1281

A STUDY OF THE EFFECT OF PROCESSING SEQUENCES ON FLAVOUR OF HTST STERILIZED EVAPORATED MILK

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INTRODUCTION

IT is well known that the cooked flavour and dark colour of evaporated milk are definitely less when sterilization is accomplished by high-temperature, short-time (HTST) methods instead of by the conventional methods. HTST sterilization may be conducted in the cans, or by a continuous-flow process followed by aseptic canning. Disadvantages of the HTST process include frequent gel formation in the stored product, and more rapid fat separation particularly when homogenization precedes sterilization; and homogenization must precede sterilization when the "in-can" process is used.

Research directed towards diminishing the gelling tendency and fat separation has considered such factors as pre-sterilization heat treatment of the concentrate (7), addition of colloidal stabilizers (1) and an increase in the sterilizing time far exceeding that necessary for bacterial sterility (5). Pre-sterilization heating of milk is universally used in the industry to control the heat stability and viscosity of the finished product. Excessive pre-heating, however, may partially nullify the advantage of a lessened cooked flavour which is gained by HTST sterilization. This factor may be particularly important when the goal is a sterile concentrate which will make a satisfactory beverage milk.

The purpose of this work was to compare the effect of various pre-heat treatments on the development of cooked flavour and on the relative beverage qualities of HTST sterilized concentrated milks.

EXPERIMENTAL

Equipment

The sterilizer was a Mallory small-tube heat-exchanger with heating, holding and cooling sections arranged essentially as described by Curran *et al.* (4). In addition, a homogenizing valve, vacuum pan and aseptic canning device, in that order, were

connected to the outlet end of the cooling section. With this arrangement it was possible to homogenize and condense milk under aseptic conditions. In order to homogenize in this sequence, it was necessary for the entire tubular equipment to withstand the homogenizing pressure of 3,000 lb/sq. in.

Processing procedure

Mixed herd-milk was standardized to a solids-not-fat : fat ratio of 2·25 and then divided into 4 lots, which were treated according to the following sequence of operations:

Lot A was preheated to 145°F for 30 min, concentrated, sterilized, homogenized and aseptically canned.

Lot B was preheated to 194°F for 20 min, concentrated, sterilized, homogenized and aseptically canned.

Lot C differed from Lot B in only one respect. The concentrate was given an additional forewarming treatment of 200°F for 30 min.

Lot D differed from Lot B in only one respect. It was concentrated after sterilization instead of before.

All lots were concentrated to 26·0% total solids. Sterilization was at 278°F for 15 sec. Homogenization was at 3,000 lb/sq. in. and 135°F. The sterile, homogenized products were further cooled to about 100°F just before they were canned. When concentration preceded sterilization it was carried out in a separate unit.

The pre-heat treatment given lot A is an accepted pasteurization procedure. The pre-heat treatment given lots B and D approximates to the forewarming used in some commercial operations. The additional heat treatment given to the concentrate of lot C has been recommended as a means of controlling gelation during storage (7). This treatment results in practically complete denaturation of serum proteins and the development of a heated flavour.

Several small cans of each lot were stored at 40° and 70°F. Flavour comparisons were made initially and after 3, 7 and 18 weeks of storage.

Organoleptic evaluation procedure

The paired comparison design of taste testing described by Terry *et al.* (8) was used for evaluating the relative qualities of the samples. This design uses ranked data obtained by pair-wise comparisons of more than 2 samples. It is only necessary with this design that a judge be qualified properly to evaluate the attribute being considered. The judging panel participating in this study was selected for their taste acuity for various milk off-flavours and for their consistency as a group (6).

With this method, each judge is presented with one pair at a time. He then selects the sample having more (or less) of the specified attribute. This sample is assigned a rank of 2, the other a rank of 1. For a consistent taste panel, these values are additive for each sample and each repetition. The sum of these ranks constitutes the test data required for analysis. Analysis is made by arranging the rank totals in ascending order, and using tables which have been prepared to facilitate interpretation (2, 3).

One column in the tables gives the level of significant differences in the data. If this value is less than the predetermined level ($P < 0{\cdot}01$ in this case), one may proceed to interpret the estimated sample ratings.

The milks judged in this study were reconstituted to 12·5% total solids, brought to a temperature of 70°F and presented in pairs to each of 6 judges. About 3 min were allowed for tasting each pair. Each judge was presented with each pair in duplicate. Thus, there were 12 replicate decisions for each pair.

A fresh market milk was included in each session, making a total of 5 samples.

At the initial taste session the panel was asked to choose the sample of a pair which had the most cooked flavour. Initially, it was planned to have the panel make a choice on the basis of cooked flavour throughout the storage period. However, other off-flavours developed in some of the samples during storage and they obscured the cooked flavour. These off-flavours were not easily described. Therefore, at the remaining sessions, the panel was instructed to indicate the sample which had the most "off-flavour", or which was less desirable as a beverage milk.

RESULTS AND DISCUSSION

The sum of the panel ranks and corresponding sample ratings (*p*-values) for each session during the storage period are given in Table 1. The samples designated A, B, C

TABLE 1

Flavour ranks and corresponding ratings (p-*values*) *of evaporated milks made under different manufacturing conditions*

Taste session number	*Storage period and temperature*		*Milks with corresponding rank and* p-*value*			
1	Initial	Sample	D	B	A	C
		Rank	42	49	58	67
		p-value	0·61	0·26	0·10	0·03
2	3 weeks, 40°F	Sample	D	A	B	C
		Rank	41	45	59	71
		p-value	0·62	0·34	0·04	0·00
3	3 weeks, 70°F	Sample	A	D	B	C
		Rank	42	45	59	70
		p-value	0·56	0·37	0·06	0·01
4	7 weeks, 40°F	Sample	A	D	B	C
		Rank	40	45	60	71
		p-value	0·69	0·29	0·02	0·00
5	7 weeks, 70°C	Sample	A	D	B	C
		Rank	41	50	55	70
		p-value	0·66	0·21	0·12	0·01
6	18 weeks, 40°F	Sample	D	A	B	C
		Rank	42	47	55	72
		p-value	0·58	0·31	0·11	0·00
7	18 weeks, 70°F	Sample	A	D	C	B
		Rank	24	27	28	29
		p-value	0·39	0·24	0·20	0·17

and D correspond to the experimental lots described above. The fresh milk, X, was chosen as the better sample in practically every pair during sessions 3, 5, 6 and 7. In such cases the tabulated p-value for fresh milk becomes 1·00, and that of each of the others is zero. Therefore, it would be impossible to distinguish differences between the experimental samples. Consequently, the ranks involving the fresh milk were omitted from this table.

Pairwise comparisons may be made by expressing the results as a probability that sample A, for example, would be preferred over sample B. This probability is estimated to be $\frac{p_A}{p_A + p_B}$, where p_A and p_B are the p-values found in the table for samples A and B, respectively.

A complete tabulation of these probabilities is given in Table 2. These values include the data involving the fresh milk during the initial session and after 3 and 7 weeks of storage at 40°F. In interpreting these values, for example, the first value in column (3), 0·78, means that one would expect sample X to be rated over sample D 78 times out of 100 pairings between these two samples.

General trends in relative comparisons of the samples may be more readily seen in Table 1 than Table 2. However, one is cautioned against using the order of ranks to compare differences in specific cases. The magnitude of differences in p-values, and probability ratings in Table 2 are a better indication of significant differences.

TABLE 2

Probabilities that sample in column (1) would be preferred over sample in column (2)

			Storage time and temperature					
			3 weeks		*7 weeks*		*18 weeks*	
Sample		*Initial*	*40°F*	*70°F*	*40°F*	*70°F*	*40°F*	*70°F*
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
X	D	0·78	0·68		0·93			
X	B	0·89	0·79		0·99			
X	A	0·96	0·95		0·83			
X	C	0·97	1·00		1·00			
D	B	0·70	0·90	0·86	0·86	0·64	0·84	*
D	A	0·86	0·63	0·40	0·29	0·24	0·65	*
D	C	0·91	1·00	0·97	1·00	0·95	1·00	*
B	A	0·73	0·17	0·10	0·06	0·15	0·26	*
B	C	0·80	1·00	0·86	1·00	0·92	1·00	*
A	C	0·60	1·00	0·98	1·00	0·99	1·00	*

* Milks were not significantly different at the predetermined level of probability.

Sample C was chosen as the less preferable, or most cooked, at all except the final taste session. It will be recalled that the concentrate of lot C was heated to 200°F for 30 min in addition to the usual forewarming treatment.

The probability of preferring evaporated milk A, B and D over C was 1·00 (Table 2) throughout the storage period at 40°F. The relative standing of C was a little better after 3 and 7 weeks at 70°F, and practically equal to the others after 18 weeks at 70°F. These data indicate that the development of undesirable flavours was more rapid in the milks given the milder pre-heat treatments when stored at 70°F.

Sample B was rated next to the last during most of the storage period. It received

the same processing treatment as C except for the additional heating of the concentrate which the latter received.

Samples A and D were ranked above the other 2 during all sessions except initially, when B received a slightly higher rating than A (Table 1). Since D and B received the same treatment, except that D was concentrated after sterilization, these data indicate that part of the heated flavour resulting from forewarming and sterilizing is volatile, and that a significant improvement in flavour can be made by aseptic concentration.

Sample A, which received only a pasteurization treatment prior to sterilization, was significantly better (except when freshly made) than B, which was forewarmed at 194°F for 20 min.

The fresh milk was ranked first at all sessions. This was particularly true when compared with the evaporated milks stored at 70°F for 3 or more weeks. However, initially and after 3 and 7 weeks at 40°F, a few preferences were expressed for evaporated milks A and D when paired with the fresh milk. The choice of evaporated milks over the fresh milk was less frequent after 7 weeks at 40°F. This trend is shown in Table 2 by the gradual increase in probability of rating the fresh milk over the sterile milks with age. Assuming the fresh milk to be consistent in quality during this study, this trend gives some information on the changes in flavour of the stored evaporated milks. For example, deterioration in flavour was more rapid at 70°F than at 40°F. It should be emphasized, however, that it is not the primary purpose of this taste-testing design to show changes in quality, but rather to show relative merits with respect to some specific attribute.

Added information was obtained by asking the panel members to comment voluntarily on the flavour quality of the sterile milks. Initially and after 3 weeks of storage at both temperatures and after 7 weeks at 40°F, several favourable comments on beverage quality were expressed with respect to samples A and D. Such comments as "slight or trace of heated flavour", "slight cooked but pleasing", "good milk, and slightly astringent" were made. Less favourable comments were made on sample C. After 7 weeks at 70°F and after 18 weeks at both temperatures such comments as "slight stale or storage taste" were made. After 18 weeks at 70°F the comments indicated disapproval of all the milks as beverage milks.

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SUMMARY

The effects of variations in pre-sterilization heat treatments and of concentrating before and after sterilization on cooked flavour and relative beverage quality of high-temperature, short-time (HTST) sterilized evaporated milks were studied.

A paired comparison design of ranking the flavour qualities of the samples was used. The milks were reconstituted before tasting.

(i) During storage at 40°F and 70°F for 18 weeks, milk pre-heated to 145°F for 30 min was preferred over that preheated to 194°F for 20 min.

(ii) Heating the concentrate to 200°F for 30 min in addition to forewarming at 194°F for 20 min resulted in a more cooked flavour and a less-satisfactory beverage milk than when milder pre-heat treatments were given.

(iii) Concentration of milk preheated to 194°F for 20 min after sterilization resulted in a higher ranking than when the concentration was done before sterilization.

(iv) Storage at 40°F resulted in a higher relative standing for the milks given the milder preheat treatments than storage at 70°F.

(v) The milk heated to 145°F for 30 min, and that heated to 194°F for 20 min and concentrated after sterilization, received fairly satisfactoryratings as beverage milks initially and when stored at 40°F for a few weeks. However, they were less preferred than fresh market milk.

UNE ETUDE DE L'INFLUENCE DES PHASES DU TRAITEMENT SUR LA SAVEUR DU LAIT EVAPORE STERILISE PAR PROCEDE RAPIDE A HAUTE TEMPERATURE

RESUME

On a étudié l'influence des variations du traitement par la chaleur avant la stérilisation et de la concentration avant et après la stérilisation sur le goût de cuisson et sur la qualité de boisson du lait évaporé stérilisé par procédé rapide à haute température.

On s'est servi d'un système de comparaison par paires afin d'établir une hierarchie de la qualité du goût des échantillons. Le lait était reconstitué avant qu'on en goûtait.

(i) Lorsqu'il était conservé à la température de 40°F ou de 70°F pendant 18 semaines, le lait qui avait été préalablement chauffé à une température de 145°F pendant 30 min fut trouvé meilleur que le lait préalablement chauffé à une température de 194°F pendant 20 min.

(ii) En chauffant le lait concentré à une température de 200°F pendant 30 min après l'avoir préalablement chauffé à une température de 194°F pendant 20 min, on a obtenu un goût de cuisson plus prononcé et un lait considéré comme moins satisfaisant en tant que boisson que lorsqu'on avait appliqué préalablement un traitement par la chaleur plus modéré.

(iii) En concentrant après la stérilisation de lait chauffé préalablement à une température de 194°F pendant 20 min, on a obtenu de meilleurs résultats que lorsque la concentration avait lieu avant la stérilisation.

(iv) En conservant à une température de 40°F le lait auquel on avait appliqué préalablement un traitement par la chaleur modéré on a obtenu des résultats relativement meilleurs qu'en le conservant à une température de 70°F.

(v) Le lait chauffé à une température de 145°F pendant 30 min, ou à tempérture de 194°F pendant 20 min, et concentré après la stérilisation, fut trouvé une boisson fort satisfaisante tant immédiatement après le traitement qu'après avoir été conservé pendant quelques semaines à une température de 40°F. Cepandant, il fut trouvé moins satisfaisant que le lait frais.

EINE STUDIE ÜBER DIE WIRKUNG VON EINSTUFUNGSVERFAHREN IN BEZUG AUF DEN GESCHMACK VON HOHER TEMPERATUR, KURZFRISTIGER, STERILISIERTER, EVAPORIERTER MILCH

ZUSAMMENFASSUNG

Das Studium beschränkte sich auf die Wirkung von Variationen in vorsterilisierten Hitzeverfahren und auf Konzentration bevor oder nach Sterilisation, auf gekochten Geschmack und relativer Qualität von Getränken von hoher Temperatur, kurzfristiger sterilisierter Milch (HTST).

Eine gepaarte Vergleichsliste in Einstufung der Geschmacksqualitäten der Muster wurde verwendet. Milch wurde vor dem Schmecken rekonstituiert.

(i) Milch die durch 18 Wochen zwischen 40°F und 70°F gelagert wurde, und auf 145°F durch 30 Min vorehitzt wurde, wurde Milch die auf 194°F durch 20 Min vorerhitzt wurde, vorgezogen.

(ii) Erhitzung des konzentrierten Produkts auf 200°F durch 30 Min zusätzlich zur Vorwärmung auf 194°F durch 20 Min, ergab einen mehr gekochten Geschmack und ein weniger befriedigendes Milchgetränk, als wenn niedere Vorhitzeverfahren angewendet wurden.

(iii) Konzentration der Milch, vorgewärmt auf 194°F durch 20 Min nach Sterilisation, ergab eine höhere Einstufung, als wenn die Konzentration vor der Sterilisation vorgenommen wurde.

(iv) Lagerung in 40°F ergab eine relatif höhere Einstufung, als Milch, die dem niederen Vorhitzeverfahren ausgesetzt war, als Lagerung in 70°F.

(v) Milch erhitzt auf 145°F durch 30 Min, und erhitzt auf 194°F durch 20 Min und konzentriert nach Sterilisation, erhielt anfänglich eine leidlich befriedigende Einstufung als Milchgetränk und wenn sie in 40°F für einige Wochen gelagert wurde. Jedoch, wurde sie nicht frischer Marktmilch vorgezogen.