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DONATA ADAMSKA
JAN STEGMAN
STANISŁAW ZALEWSKI

EFFECT OF TECHNOLOGICAL PROCESS PARAMETERS ON VITAMIN C CONTENT IN COOKED CABBAGE

Warsaw Agricultural University

Key words: cabbage, technological process, vitamin C losses, chemistry rheology, organoleptic analysis

The aim of the studies was to reduce vitamin C losses in cooked cabbage by modifying the technological process. The effect of the foolowing factors on nutritive value was determined: storage of raw cabbage from autumn to spring, time of shredded cabbage storage before cooking, the method of cooking, hardness of cooking water, time of salt addition during cooking and method of storing cooked cabbage. The chemical determinations included dry mass, ash, ascorbic acid and dehydroascorbic acid contents; sensory qualities were assessed rheologically and organoleptically.

Various authors put the average vitamin C content in cabbage at anywhere between 35 and 50 mg% [2, 10-12]. The annual per capita consumption of this vegetable in Poland is around 40 kg [6] which means it may potentially cover as much as 70-80% of the vitamin C requirements in this country. Assuming that two thirds of the consumed cabbage is cooked and that half the cabbage used in cooking is stored in the form of whole unsoured heads, the technological process of cooking white cabbage affects 25% of the potential source of vitamin C required by Poland's population. Analyses of the various stages of this process should reveal where the quality of cabbage and quantity of vitamin C is affected and what can be done to reduce their losses. Unsuitable technologies in cookeries — prolonged cooking and especially hot-storage of cooked dishes — lead to considerable losses of vitamin C, often of up to 55% [5] despite its high stability in cabbage compared with other raw plants. The losses increase with the increase of storage time and are enhanced by incorrect storage [9] and faulty variety selection of cabbage to be stored [8].

MATERIAL AND METHODS

The experiments were performed with "Kamienna głowa" cabbage of the 1987 crop obtained from private sector suppliers. The cabbage was purchased in November and then stored at 5°C and 75-80% humidity until the end of April.

METHODS

The following factors were studied in order to determine their effect on vitamin C and dry mass content and quality of cooked cabbage:

— storage of raw cabbage from November to April,
— time of storage of shredded cabbage prior to cooking (0.5 and 1.5 h),
— cooking in water at 100 and 116°C and in a microwave oven,
— cooking water hardness (soft, medium hard, hard),
— time of salting during cooking (at the beginning and after cooking),
— time of warmholding after cooking at 60°C (0-3 h)
— cold storage at 5°C for 18 h followed by heating to 60°C.

Technological tests involved determinations of yield and organoleptic assessment by the method of unstructured graphic scale [1]. Each studied sample consisted of 200 g of shredded cabbage at 70 cm^3 of boiling water, and 3 g of salt. The selected chemical indicators of nutritive value — dry mass, ash, ascorbic acid and dehydroascorbic acid contents — were determined according to the Polish Standards PN-71/A 75101. In all experiments the cabbage was cooked to optimum consistency determined organoleptically during preliminary tests and then controlled objectively with a Labor penetrometer (3 cm layer in 10 repetitions).

The results of organoloptic tests are arithmetic means of 7-9 determinations in each of the two repetitions that were made, and results of analytical determinations are means of figures from three parallel samples in three repetitions. The results were analysed statistically, with standard deviation and significance of differences being determined with the U_R test [13].

RESULTS AND DISCUSSION

The effect of temperature and manner of cooking on vitamin C losses in cabbage is illustrated in Fig 1. In a pressure cooker the desired consistency of cabbage was obtained after 7 min as compared with 17 min during traditional cooking at 100°C. Cooking time was thus reduced 2.5-fold, and the temperature coefficient of cabbage softening at a 10° temperature increase (in the 100-116°C range) was 1.6; the corresponding vitamin C losses coeficient was 1.2 which means that increasing cooking temperature did more to soften the cabbage than to decompose vitamin C, leading to a ca 10% better retention of this vitamin in cabbage cooked in a pressure cooker. The microwave oven reduced cooking time by only about one third as compared to the traditional method, a result far worse than the 5- and 10-fold reductions reported in the literature [7]. Ascorbic and dehydroascorbic acid content in microwave treated cabbage only slightly higher than in cabbage traditionally cooked in water at 100°C. It seems therefore advisable to cook cabbage at higher pressure; the microwave oven slightly reduced cooking time without significantly affecting the behaviour of vitamin C in the cooked vegetable.

As can be seen in Fig. 1, ascorbic acid losses were almost twice higher than total vitamin C losses. Hence, the rate of ascorbic acid transformation into dehydroascorbic acid is higher than the further decomposition of the latter, the result of this being that although ascorbic acid predominates in raw cabbage, the contents of both forms of vitamin C are more or less equal after cooking. Worth noting is the considerable stability of vitamin C in cabbage, ranging from 68 to 76% depending on the method of cooking. The method of cooking had no effect on dry mass and ash losses which amounted to 40 and 50%, respectively, in all three kinds of thermal treatment.

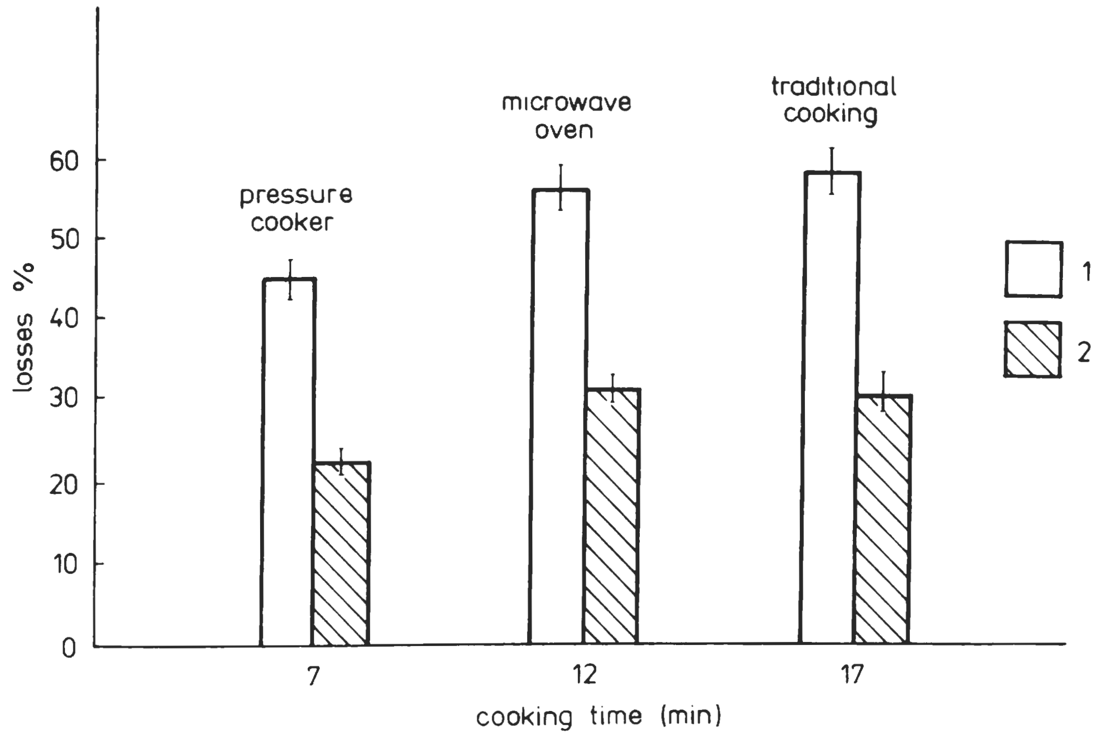

Fig. 1. Effect of cooking method on time of cooking and vitamin C losses in cooked cabbage

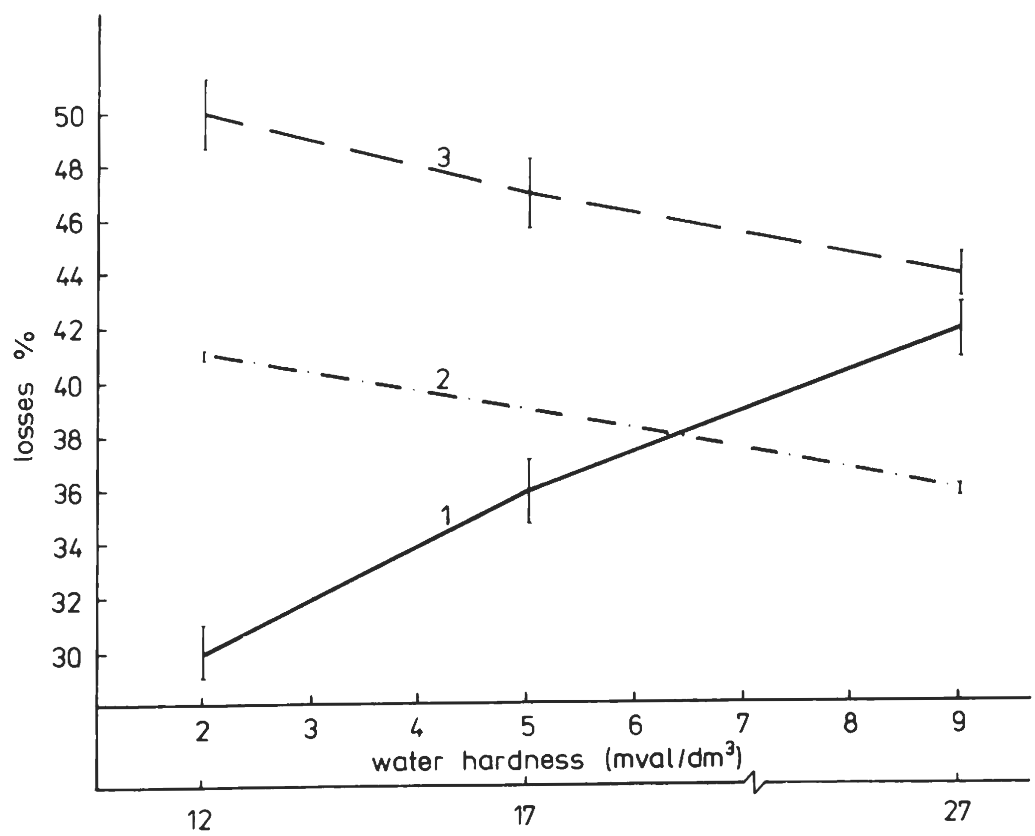

Fig. 2. Effect of water hardness on losses of nutritive components in cooked cabbage; 1 — witamin C, 2 — dry mass, 3 — ash

Observing the actual procedure employed in cookeries, we found that in most cases the cabbage is shredded 0.5-1.5 h before cooking. Accordingly, in our experiments we cooked the cabbage traditionally at 100°C 0.0, 0.5 and 1.5 h after shredding. The differences in vitamin C contents in cabbage samples cooked at various time intevals after shredding were insignificant. The losses of ascorbic and dehydroascorbic acids (compared with untreated cabbage) were 53 and 30%, respectively, in the case of cabbage cooked immediately after shredding, 56 and 32% in cabbage cooked 0.5 h after shredding, and 58 and 34% in cabbage cooked 1.5 h after shredding. The considerable stability of vitamin C in cabbage,

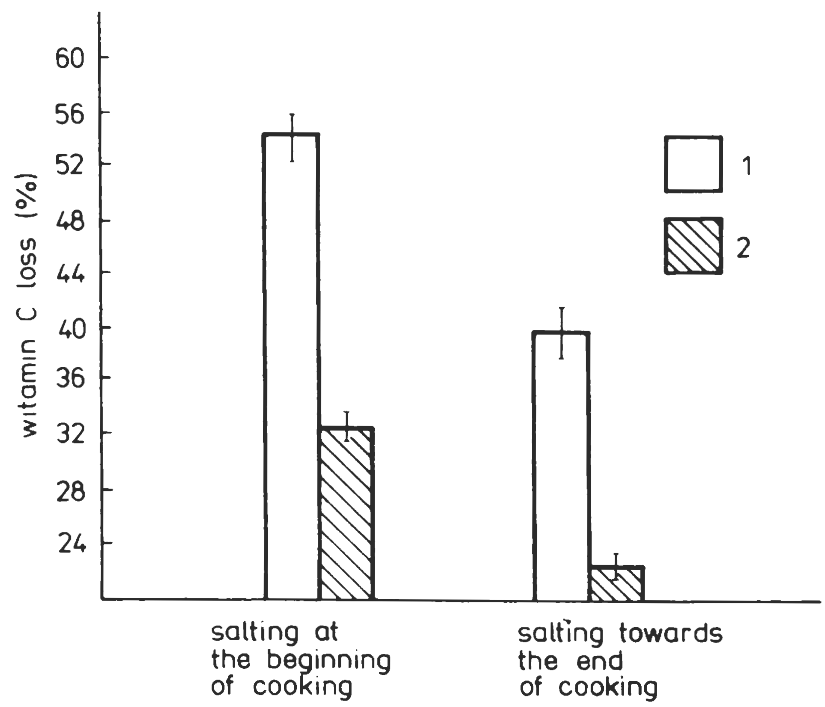

Fig. 3. Effect of time of salting in vitamin C content in cooked cabbage; 1 — ascorbic acid, 2 — ascorbic and dehydroascorbic acids

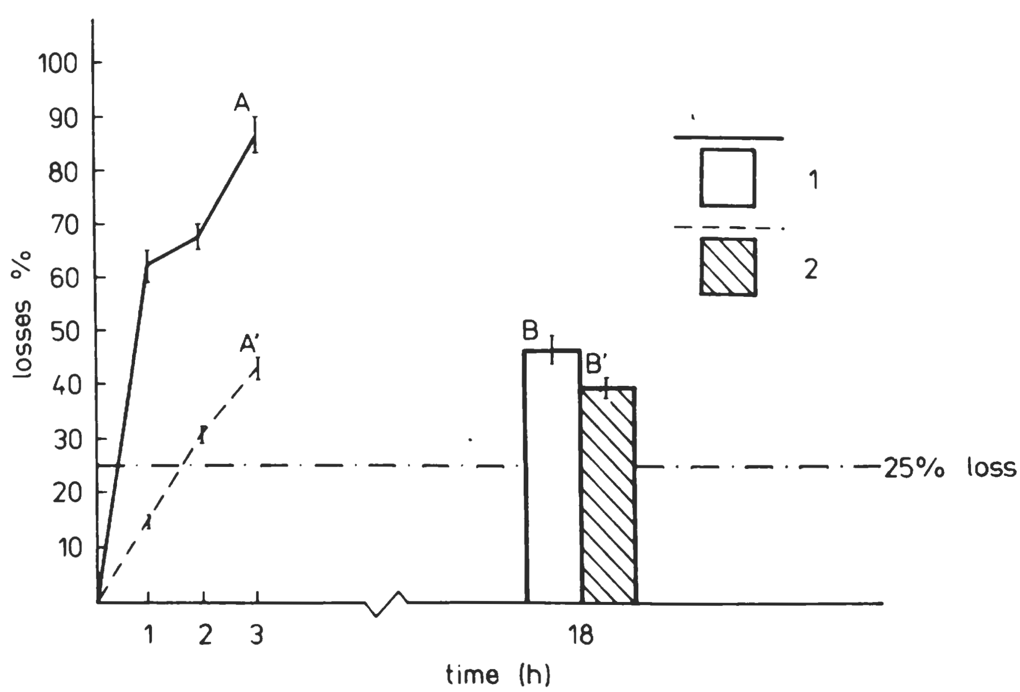

Fig. 4. Effect of time and manner of storing cooked cabbage on vitamin C losses; A, A' — storing at 60°C; B, B' — storing at 5°C for 18 h followed by heating to 60°C; 1 — ascorbic acid, 2 — ascorbic and dehydroascorbic acids

compared with other vegetables, was thus confirmed. It remained fairly stable even when the cabbage was shredded and exposed to oxygen and light [3, 4, 14].

In further experiments we found a significant effect of water hardness on the time of cooking to the desired consistency. At 2, 5 and 9 mval water hardness, cooking times were 12, 17 and 27 min, respectively. The losses of vitamin C during cooking in water of the various hardnesses increased with the increase of cooking time, and the differences were in all three cases statistically significant. An interesting regularity was observed: despite the prolongation of thermal processing caused by increasing hardness of water, the losses of dry mass and ash decreased, and the obtained results were all statistically significant. This phenomenon is most probably due to inhibition of elution resulting from the action of calcium and magnesium ions in the harder waters on the inner lamina and cell membrane.

Experimenting with salt additions, we found that it is better to salt the cabbage at the end of cooking. Salting at the beginning of the process led to a 55%

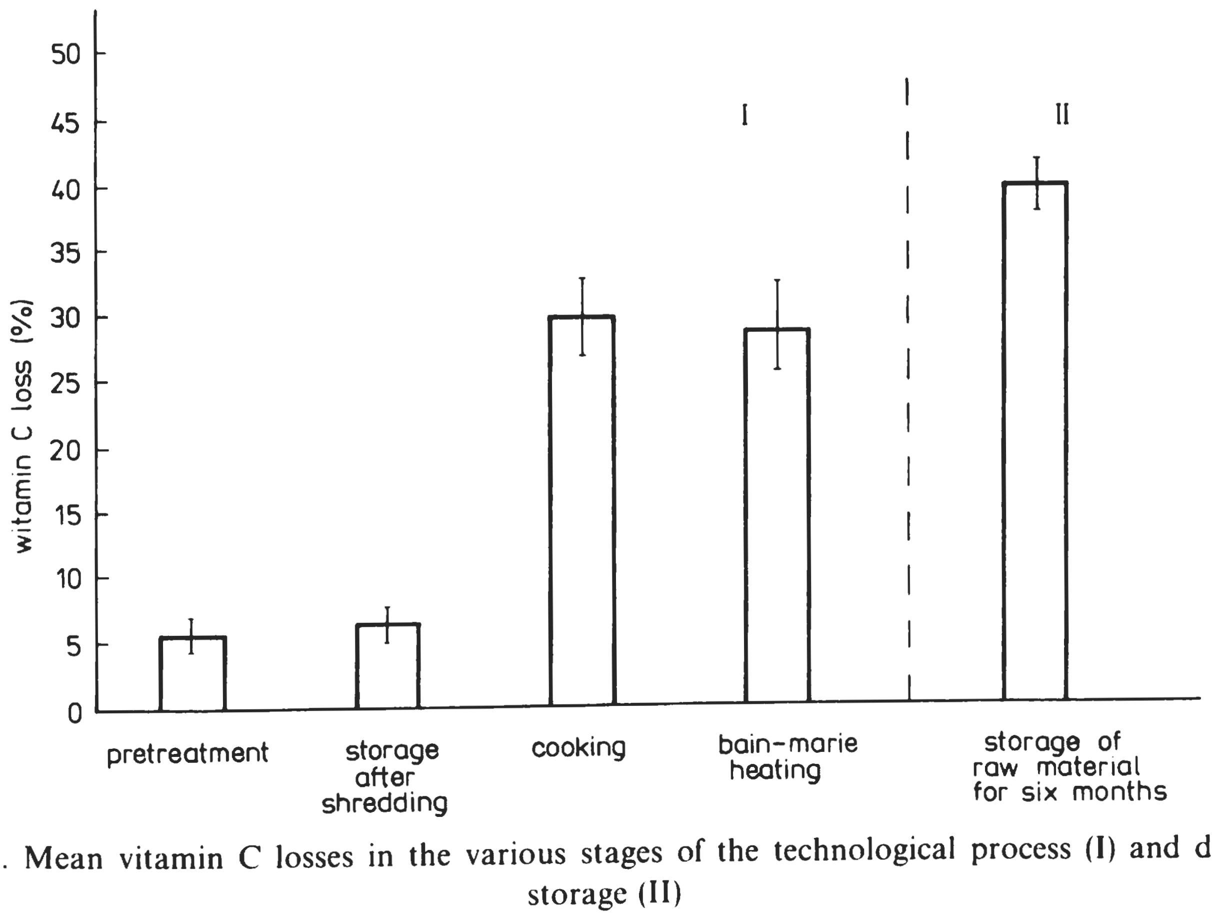

Fig. 5. Mean vitamin C losses in the various stages of the technological process (I) and during storage (II)

loss of ascorbic acid and 33% loss of vitamin C while in cabbage salted at the end of cooking the figures were 40 and 23% respectively. The moment of salt addition had no effect on the time of cooking the cabbage to the desired consistency. The better preservation of vitamin C in cabbage salted in the final stages of cooking may be due to the fact that a 1.5% salt addition causes plasmolysis aiding the migration of cell content to the water.

Other experiments revealed that one of the critical stages of processing is warmholding of cooked cabbage at 60-70°C. Fig. 4 shows that the drop of total vitamin C content was proportional during three successive hours of warmholding at 60°C, and slower than the drop of ascorbic acid content, similarly as in the case of cooking. The cooling of cooked cabbage to 4°C clearly stabilized vitamin C content. In the cooled cabbage stored for 18 h and then reheated to 60°C, the decrease of total vitamin C content was the same as after three hours of warmholding treatment (43%) but cooked cabbage contained more ascorbic acid than warmholded one.

The conclusions from experiments concerning vitamin C losses during the technological process are that the most critical stages are traditional cooking at 100°C (ca 30% loss) and warmholding (ca 29% loss). Pretreatment (6% loss) and storage of cabbage after shredding (7% loss) have only a slight effect on the vitamin C content in cooked cabbage (Fig. 5).

In view of our results, we propose to abandon traditional cooking technologies used till now in favour of cooking cabbage in a pressure cooker and adding salt once the vegetable is cooked. In our experiments with this method we obtained a 14% better retention of vitamin C in the cabbage. This is a relatively modest gain but one calculated in relation to the optimal cooking procedure of small portions of cabbage. When greater quantities are cooked, both in households and cookeries, by the typical methods, the gains will be higher. The sum total of gains in the various stages of the cooking process, calculated from the potentially avoidable vitamin C losses, is 30%.

The vitamin C content in cooked cabbage also depends to a considerable extent on the season of the year, i.e. on changes in the vagetable during storage. Mass loss in cabbage stored from November amounted to 20.4% in January and 39% in April. At the same time the ascorbic acid and vitamin C contents dropped from 37 and 47 mg% respectively, in November to 26 and 29 mg% in April. This indicates that storage, unlike cooking and warmholding, is more conducive to

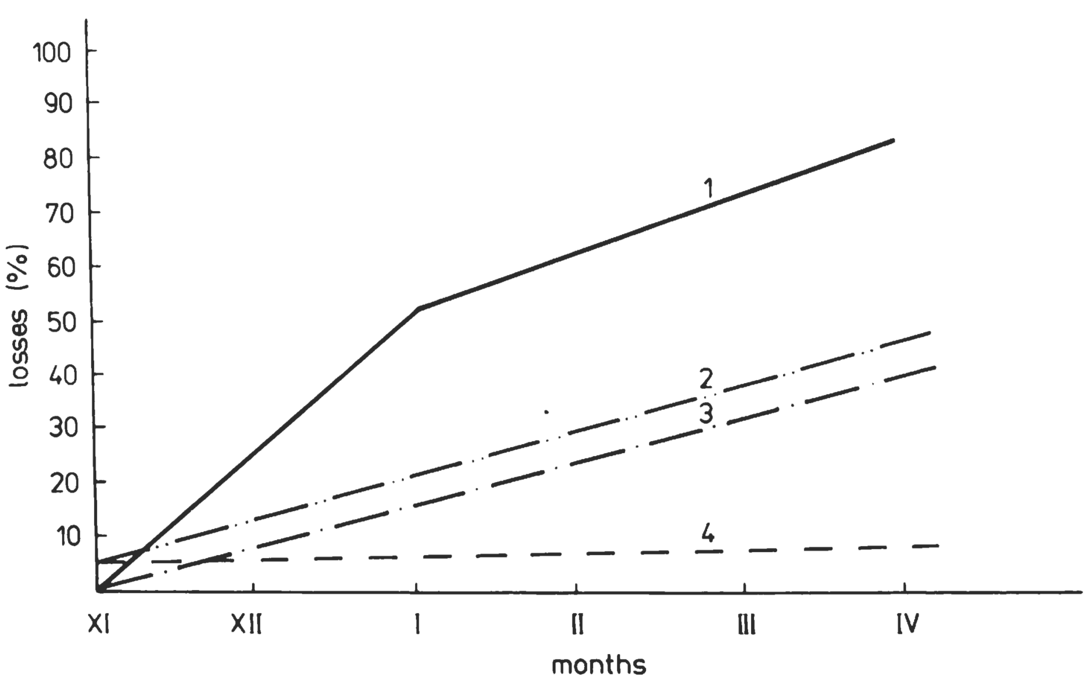

Fig. 6. Effect of storage on vitamin C and mass losses in raw cabbage; 1 — total vitamin C losses due to pretreatment and storage, 2 — total mass losses, 3 — storage losses, 4 — pretreatment losses

further transformations of dehydroascorbic acid than to oxidation of ascorbic acid, the result being that in raw material stored for a long time only a small proportion of vitamin C is in the form of dehydroascorbic acid.

As regards vitamin C losses from field to consumer plate in cabbage during storage (Fig. 6) one must consider natural losses during pretreatment and additive losses of the vitamin in the raw material mass. The latter cumulate during storage, attaining 25% in December, 63% in February and as much as 84% in April. Given this fact, we believe that statistical and production data concerning cabbage as a vitamin C source in the Polish diet must be modified. One way of doing this is to use the mean vitamin C content half way through storage (February). This figure will reduce the initial estimates that cabbage is a potential source of 70% of vitamin C required in the diet by about half — to 30-35% — and only once this corection is made it is possible to reliably estimate losses in technological processes (souring, salads production, cooking, etc.). Despite the high losses of vitamin C during storage, further compounded by technological processes, cooked white cabbage nevertheless remains its valuable source: even towards the end of the storage period (April) 150 g of cabbage immediately after cooking contains 24 mg of vitamin C which amounts to 30% of the daily requirement. Nutrition experts believe that vegetables consumed with the second course of the main meal ought to provide at least 20% of the required daily intake of vitamin C. This serving of boiled cabbage satisfies this requirement, even at the end of the storage period and after 3 h of warmholding heating.

CONCLUSIONS

1. The mean losses of vitamin C in the various stages of the technological process are:
   — 6% during pretreatment,
   — 7% during storage after shredding (1.5 h),
   — 30% during cooking,
   — 29% during warmholding (3 h).
2. During six months of storage cabbage mass decreases by 39% and vitamin C content also by 39%, while dry mass and ash contents increase slightly (by 6.8 and 8.1%, respectively).
3. The determined advantageous parameters of the technological process (cooking cabbage immediately after shredding in soft water in a pressure cooker, salt addition after cooking) reduce vitamin C losses by 14% compared with the traditional method of cooking.
4. Cooked white cabbage turned out to be a good source of vitamin C. A 150 g serving of freshly cooked cabbage provided from 70% (November) to 30% (April) of the required daily dose of this vitamin.
5. In statistical data speaking of a 40 kg annual per capita consumption of cabbage allowance must be made for vitamin C losses during storage, pretreat-

ment, and technological processing. Losses during storage amount to 25% till December, 63% till February, and 84% till April (compared to newly harvested regetable) and these figures must be taken into account when calculating the amounts of vitamin C actually found in cooked or otherwise processed cabbage.

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Authors address: 02-975 Warszawa, Nowoursynowska 166

D. Adamska, J. Stegman, S. Zalewski

WPŁYW PARAMETRÓW PROCESU TECHNOLOGICZNEGO NA ZAWARTOŚĆ WITAMINY C W GOTOWANEJ KAPUŚCIE

Instytut Żywienia Człowieka SGGW-AR, Warszawa

S t r e s z c z e n i e

Przebadano wpływ: cyklu przechowalniczego (6 mies.), czasu przechowywania kapusty po poszatkowaniu a przed gotowaniem (0-1,5 h), sposobu gotowania (100°C, 116°C i w mikrofalach), twardości wody i momentu solenia, czasu bemarowania (0-3 h) oraz przechowywania chłodniczego po gotowaniu (18 h) — na zawartość kwasu askorbinowego, witaminy C, suchej masy i jakość kapusty gotowanej. Stwierdzono, że straty wit. C podczas obróbki wstępnej (szatkowanie) i przechowywania po szatkowaniu są niewielkie — odpowiednio 6 i 7%, podczas gdy gotowanie i bemarowanie prowadzi do znacznych strat wit. C — 30 i 29%, podobnie jak 6-miesięczny cykl przechowalniczy (39%). Korzystnie na zachowanie wit. C wpłynęło gotowanie w wodzie miękkiej i solenie po ugotowaniu (14% poprawy). Porcja gotowanej kapusty (150 g) jest dobrym źródłem wit. C pokrywając w listopadzie 70%, a w kwietniu 30% dziennego zapotrzebowania. Dane bilansowe dotyczące udziału kapusty w pokryciu zapotrzebowania na wit. C powinny uwzględniać straty cyklu przechowalniczego, które do kwietnia, łącznie ze stratami masy, sięgają 80%.

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Streszczenie

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