The Production of Quick-Tempered Shortenings

G. W. REIGEL and C. E. McMICHAEL, Votator Division, Chemetron Corporation, Louisville, Kentucky

Abstract

The post-cooling of high-ratio and all-purpose shortenings in a specially designed chiller, coupled with agitation during that cooling, has made it commercially practical to ship these bulk shortenings to the consumer within 24 hours after they have been packed.

This should result in floor-space saving, lower handling costs, and an improvement in product uniformity.

The Process of Tempering

MOST TECHNOLOGISTS agree that a shortening is tempered when the crystal structure of solids, which entraps the liquid phase, comes to equilibrium by forming a desirably stable crystal matrix. Bailey (1) liked to use the word "unmixing" in describing what happens in the tempering process. The mixture of low-melting and high-melting components of the solids undergoes a transformation in which the low-melting ones remelt and then recrystallize in a higher melting, more stable form. This process may take from 1 day to 10 days or more, depending upon the shortening formulation, the size of the package, and the storage conditions. After the packaged shortening takes its initial set, there are invariably some alpha crystals present. These may transform in the solid state or they may remelt and slowly recrystallize in the beta prime form during tempering. Some beta crystals may also be formed during this process. The beta prime form is the desirable one for plastic shortening. The size of the crystals forming the lattice which entraps the liquid affects the quality of the bakery products made with the shortening as reported by Hoerr and Ziemba (2).

Plasticizing of Shortenings

Plastic shortenings are usually made by incorporating a gas into the fat as it enters the intake side of a pump which feeds a scraped-surface chiller, commonly known as an "A" unit. The fat-gas mixture is rapidly chilled to a point at which it is supercooled. It then passes through an agitated section, commonly known as a "B" unit, where crystallization is almost completed. The now semifluid plastic shortening passes through an extrusion valve and into the package. The packaged product is then stored at a controlled temperature for a period of from 1 to possibly 10 days until the above-mentioned equilibrium is reached. For high-ratio shortenings, the time of storage or tempering is usually longer than for all-purpose shortenings in the conventional operation.

The Quick Tempering Process

We have developed a process in which the shortenings apparently reach equilibrium, as far as crystal form and size are concerned, within 24 hr after packaging. The process involves subjecting the shortening discharged from the agitated "B" unit to additional cooling and work prior to packaging. Figure 1 is a schematic flow diagram of the process.

Briefly, the quick-tempering process adds a post-cooling step to the conventional system. After the

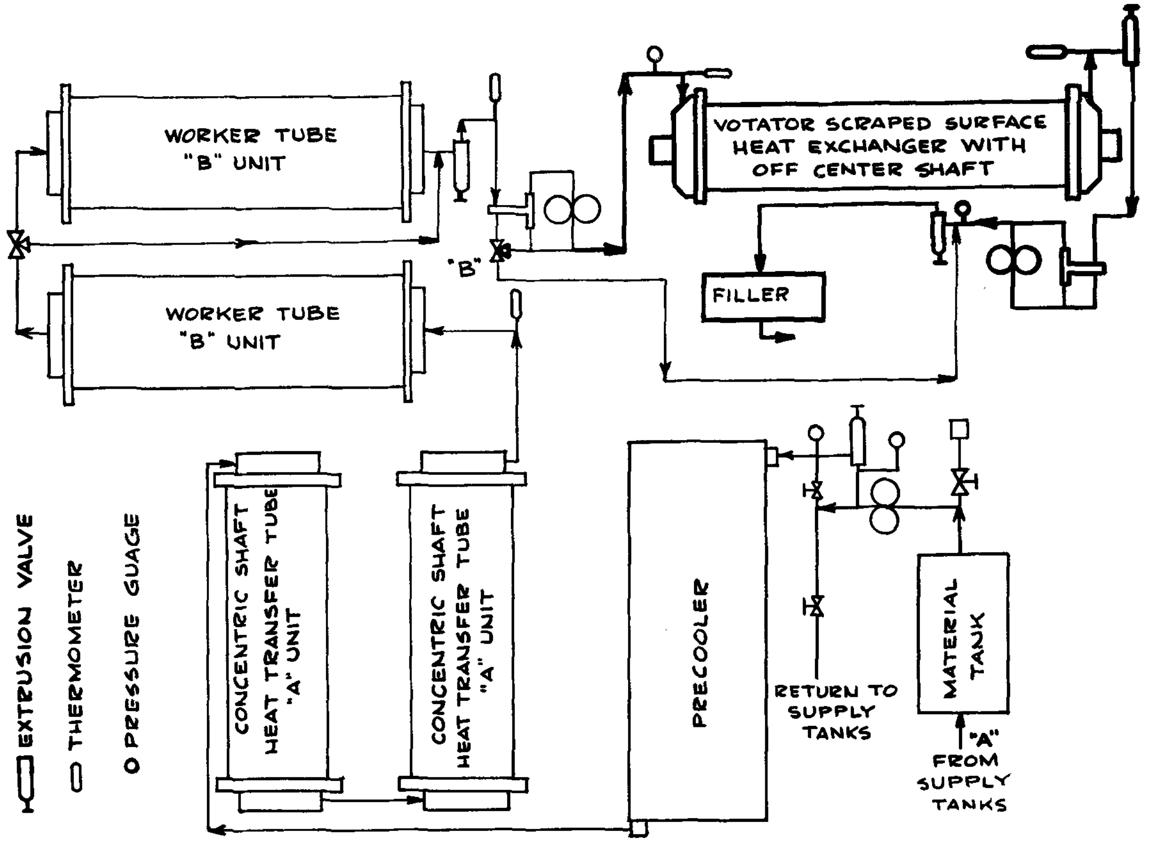

FIG. 1. Votator shortening plasticizing system with post-chilling.

small crystals have been formed in the "B" unit, the shortening mass is recooled with scraper blade agitation to a temperature a few degrees below the original cooling temperature attained in the "A" unit. This is accomplished in a Votator unit in which the mutator shaft is mounted off-center of the axis of the product cylinder. Because of this mounting, a kneading action occurs as the scraper blades cam in and out.

The off-center mounted shaft is rotated more slowly than the concentrically mounted one in the "A" unit. For example, in a 10,000 pound-per-hour, shortening system, the "A" unit shaft rotates at 450 to 475 rpm, while the off-center mounted shaft unit rotates at 225 to 250 rpm. An obvious advantage results from the slower speed when processing the viscous shortening emanating from the "B" unit. Less power is required to rotate the shaft and, by virtue of the lower power, less heat is put into the product, so a lower temperature can be attained, thereby preventing growth of the crystals. The small crystals remain small and the mechanical agitation quickly effects transformation to the more stable beta prime form.

With this quick-tempering process, it is practical to ship shortenings to customers the day after packaging for immediate use in bakery products.

Performance tests show that the product is the equivalent of a well-tempered shortening within 24 hr, as contrasted with the performance after 3 to 10 days for the same conventionally processed shortenings.

The same results were achieved on an all-purpose shortening. The product of the quick-tempering process performed as well in baking and icing tests made within 24 hr as the conventionally processed shortening did after tempering for the usual time of four days.

One can theorize at length about physicochemical phenomena, but we think that a shortening which has a solid fat index of 20% at 70F probably has only about 10–12% solids as it goes into the package from the conventional system and reaches 20% solids only after the usual tempering period. On the other hand, when employing this quick-tempering process, the product has almost reached equilibrium when it comes out of the off-center shaft unit. And further, it has the small crystals in the beta prime state which is desirable for a plastic shortening.

In support of this, Figure 2 shows the shortenings photographed with polarized light at 450X magnification.

This shows a conventionally processed high-ratio shortening at top left 24 hr after filling. Average crystal size is about 75μ and the maximum crystal size is about 300μ. Quite an agglomeration of crystals is evident.

The photomicrograph at top is divided, showing the same conventionally processed shortening on the left after tempering 10 days, and on the right the same formulation of high-ratio shortening processed using the post-cooling technique within 24 hr. The smaller crystal size is quite apparent. The average crystal size is about 15μ and the maximum about 150.

Pilot Plant Tests

The pilot plant work was carried out on an all-vegetable high-ratio shortening of a fairly typical composition containing about 3.5% alpha-monoglycerides. Investigation of range of temperatures indicated that the optimum conditions were: out of "A" unit, 65–70F; out of "B" unit, 80–82F; out of off-center unit, 60–65F; into package, 72–75F.

When consistency and baking tests appeared normal within 24 hr, the aid of a prominent shortening

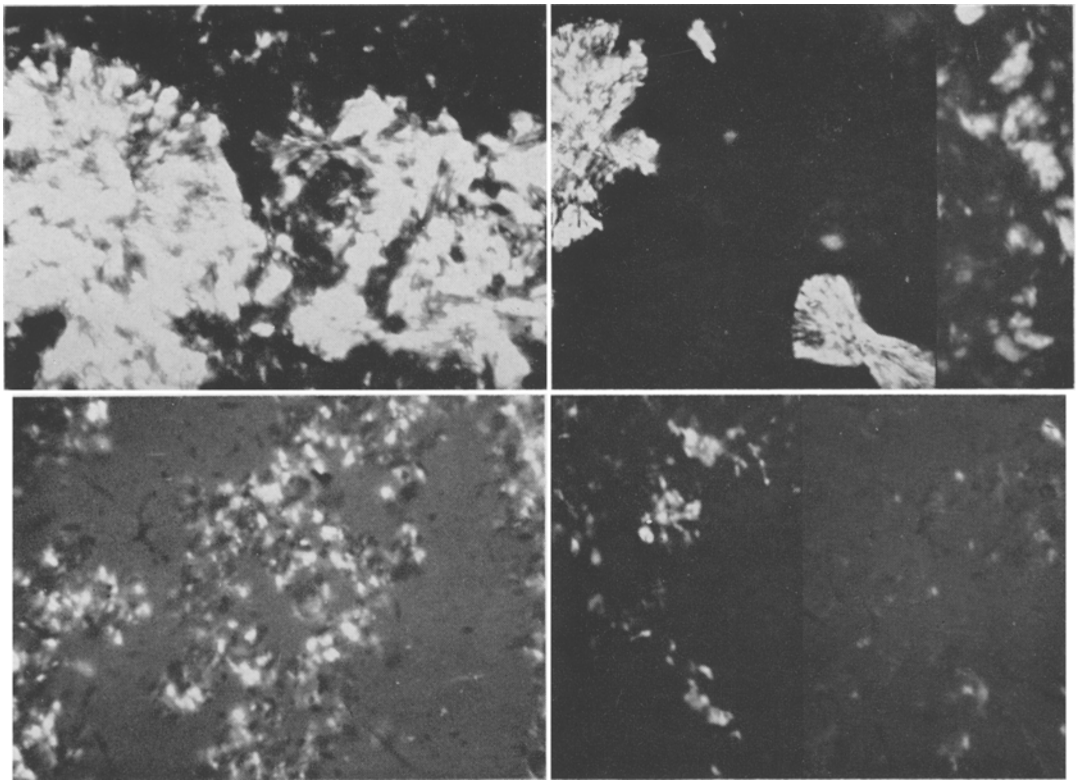

FIG. 2. Shortenings photographed with polarized light; mag. × 450.

TABLE I

Processing Conditions and Performance Results for High-Ratio Shortenings

Processing conditions	Conventional		Conventional + Off-ctr. Rechilling					Rechill. + "B" unit	
	1	2	3	4	5	6	7	8	9
"A" Unit outlet, F	69	69	69	69	68	68	69	68	68
"B" Unit outlet, F	83	83	83	83	82	82	83	82	82
Off-center unit outlet	....	....	69	69	59	65	68	69	59
2nd "B" Unit outlet, F			..	...	...	..		75	73
Filling temperature, F	85	85	78	83	69	73	77	84	79
Filling pressure psig	300	500	500	500	500	500	500	500	500
Performance w/cake									
24 hr after filling									
Pound cake sp. gr.	0.85	0.87	0.80	0.79	0.84	0.83	0.83	0.83	0.85
Pound cake volume cc/lb.	1150	1140	1230	1230	1150	1160	1190	1160	1090
10 Days after filling									
Pound cake sp. gr.	0.85	0.85	0.82	....	....	....	....	....	....
Pound cake volume cc/lb.	1110	1120	1220	....	....	....	....	....	....
Cream icing									
24 Hr after filling									
sp. gr. @ 15 min.	0.75	0.78	0.76	0.76	0.77	0.76	0.75	0.76	0.76

manufacturer was enlisted. A commercial-sized unit was installed in the plant. The operating conditions for this type of product were selected as: out of "A" unit, 70F; out of "B" unit, 80F; out of off-center unit, 65F; out of booster pump, 69F; at filler, 75F.

Commercial Plant Results

The above operation produced a finished shortening which gave, within 8 hr, the same results on a baking test as a similar formula, conventionally processed, which had been tempered for 10 days.

Bottom left picture shows an all-purpose shortening, plasticized in the conventional manner, 24 hr after packing.

Bottom right picture is again divided, showing all purpose shortening on the left after tempering 10 days, and on the right the same formulation processed with post-cooling after 24 hr. The difference is quite apparent.

What does all this mean? With post-cooling and working, finer, more uniform crystals in stable beta prime form are quickly obtained.

Table I presents performance tests on the high-ratio shortening: 1, 2, conventionally processed, 3–7 quick tempering which is the conventional plus rechilling in the off-center shaft unit, and 8, 9, quick tempering plus an additional "B" unit. Apparently, with the shortening formulations used, the additional "B" unit did not prove to be of any benefit. It is possible that in other shortening formulations the additional work provided by the "B" unit as in 3) would be desirable.

All-purpose shortenings were processed using the post-cooling technique. Table II presents the analysis, the operating conditions, and the performance tests run about 20 hr after filling.

TABLE II

	Run 1	Run 2
Color	6y–0.6 Red	5y–0.5 Red
Free fatty acid	0.02%	0.02%
Wiley melting point	116.2F	115.4F
S. F. I. @ 50F	26.1	25.0
S. F. I. @ 70F	20.6	19.8
S. F. I. @ 92F	14.8	13.5
S. F. I. @ 104F	9.1	8.9
Votator system with rechilling		
"A" Unit outlet temperature	69F	66F
"B" Unit outlet temperature	78F	81F
Off-center unit outlet	70F	68F
Temperature @ filler	78F	78F
Filling pressure	300 psig	300 psig
Performance: 20 hours after filling		
Pound cake		
Batter sp. gr.	0.86	0.85
Batter temperature	74F	75F
Cake volume	1100 cc/lb	1060 cc/lb

REFERENCES

1. Bailey, A. E., "Industrial Oil and Fat Products," 3rd ed., Edited by Daniel Swern, Interscience Publishers, Divison of Wiley and Sons, New York, 1964, p. 279.
2. Hoerr, C. W., and Ziemba, "Fat Crystallography Points Way to Quality," Food Eng. 37, 90 (1965).

[Received June 15, 1966]