

Note on the Effect of Removal of Free Flour Lipids on the Internal Structure of Cookies as Observed by a Resin-Embedding Method¹

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Kissell et al (1971) reported the effects of flour lipids on cookie quality and reviewed previous studies of wheat-flour lipids as a quality factor. In general, these studies have emphasized effects on external characteristics such as spread and top grain. Yamazaki and Donelson (1976) recently reported the effects of removal of free lipids on internal structure, including scores for internal appearance. Although such scores are subjective, they provide an index for evaluating effects that are not evident in photographs of intact cookies. The following report describes embedding and staining procedures that permit objective demonstrations of the deleterious effects of lipid removal on the internal structure of cookies.

MATERIALS AND METHODS

Cookie Preparation

Four straight-grade flours were milled in the Wooster Laboratory (Table I). Free lipids were extracted with hexane as described previously (Clements 1977). Cookies were baked in duplicate from control and extracted flours according to micro method III of Finney et al (1950).

Embedding and Staining Procedure

Vertical cross sections were prepared by scribing each cookie on the top and bottom surfaces about 1 cm from the center and breaking to give a straight edge. The smaller portion was discarded, and the broken edge of the remaining piece was lightly sanded to give a smooth surface. Specimens of cookies baked from a hexane-extracted flour and from its control were cemented together (with a fast-drying household cement), separated by a wood spacer (4-5 mm thick) set back 2-3 cm from the break and with the straight edges aligned. The two cookies were positioned, straight-edges down, in a 3-cm deep flat bottomed boat (made of aluminum foil and providing about 1 cm of space on all sides of the combined cross-sections). The specimens were taped into position to prevent floating and were transferred to a vacuum desiccator (without desiccant).

A volume of resin (Castolite, Rocket Plastics Co., Montgomery, OH) calculated to provide a bed in the boats about 2 cm deep was measured, and white pigment (Rocket Plastics Co.) was added to give the required opacity. Resin catalyst was added and thoroughly mixed in; the resin was immediately poured into the boats. The desiccator was covered and evacuated to about 3 mm Hg; after 4-5 min, the vacuum was released. Evacuation was repeated twice to insure infiltration and was maintained the third time until bubbling essentially ceased (10-15 min). The vacuum was released, and the resin was allowed to harden for at least 24 hr. The foil was then peeled from the specimens, and exposed portions of the cookies were broken off. The bottoms of the specimens were sanded on a flat belt sander (fine or medium fine) to expose the cross-sections

near the center of the cookies. The specimens were further finished by light hand sanding by orbital movement on fine emory cloth supported on a smooth, flat surface.

TABLE I
Characteristics of Flours Studied

Variety	Class	Protein ^a (%)	Ash ^a (%)	Free Lipid ^a (%)
Arthur	Soft red winter	12.7	0.530	1.2
Chris	Hard red spring	15.9	0.466	1.2
Eagle	Hard red winter	11.2	0.579	1.0
Yorkstar	Soft white winter	7.6	0.506	1.0

^aDry basis.

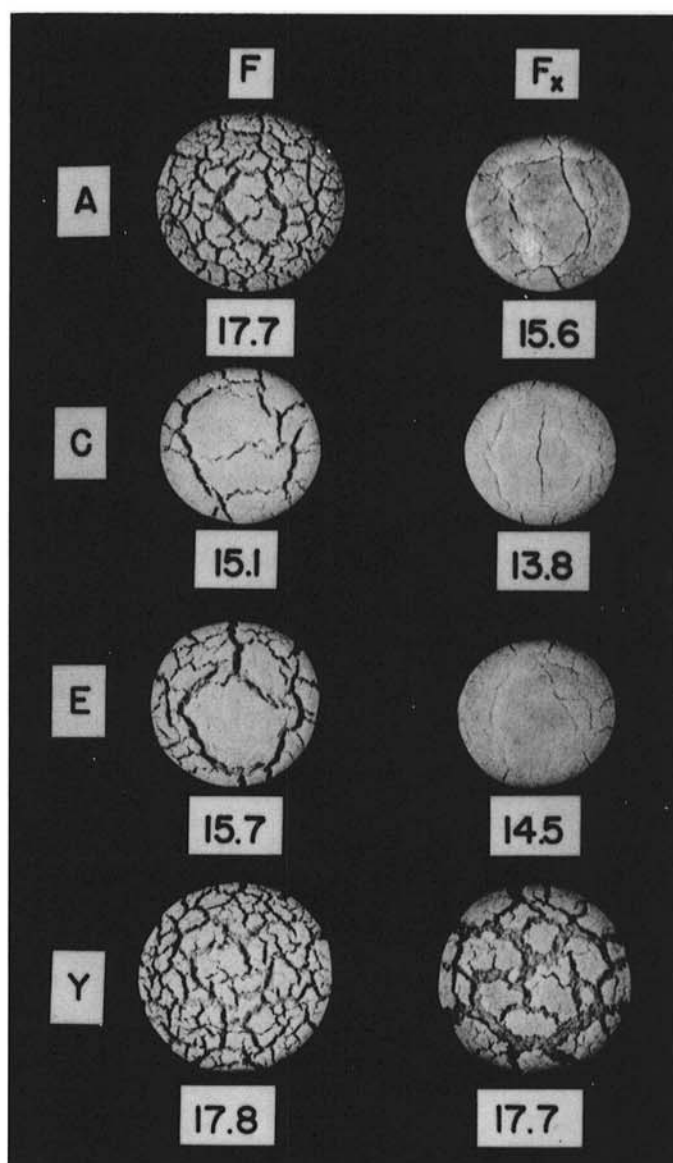


Fig 1. Sugar-snap cookies baked from nonextracted flours (F) and hexane-extracted flours (F_x) from Arthur (A), Chris (C), Eagle (E), and Yorkstar (Y) varieties. Values below cookies are combined diameters (cm) of two cookies.

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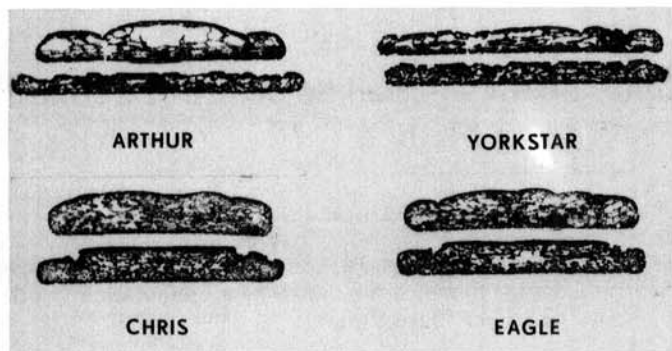


Fig. 2. Vertical cross-sections of cookies baked from nonextracted flours (bottom) and hexane-extracted flours (top) from Arthur, Yorkstar, Chris, and Eagle varieties. Cookies were embedded in opaque resin, and ground surfaces were stained with Sudan black B in acetone.

Sections were stained by placing a specimen face up and repeatedly swabbing 0.5% Sudan black B in acetone on the surface. Excess dye was carefully wiped from the surface with a tissue saturated with acetone. After the specimen was allowed to dry, it was again lightly sanded and rubbed with fine steel wool. The procedure was repeated if necessary to give a uniform dense stain against a white background, and the polished surface was lightly sprayed with several coats of transparent art fixative to prevent bleeding of stain.

In addition, lateral cross-sections were prepared from cookie strips, about 3 cm wide, extending across the centers of the cookies. The specimens were placed (top up) in boats of appropriate size, and embedded, sanded (from the bottom), and stained as above.

RESULTS AND DISCUSSION

Figure 1 shows typical external effects of removal of free flour lipids. The diameters of cookies made from Arthur, the soft red winter wheat, decreased about 2 cm, whereas those from Chris, the hard red spring wheat, and Eagle, the hard red winter wheat, decreased about 1 cm. Top grain, a consequence of spread, was drastically reduced in all three varieties. Cookies made from Yorkstar, the soft white winter wheat, showed negligible change in diameter, but top-grain became very coarse.

Vertical cross-sections of these same cookies (Fig. 2) show the internal changes associated with removal of free lipids. The drastic effects in cookies from Arthur flour are typical of effects noted with flours from soft wheats in general (Yamazaki and Donelson 1976). Cell walls break down during oven expansion, resulting in formation of large pockets enclosed by a thin shell. The structure solidifies early in the baking process, resulting in limited spread and almost total absence of top grain (evident as valleys in vertical cross-sections). Although lipid removal from Arthur and Yorkstar flours resulted in quite different external effects in cookies baked from the respective flours, it appeared to have the same internal effect, i.e., breakdown of cell structure. Retention of spread in cookies baked from Yorkstar flour, however, suggests that weak

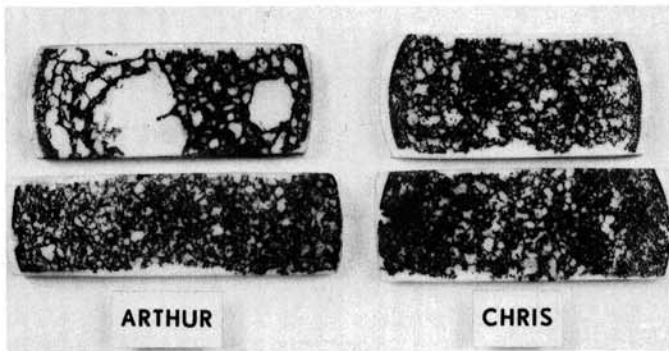


Fig. 3. Lateral cross-sections of cookies baked from nonextracted flours (bottom) and hexane-extracted flours (top) from Arthur and Chris varieties. Cookies were embedded in opaque resin, and ground surfaces were stained with Sudan black B in acetone.

gluten and high dough plasticity (characteristic of flours from Eastern soft white wheats) lead to collapse. Doughs from Arthur flour are apparently sufficiently elastic to sustain expansion until solidification occurs. Sections of cookies baked from the hard wheat flours (Chris and Eagle) show that lipid removal causes a general increase in cell size, but not to the extent noted in cookies from nonextracted flours and consequently a less drastic effect from lipid removal. Lateral cross-sections (Fig. 3) display the very large cavities in cookies baked from hexane-extracted Arthur flour and the small cells in cookies baked from hexane-extracted Chris flour and from the nonextracted control flours.

The above examples demonstrate the importance of the free flour lipids in the development of the sugar-snap cookie during baking. Other stains and staining procedures may be employed, and it may be desirable to stain specimens before embedding (or baking). Unstained sections can be viewed under long-wave ultraviolet light, under which the cookie matrix fluoresces vividly and the resin appears black. These techniques should be useful in further studies of baking mechanisms and in the demonstration of structural effects.

ACKNOWLEDGMENT

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