPO inactivation with the same operating parameters cannot be reached; the inactivation cannot be achieved even if the product at 20 °C is treated at 900 MPa. A nearly complete inactivation of the polyphenoloxidase activity can be obtained only when preheating the product to 50 °C and submitting it to 700 and 900 MPa for times longer than 300 s and 150 s, respectively.

If one were to combine the treatments it would be possible to inactivate completely the PPO during the preparation phase through blanching (however this would not save the product from the microbiological point of view) and then utilize the high pressures (500 MPa would be enough) for the microbic stabilization.

In this way the characteristic thermal damages caused by the pasteurization would be limited and it would be also possible to use cheaper H.P. equipments.

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