HIGH PRESSURE STABILIZATION OF LEMON JUICE

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SYNOPSIS

A laboratory scale apparatus has been designed, set up and operated to investigate the effect of high hydrostatic pressure on the stabilization of foodstuffs. Experiments have been performed using lemon juice, whose stabilization process presents some peculiar difficulties. Preliminary results confirm that the technique is suitable for producing high quality lemon juice, with satisfactory shelf life, provided that a minimum pressure of 3.000 bar is applied.

INTRODUCTION

Stabilization of lemon juices is required to reduce microbial activity as well as the activity of pectinase enzyme, which is likely to cause gelification phenomena, degeneration of taste properties and reduction of the characteristic turbidity of the juice. However, stabilization is not a straightforward operation, due to the highly acid nature of the juice. When heating such product, the acid hydrolysis of pectins can take place. This in turn promotes gelification phenomena, and produces a significant change in juice transparency. As a consequence, while thermal processing is able to reduce the activity of pectinase enzymes, it is likely to produce directly phenomena not much different from those due to the presence of such enzyme[1,2]. This is the main reason why commercial lemon juices are currently stabilized through the addition of chemicals, such as sulphur dioxide and other sulphur compounds. In order to eliminate potentially dangerous chemicals in food processing, research efforts toward the set up of non-thermal, non-chemically aided stabilization processes of acid juices are produced.

EXPERIMENTAL

The experimental apparatus used, designed specifically for food processing, is sketched in Figure 1. It consists of an autoclave with a volume of 250 ml and can be operated up to pressures of 7.000 bar. Pressurization is obtained by the use of an intermediate fluid, which is in turn pressurized by two diaphragm pumps in series[3]. This is a modification of the conceptual design of commercial units, in which the fluid medium is direclty compressed in the autoclave or indirectly by a pressure intensifier. Both methods produce an intrinsically slow pressure rise, being set up for different needs. The use of pumps,

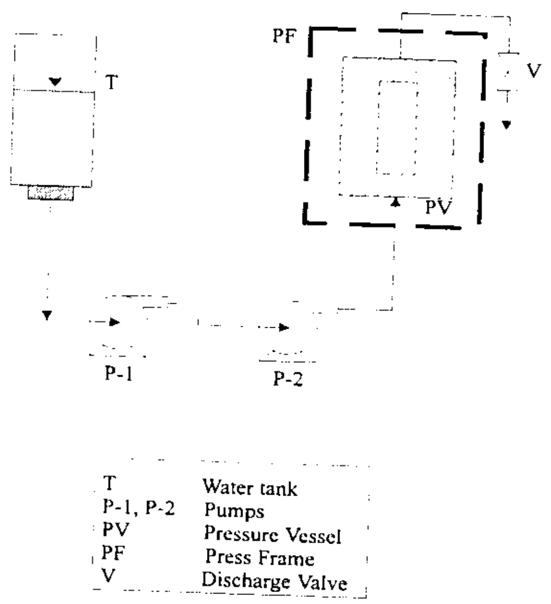

Fig. 1: Diagram of the experimental apparatus.

while limits the maximum achievable static pressure, allows fast pressurization and can be the basis for the development of continuous apparatus.

Pressure can be released by an expansion valve. The valve can also be operated in order to produce pressure fluctuations superimposed to the static value during the process, provided that the pumps are continuously in operation. This feature is used to detect the effect of dynamic pressure components on the stabilization of food samples. Instantaneous pressure is measured by a strain gage and recorded continuously during each test.

The apparatus is controlled by a microprocessor, which allows to program specific pressure cycles. Preliminary tests, however, are carried out with simple pressurization cycles, the operative variables being the maximum pressure level and the process time.

Samples of lemon juice are obtained by plain squeezing of lemons of the same cultivar, supplied by the Istituto di Frutticultura in Caserta. After physical filtration for the elimination of coarse suspended solids, the juice is thermally sealed in 10 ml pouches made out by poliethylene-aluminium coupled material.

Pressure levels tested are: 3.000, 4.000. 4.500 bar, with a treatment time of 2, 5 and 10 minutes. Preliminary tests demonstrated that the effect of process time, in the range investigated, was not significant. Accordingly, most experiments were carried out with a process time of 5 minutes, and experimental data reported refer to such time.

Some samples of each batch of lemon juice are stored in cold conditions at 8° C without any treatment, for comparison purposes. They are referred to in the following as non pressurized juice (N.P.J.). The other are processed under the conditions stated above. Processed samples are stored at room temperature. Chemical and microbiological determinations are performed on processed and non processed juice just after the test and after 10 and 40 days, in order to follow the evolution of significant components.

The main analytical determinations are the following:
-pH, acidity, carbohydrates, according to the official Italian regulations [4].
-C vitamin and naringine [1]
-aromatic components by GM cromatography [5]
-microbiological determinations for yeasts and moulds [3]

RESULTS AND DISCUSSION

Results of microbiological analysis, limited to yeasts and moulds which are the only biological entities able to survive in very acid juices, are reported in Table 1 for samples processed at different pressure levels, in comparison with non processed samples, after a storage of 40 days. It appears that from this point of view, full stabilization is already obtained at a pressure level of 3.000 bar and maintained after 40 days. In spite of the highly acid ambient, non processed juice is heavily spoiled by yeasts and moulds after 10 days.

	Yeasts c.f.u./g	Moulds c.f.u./g
N.P.J.	<10	<10
3000	-	-
4000	-	-
4500	-	-
after	10	days
N.P.J.	10^4	10^3
3000	-	-
4000	-	-
4500	-	-
after	40	days
N.P.J.	$>10^7$	$>10^7$
3000	-	-
4000	-	-
4500	-	-

Table 1: Result of microbiological analysis of lemon juice

Results of chemical determinations are reported in Table 2. These these data demonstrate that the most significant components from the taste and nutritional point of view are stable after processing. In this case, the pressure level produces some effect, which can be detected by comparison of the compositon as a function of the preservation time. The reduction of the naringine level can be considered as a fair achievement, being this component responsible for the bitter taste of lemon juice. As predicted, key nutritional components such as C vitamine are rapidly degenerating in non processed juice.

	Moisture Content %	pH	Acidity g Citr. Ac./(100 ml F.J.)	Carbohydrate %	Sucrose %	Citric Ac. g/100 g	Malic Ac. mg/100 g	Naringin ppm	Ascorbic Ac. mg/100 g
N.P.J.	90	2.8	7.50	3.75	1.90	6.60	270	280	69.10
3000	90	2.6	8.20	3.75	1.80	6.70	272	270	68.50
4000	90	2.6	8.20	3.70	1.90	6.60	270	250	68.60
4500	90	2.5	6.60	3.71	1.90	6.60	268	258	68.30
				after	**10**	**days**			
N.P.J.	90	2.8	6.76	3.70	1.80	6.20	260	300	60.10
3000	90	2.8	7.60	3.70	1.80	6.50	268	270	67.70
4000	90	2.9	7.43	3.70	1.90	6.50	268	260	67.00
4500	90	2.9	7.60	3.70	1.80	6.50	263	258	65.30
				after	**40**	**days**			
N.P.J.	90	2.8	6.76	3.70	1.80	6.20	260	300	60.10
3000	90	2.8	7.63	3.70	1.80	6.40	269	270	65.70
4000	90	2.6	7.40	3.70	1.90	6.30	260	251	61.90
4500	90	2.6	7.50	3.70	1.90	6.40	260	226	60.00

F.J.=Fresh Juice N.P.J.=Not-pressurized Juice

Table 2: Effects of pressure treatments on main lemon juice components.

Determination of aroma components by gas mass chromatography is reported in Table 3. It can be verified that most aroma components are slightly affected by pressurization and keep almost stable during storage.

	Mircene-β µl/l	d-limonene µl/l	linalool µl/l	terpineol-α µl/l	terpineol-4 µl/l
N.P.J.	1.6	27.3	3.2	0.7	1.1
3000	-	-	-	-	-
4000	-	-	-	-	-
4500	-	-	-	-	-
		after	**10**	**days**	
N.P.J.	1.5	22.6	2.7	0.7	1.1
3000	1.6	25.0	2.4	0.3	0.9
4000	1.5	24.9	2.0	0.4	1.0
4500	1.6	17.9	2.0	0.6	1.0
		after	**40**	**days**	
N.P.J.	0.9	8.7	1.1	0.9	0.8
3000	1.5	18.8	1.8	0.5	1.0
4000	1.5	13.3	1.6	0.8	1.0
4500	1.5	11.6	1.4	0.9	1.0

N.P.J.=Not-pressurized Juice

Table 3:Effects of pressure treatments on main aroma components of lemon juice.

In particular, d-limonene which is considered as the less stable aroma component, undergoes a slight reduction during pressurization and than its level keeps constant. The reduction seems to be larger at higher pressure levels. On the contrary, more drastic effects are observed on non processed juice samples for the longer preservation times.

CONCLUSIONS

Preliminary tests performed so far demonstrate that high pressure treatment is a valuable technique in the stabilization of lemon juice, preventing the development of moulds and yeasts and preserving almost at the initial value the level of key chemical components. It means that a valuable product can be obtained, with full aroma, taste and nutritional value. The high added value of such product, which has no current competitors, could make for the application on large scale of the high pressure stabilization technique.

While it can be stated that a pressure level of 3.000 bar is sufficient to ensure an effective stabilization, further work is necessary and is currently performed to determine the effect of pressure level above this value, which cannot be completely elucidated by present data. This work also aims at defining the optimal processing cycle and at determining the maximum shelf life of such product.

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