Research on the factors influencing the processing of preparing the pickled cucumbers

VIOLETA CONSTANTINESCU[*], GH. CAMPEANU[**], L. ENACHE[**], CARMEN CAMPEANU[**]

[*] *"DUMITRU MOTOC" Technical College of Food Industry, Bucharest, Romania*

[**] *Faculty of Biotechnology, UASVM Bucharest, 59 Bd. Marasti, Bucharest, Romania*

Abstract

A comparative research on the processing parameters was carried out on the lactic fermentation of cucumbers as well as on the quality and stability of the final product. The studied variants had as variables:

- the preliminary thermal treatment (blanched fresh cucumbers or fresh cucumbers, in water at 77 °C for 3 min.);

- the composition of brines: the classic brine ("clean"), brines with variable concentrations of salt (4%, 5%, and 6% NaCl) and brines with conservants (Na benzoate 0,25%, Ca lactate 0,25%, acetylsalicylic acid 0,05%, plus a concentration of 2% or 4% NaCl).

- temperature condition during lactic fermentation (15-19 °C or 20-25 °C).

The variants without blanching of the cucumbers brought about superior results as compared to those with blanching, for both quality of the fermented cucumbers, at the end of fermentation, and mostly for their conservation for a longer period of time.

The first were found to have a more intense color, a better looking aspect, an increased firmness, and no holes in the core, a more pleasant taste, odor and flavor. The process is completed in about 60 days, for the not blanched variants, while for the blanched ones it was completed in approx. 45 days.

The classic brined variants ("clean"), having 6% NaCl, and 1,17% of acidity (pH 3,51) at the end of fermentation, also had a good evolution, having as well in view a long-dated conservation. If only to the product quality at the end of fermentation is to be considered (irrespective of certain period of keeping), it can be accepted that the best variant is the one using the brine containing 4% NaCl, 0,25% Na benzoate, 0,25% Ca lactate and 0,05% acetylsalicylic acid, with an acidity of 1,05% (pH 3,84). When kept for a longer period, this variant brings about an insipid taste associated with the conserver savour.

Key words: cucumbers, fermentation, pickles, texture, firmness, lactic acid.

Introduction

Brined cucumbers have traditionally been held in brines with a 5-7% concentration of NaCl, for about one month, when the lactic fermentation occurs. In order to assure an adequate storage (from a few months up to one year or even more), the concentration of NaCl (those of Parma suggest 12 %) is supposed to increase up to 8-16%.

Bell and Etehells, 1961, [2], have justified the increase of NaCl concentration by securing the microbial control, preventing enzymatic softening, as well as to protect the product against freeze damage in freezing climates (where the temperature falls below – 17 °C, which is the case of Bucovina – Radauti). Keeping the casks with pickled cucumbers, two or three abreast (the last row must be submerged at least 75 cm under the water level) within ponds, rivers of lakes is also traditionally characteristic of this region.

Novaceanu, 1978, [16], proved that, in a 4-5% NaCl concentration of the brine, the cucumbers are not supposed to be preserved, at temperatures ranging between 5 to 18 °C, for a period exceeding the 21-st of March.

Fleming and others, 1987, [8], investigated the influence of $CaCl_2$ on the cucumbers pickling, preserving and especially on preventing from enzymatic softening, as well as on brines, using lower NaCl concentrations. Buescher, 1986, [5], affirms thereat, that the enzymatic protection is the most important advantage brought about by $CaCl_2$.

Looking for the most favorable NaCl concentration in brines, Fleming, 1988, [8], proved that in the case of anaerobic fermentation in (controlled) anaerobic tanks, a NaCl concentration of 2,3 % is able to secure the cucumbers pickling, but not also their preservation (they used to soften), whereas the best results are to be obtained in NaCl concentrations of 4,6 %.

In the U.S.A., the US Environmental Protection Agency issues the guideline limit of 230 ppm chloride in freshwater bodies (1987). Hence, the environmental problem (in the U.S.A.), where brines are discharged into private or municipal wastewater streams polluting the freshwater supplies thus, the task of the cleaning stations becoming more difficult.

Simultaneously with the alternative decrease of the NaCl concentration, a compensatory introduction of various preservers, in variable concentrations was also considered.

The use of $CaCl_2$ in the pickling process was applied by several authors (Fleming, Durkee, Lowe and others). They proved out its positive effect in protecting cucumbers against softening, by means of two major functions of the Ca^{2+}: the pectin macromolecules twisting, and the decrease of their demethylating process.

In 1996, Fleming, [9], worked with two experimental alternatives, namely:

- BNS (blanched, no salt) in which fresh cucumbers, blanched in water at 77 °C for 3 minutes, were covered with a saltless brine containing only a calcium acetate buffer.
- SNB (salt, no blanched) in which the cucumbers were not blanched, and the covering brine contained calcium acetate and sufficient NaCl to get a final concentration of 4,4% NaCl.

At the end of the fermentation, Na benzoate (0,1%) was added to some of the samples, and its positive effect on the pickled cucumbers microbial stability was noticed. When using Na benzoate, Fleming demonstrated that during the storage period, the propionic acid at a pH below 3,3 was no longer produced, and neither did butyric acid at a pH value below 3,7.

The blanching method (BNS) was therewith shown to produce the softening of the cucumbers as well as about 30% loss of their weight. As for this method, softening is supposed to increase with storage having a pH below 3,0, but adding 4% NaCl is certain procedure to secure a better stability of the fermented cucumbers for 12 months.

However, the influence of Na benzoate on perverting taste, especially when the preservation lasts longer, should be considered as well.

Materials and methods

Fresh cucumbers - Cornichon variety - several hybrids of this variety, supplied by Berser and Pipera greenhouses in Bucharest (Romania) were used in our experiments.

The cucumbers were 6,1 – 9 cm long, according to STAS SR 1416 – 1996 [17]. They were especially selected for experiments (in good condition, not notably desiccated or mechanically damaged), and washed in running water.

Two basic methods were applied: blanching (70 °C/3 min) followed by cooling down to 40 °C, under water jet; and no blanching.

The brine variants that were used in each procedure are shown in table 1.

Table 1. Technological alternatives used for preserving cucumbers by means of lactic fermentation

Hybrid	Alternative	Technology used	Fermentation temperature	Brine composition
LEVINA	LP_1	Unblanched / Fresh cucumbers	15-19°C	2% NaCl+ 0,55% additives
	LP_2			4% NaCl+ 0,55% additives
	LP_3			6% NaCl
	LO_1	Blanched cucumbers	15-19°C	2% NaCl+ 0,55% additives
	LO_2			4% NaCl+ 0,55% additives
	LO_3			6% NaCl
CRISPINA	CP_1	Unblanched / Fresh cucumbers	15-19°C	2% NaCl+ 0,55% additives
	CP_2			4% NaCl+ 0,55% additives
	CP_3			6% NaCl
	CO_1	Blanched cucumbers	15-19°C	2% NaCl+ 0,55% additives
	CO_2			4% NaCl+ 0,55% additives
	CO_3			6% NaCl
Unspecified	P1	Fresh cucumbers	20-25ºC	4% NaCl
	P2			5% NaCl
	P3			6% NaCl

The lactic fermentation process was carried out in lidded jars of 3000 ml, with "OMNIA" shutting system. After arranging cucumbers and adding spices, brine (at about 20°C), as well as some plastic grates, meant to assure the permanent brine submergence of the cucumbers, was used. The jars were shut tightly. After decantation, they were ocasionally stirred, so as the liquid to be homogenized.

Additives, in all the experimental variants that are supposed to contain such ones were added in the following proportions: 0,25% Ca lactate, 0,25% Na benzoate and 0,05% acetylsalicylic acid.

The fermentation temperatures of the different variants were those currently used in laboratory conditions, namely 20 – 25 °C respectively 15 – 19 °C, and the long-term storage was made in dark storage houses, at 0 – 5 °C.

The methods of work were adherent to the analysis of raw material (sensorial and biochemical), to the analysis of the fermentation process parameters (pH, acidity, concentration of NaCl in brine, microbiological) and to the analysis of the finished product (organoleptic, biochemical, microbiological).

Results and discussions

Among the major factors influencing the cucumbers lactic fermentation processing parameters there are some which are worth mentioning: the temperature of fermentation, the content of NaCl and the presence of various additives in brines, as well as the preliminary thermal treatment applied.

The effect of fermentation temperature

Having followed the pH alternative, i.e. acidity, through various variants with similar brine compositions, apart from the method with blanching and with no blanching, we noticed that, with the variants having the fermentation temperature between 20 – 25 °C, the fermentation process is completed in about 20 days, as compared to those where the fermentation temperature ranged between 15 – 19 °C, where the fermentation process lasts for about 60 days (in case of not blanched variants) – Fig. 1 and Fig. 2.

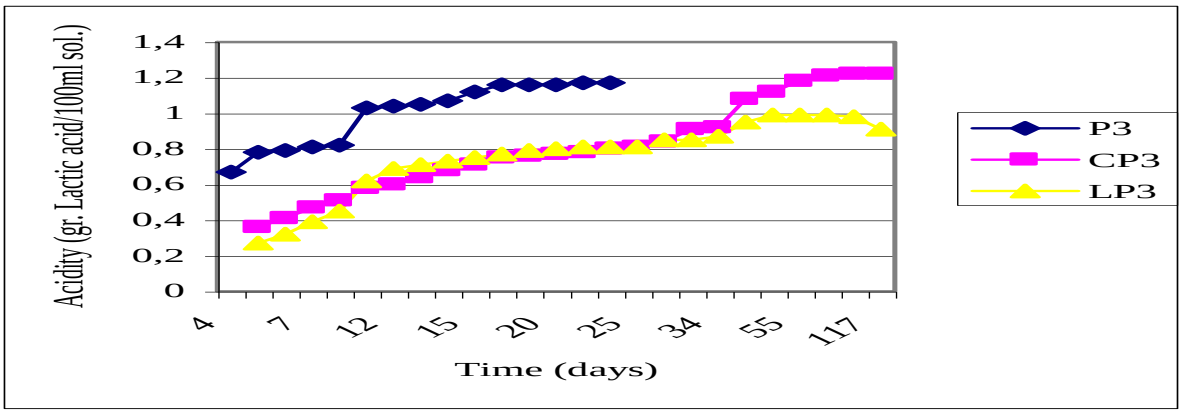

Fig. 1. Evolution of acidity during fermentation process

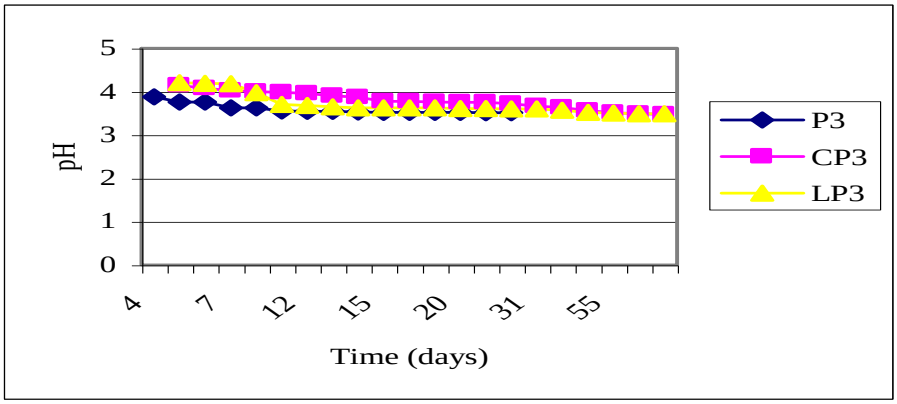

Fig. 2. Evolution of pH during fermentation process

A high fermentation temperature can also cause a quicker start of fermentation (pH lesser values, respectively acidity higher ones). As for the 20 – 25 °C fermentation, there is a pH of 3,88 (0,67% acidity), whereas with the variants fermented between 15 – 19 °C, there is a pH of 4,14 in the same day, respectively 4,20 (0,36% acidity respectively 0,27%). The final values of acidity at the end of fermentation are about 1,2% for the variants fermented between 20 – 25 °C and 1,0 – 1,2 % for those fermented between 15 – 19 °C.

The effect of brine composition (NaCl concentration and presence of various additives)

We took into account those variants having the same temperature of fermentation, in order to have the brine composition as unique variable. A quick start of fermentation (0,36% and 0,39% acidity, pH 4,14 respectively 4,41) as well as a progress superior to other variants (1,21-1,22% acidity, pH 3,47) is to be found in case of "clean" brined variants.

The variants with brines containing preservers, especially when a higher salt content is used, have slightly lower initial and final acidity values, which are supposed to alter their preserving capacities in time. Hence, with the variants having 4% NaCl and additives, the initial acidities are 0,33% and 0,25%(pH 4,6 respectively 4,87) and they accede to 1,05 and 0,87% (pH 3,84-3,80) at the end of fermentation (fig 3.and fig.4.).

According to what has been written on this special subject, a brine concentration over 4% NaCl is sure to bring about a deceleration in the lactic fermentation. But this deceleration, and impediment thereby, is much more strongly marked with those variants having brines that contain conservers, 4% NaCl at the most (respectively 2% and 4% NaCl).

It is also mentioned in the literature of the subject that a final acidity below 1% in lactic acid can cause a microbiological instability and the brine to whiten. The end of the fermentation process also infers equilibrium in NaCl concentration in fruits and brine.

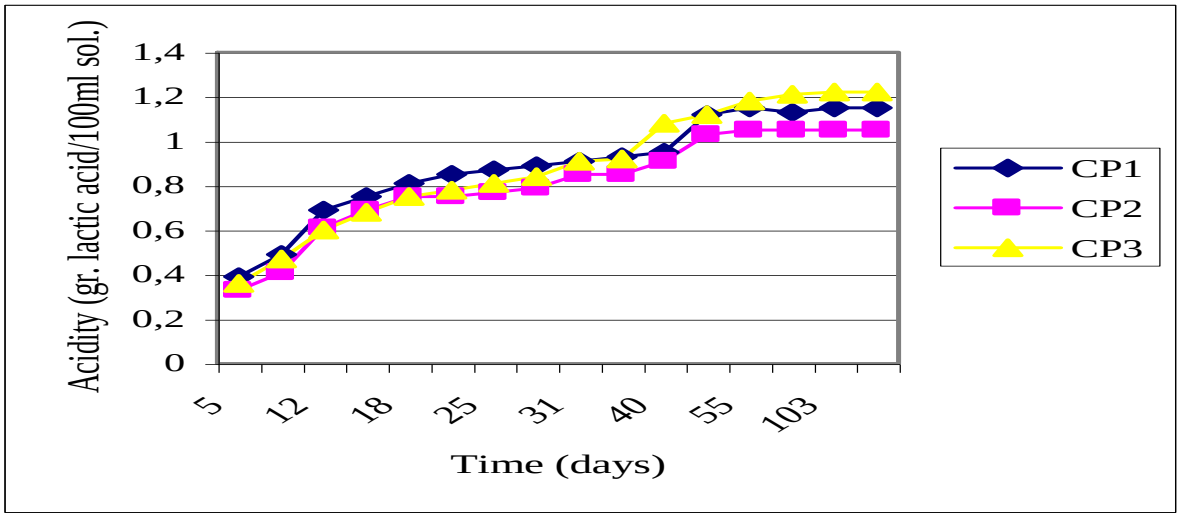

Fig. 3. Dynamics of acidity to various compounds brines (not blanched alternatives)

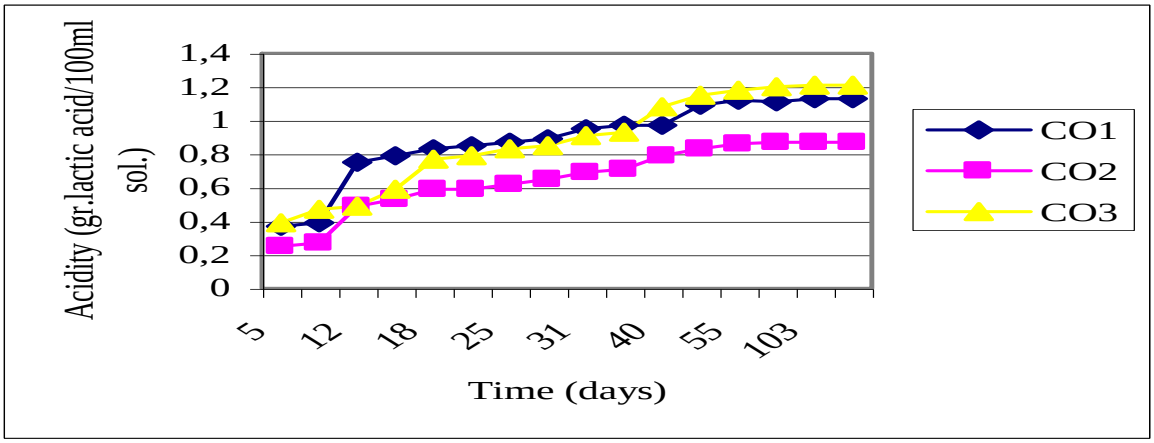

Fig. 4. Dynamics of acidity to various compounds brine (blanched alternatives)

The salt diffusion into the cucumbers is more intense at the beginning of the process and cause the brine to grow in concentration (when NaCl value is higher); but the salt diffusion is slower and insignificant at the end (after about 28 days), as concentration has been already homogeneous (see table 2).

Table 2. Variation of NaCl concentration in brines of various alternatives, during fermentation process (NaCl %)

Alternative	Fermentation day				
	12	18	28	47	117
CP1	**1,57**	**1,42**	**1,21**	**1,06**	**1,03**
CP2	**3,15**	**2,59**	**2,28**	**2,08**	**2,01**
CP3	**4,77**	**3,55**	**3,26**	**3,11**	**3,06**
CO1	**1,29**	**1,18**	**1,14**	**1,10**	**1,07**
CO2	**2,55**	**2,19**	**2,14**	**2,11**	**2,10**
CO3	**4,17**	**3,57**	**3,25**	**3,08**	**3,02**
LP1	**1,52**	**1,33**	**1,15**	**1,04**	**1,01**
LP2	**3,07**	**2,50**	**2,15**	**1,95**	**1,93**
LP3	**4,83**	**4,03**	**3,40**	**3,19**	**3,12**
LO1	**1,25**	**1,15**	**1,09**	**1,04**	**1,02**
LO2	**2,60**	**2,20**	**2,12**	**2,02**	**1,98**
LO3	**4,25**	**3,44**	**3,15**	**3,02**	**2,98**

Effect of blanching process

As to the pH variation, i.e. acidity, a higher intensity of the fermentation process is to be noticed with not blanched alternatives, especially at its beginning, gradually coming up to comparable values. The explanation of this phenomenon is that the spontaneous flora, still remaining after washing, with the not blanched variants, is favorably activating the fermentation process. We could say that a "partially controlled" fermentation is obtained by means of blanching, but the frost results (pH higher values of 4,87 and 5,02, corresponding to lower acidity-0,25%) do not seem to be a promising start. Nevertheless, having observed the pH evolution during the fermentation, one can notice sameness in values with both variants (blanched and not blanched) and even lower values with blanched variant CO2 (pH 3,80) as against CP2 (pH 3,84). (fig. 5)

This would be due to the osmosis process which is increased by blanching and which provides sugars diffusion outwards from fruits as well as their fermentation. The osmosis process improvement also provides the more intensive NaCl diffusion, being instrumental in accomplishing the fermentation process (see table 2).

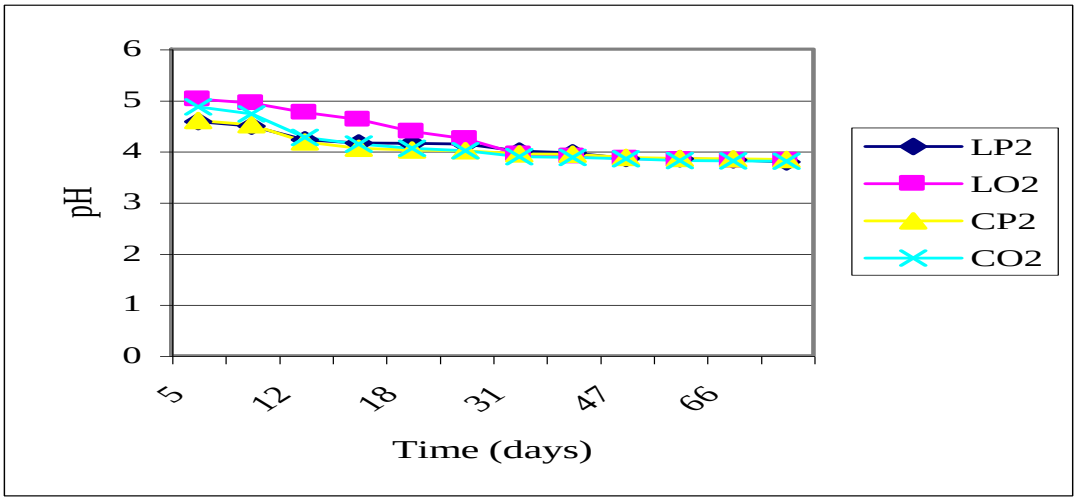

Figure 5. Variation of pH to blanched and non-blanched alternatives

Conclusions

Technological variants with no previous blanching yield better results from the organoleptical point of view (good-looking fermented cucumbers, bright color, good firmness, no holes in the core, agreeable taste and flavour), as well as from the biochemical one (a rich content in C vitamin, glucides, proteins and mineral elements).

With reference to the best recipe of brine we settled that the brine with 4% NaCl, 0,25% Ca lactate, 0,25% Na benzoate and 0,05% acetylsalicylic acid, should be also used in order to obtain products for immediate or short-term consumption. On the contrary, when long-term conservation is taken into account, the "classic" brine with 6% NaCl is best.

Conservers, such as Na benzoate, acetylsalicylic acid, can secure a good microbiological stability during the fermentation, preventing ill-timed pollutions with microorganism of different kinds. Their presence, together with NaCl, is supposed to decelerate the process of fermentation, bringing about a stagnation that will have an ill effect on the finished product, especially with the long-term preservation; the most remarkable consequence of it is an insipid taste associated to the reek of conserver (pungent or petrol-like).

Using Ca lactate has a beneficial effect, conferring firmness on the fermented vegetables, which is highly appreciated by the consumers.

References

1. ANON, J., *Food Biotechnology*, Can Just Food Science Technology J.21, 4, pg. 334-339, (1988).
2. BELL, T.A., s.a., *Influence of salt (NaCl) on pectinolytic softening of cucumbers*, J. Food Sci, **26**, 84-90, (1961).
3. BLANCHE, N., *Conserve naturale*, Ed. Coresi , Buc., 1999.
4. BOURGEOIS, C.M., s.a., *Microbiology Alimentary*, Collection Sciences et technique agroalimentaires, Technique & Documentation, Paris, 1996, V.1.
5. BUESCHER, R.W., a.o., *Bound cations in Cucumber Pickle Mesocarp Tissue as Affected by Brining and $CaCl_2$*, Journal of Food Science vol. 51, nr. 1, pg. 135-137, (1986).
6. DAN, V., *Microbiologia produselor alimentare*, Ed. Alma, Galati, 1999.
7. FLEMING, H.P., a.o., *Assuring microbial and textural stability of Fermented Cucumbers by pH Adjustment and sodium benzoate addition*, Y. Food Sci. **61**(4), 832- 836 (1996).
8. FLEMING, H.P., a.o., *Effects of sodium chloride concentration on firmness retention of cucumbers fermented and stored calcium chloride*, Y. Food Sci. **52**, 653-657 (1987).
9. FLEMING, H.P., a.o., *Fermentation of cucumbers in anaerobic tanks*, Y. Food Sci. **53**, 127-133, (1988).
10. GUILLOU, A.A., a.o., *Calcium chloride and potassium sorbate reduce sodium chloride used during natural cucumber fermentation and storage*, Y. Food Sci **57**, 1364-1368, (1992).
11. GUILLOU, A.A, a.o., *Multiresponse Optimization Minimizes Salt in Natural Cucumber Fermentation and Storage*, J. Food Sci., **58**(6), 1381-1388, (1993).
12. HUDSON, J.M., a.o., *Pectic substances and firmness of cucumber pickles as influenced by $CaCl_2$, NaCl and brine storage*, Y. Food Biochem, **9**, 211 (1985).
13. HUDSON, J.M., a.o., *Relationship between degree of pectin methylation and tissue firmness of cucumber pickles*, Y. Food Sci **51**, 138-143, (1986).
14. KYU HANG KYUNG, *Isolation and characterization of Bacteria Resistant to the Antimicrobial Activity of Garlic*, Y. Food Sci **61**(1), 226-229, (1996).
15. LUDBROOK, K.A, s.a., *Exopolysaccharide production from lactic acid bacteria isolated from fermented foods*, J. Food Sci **62**(3), 597-600 (1997).
16. MARINESCU, M, s.a., *Microbiologia conservelor vegetale acide*, Indrumari tehnice nr. 30, Institutul ptr. valorificarea legumelor si fructelor, Buc, 1977.
17 .X X X, *Standard roman. Legume proaspete* - castraveti, SR 1416 - 1996.
18. X X X, *Standard profesional* SP 25-96 - Legume conservate prin lactofermentatie- Elaborat de Min. Agric. si Alimentatiei, 1996.
19. X X X, *FAO Production Yearbook*, Vol. 52, 1998.
20. X X X, *Analytical Methods for Pesticide Residues in Foodstuffs*, Ministry of Public Health, Welfare and Sports, the Netherlands, Sixth Edition, 1996.