Some Effects of Solvent Extraction on Cooking Characteristics of Spaghetti

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ABSTRACT

Various amounts of lipid and protein were removed from spaghetti by subjecting strands to various extracting solvents. These samples were cooked for different periods of time in reflux assemblies, and cooking characteristics were compared. The data indicated that removal of lipid or protein resulted in increased amounts of amylose in cooking water. Removal of protein also resulted in increased amounts of water retained in the cooked spaghetti. The cooking quality of spaghetti was impaired more by protein removal than by lipid removal. For comparison, these experiments were performed also on a spaghetti prepared from semolina and a lipoprotein complex derived from semolina.

Little is known of the events that occur during the cooking of spaghetti or of the compositional factors that determine its cooking quality. Certain lipids such as monoglycerides enhance the quality of cooked spaghetti, an effect attributed to the ability of monoglycerides to complex amylose (1). Somewhat related to this is the improving effect of monoglycerides in baked goods, which also is attributed to starch-complexing phenomena (2). Undoubtedly, in the cooking of spaghetti, many factors are operative which may add or detract from the quality of the cooked product. This investigation showed some large quality differences that can be obtained by radical manipulation of the lipid and protein content of spaghetti.

MATERIALS AND METHODS

Spaghetti

A normal spaghetti and a lipoprotein-enriched spaghetti were used. The latter was obtained from a blend of 9 parts of semolina and 1 part of a material containing a lipoprotein complex (described below). The normal spaghetti (produced from semolina) contained 12.9% protein, and the lipoprotein-enriched spaghetti, 16.2%. The spaghetti was made in a D'Maco laboratory press which employs vacuum and continuous extrusion.

Lipoprotein Complex

Semolina and water (2:3) were mixed and allowed to stand 0.5 hr., after which an equal amount of water was added to give a slurry (1:3). This slurry was mixed for 3 min. in a Waring Blendor and then centrifuged for 5 min. at 2,000 r.p.m. The low-density lipoprotein complex, which constituted the top layer, was removed and freeze-dried. The yield was 8.1% of the parent semolina. This material contained 48.1% protein (14% moisture) and 15 p.p.m. of pigment. The crude fat, determined by acid hydrolysis, was 4.3%. Ethanol (70%) extracted 54.2% of the protein of the complex compared to 58.6% of the semolina protein.

Protein, fat, and pigment analyses were made by official AACC methods (3).

Solvent Extraction of Spaghetti

Spaghetti strands were immersed in various lipid and protein-extracting solvents at a ratio of 1:5 and allowed to stand 24 hr. at room temperature. For the water-saturated butanol, this time was extended to 48 hr. The extract was decanted and the strands were separated and allowed to dry on a cloth at room temperature. Protein analyses were made on the extracted strands to determine the amount of protein removed by extraction.

Chromatography of Lipids

Comparison was made of the profile of polar lipids extracted from spaghetti by water-saturated butanol and by the other solvents employed in this study. The extracts (25 λ) were spotted on Gelman ITLC paper (SG) and developed with chloroform, methanol, acetic acid, and water (90:10:1:1). Spots were detected with iodine vapor.

Cooking of Spaghetti

Cooking was conducted in a battery of six reflux condenser assemblies which ensured complete retention of all the cooking water. Samples of 10 g. of spaghetti in 100 ml. of water were cooked for 4, 8, 12, 16, 20, and 24 min.; then the water was drained from the spaghetti and measured by volume and for amylose content (described below). Samples of spaghetti were cooked also in beakers for various times, examined for firmness, stickiness, and related characteristics, and then photographed.

Amylose Determination (Blue Value)

The procedure of McCready and Hassid (4) was used, with the modification that 1 ml. of cooking water and 1 ml. of 0.2% iodine solution were combined in a diluted volume of 200 ml. With the use of a Coleman spectrophotometer, the absorbance of the solution at 660 mμ was determined and recorded as the Blue Value.

RESULTS AND DISCUSSION

The material used to prepare lipoprotein-enriched spaghetti is a complex which forms when flour and water are mixed in a Waring Blendor. Repeated tests on this material obtained from a number of flours revealed that the lipid was very firmly bound in the complex, resisting complete extraction by a number of solvents. The high content of firmly bound lipid and protein of this material prompted its use in fortifying a spaghetti which was to be subjected to lipid and protein-extracting solvents. Lipid-protein-binding phenomena which occur when flour is wetted have been studied in considerable detail by Olcott and Mecham (5). The lipids involved in these phenomena include both phospholipids and glycolipids (5,6,7).

Table I shows amounts of protein removed by the solvents. For a comparison of polar lipids extracted by various solvents, see Fig. 1.

Comparison was made of polar lipids present in the extracting solvents. The solvent system used was adapted from that used by McKillican (8), who separated polar lipids on silica-coated glass plates. We obtained similar separations on ITLC paper. In the figure, it is seen that the protein present in the protein-extracting solvents remains at the origin. Lipids extracted with 70% ethanol compare in profile with those extracted with water-saturated butanol. Some highly polar components are absent in the acetic acid extracts.

TABLE I

PROTEIN REMOVED FROM SPAGHETTI BY EXTRACTION

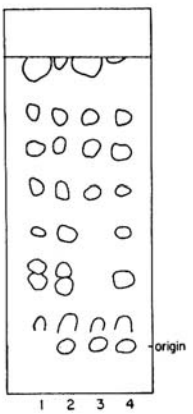
	WATER-SATURATED BUTANOL	70% ETHANOL	ACETIC ACID		
			Glacial	70%	0.1*M*
	%	%	%	%	%
Normal spaghetti	....	44.2	51.2	72.9	78.0
Lipoprotein-enriched spaghetti	....	47.5	57.4	70.4	75.3

The alteration of protein caused by an acidic solvent probably affects its lipid-binding properties.

As seen in Fig. 2, the amylose content of the cooking water increased with increasing cooking time. This increase was made greater by removal of spaghetti lipids with water-saturated butanol. An even greater increase was effected by removal of both lipid and protein, as observed with spaghetti which had been extracted with 70% ethanol, 70% acetic acid, and glacial acetic acid. It is noted that the acetic acid solvents extracted more protein than did 70% ethanol. The magnitude of the solvent effect on the release of amylose into the cooking water was less with the lipoprotein-enriched spaghetti than with the normal spaghetti. The data in Fig. 2 indicate that both lipid and protein have a role in the retention of amylose in spaghetti during cooking.

Spaghetti extracted with 0.1*M* acetic acid was very badly damaged. The cooking water from this spaghetti contained much starch, including very high amounts of amylose.

The data shown in Fig. 3 indicate the effect of protein on the amount of water imbibed by the spaghetti strands during cooking. The spaghetti



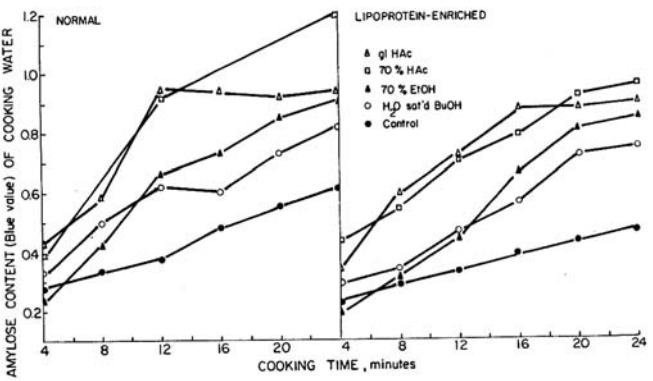


Fig. 1 (left). Chromatography of polar lipids extracted from spaghetti with various solvents. Paper: Gelman ITLC paper (SG). Eluant: chloroform, methanol, acetic acid, water (90:10:1:1). Detection: iodine vapor. 1, Water-saturated butanol; 2, 70% ethanol; 3, glacial acetic acid; and 4, 70% acetic acid.

Fig. 2 (right). Effect of solvent extraction of spaghetti on release of amylose (Blue Value) into cooking water.

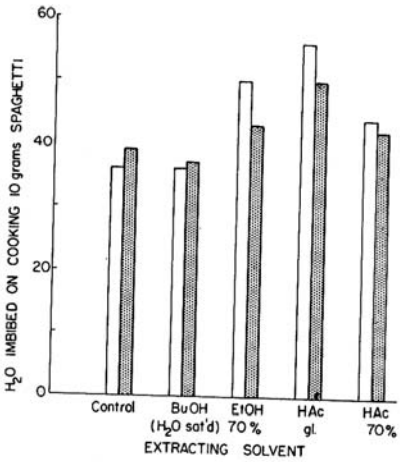


Fig. 3. Effect of solvent extraction of spaghetti on water-imbibition during cooking. Solid bar corresponds to normal spaghetti; shaded bar corresponds to lipoprotein-enriched spaghetti. Cooking time is 16 min.

extracted with water-saturated butanol showed little change from the control in this regard, whereas the use of protein-extracting solvents resulted in higher amounts of water in the cooked spaghetti. Again, the magnitude of this effect was less in the lipoprotein-enriched spaghetti. Glacial acetic acid had a greater effect than 70% ethanol, owing perhaps to the removal of some of the glutenin. Removal of a great amount of protein with 70% acetic acid produced less water-imbibition effect than glacial acetic acid. This perhaps was due to the loss of the hydration capacity of the additional protein removed with 70% acetic acid.

The pictures of the cooked spaghetti are visual evidence of the effect of removal of lipids and proteins (Fig. 4). Cooking times were chosen that gave the best comparison of the cooking tolerance of the extracted spaghettis. In all cases, the lipoprotein-enriched spaghetti resisted the effects of cooking better than the normal spaghetti. Removal of lipid led primarily to greater stickiness. Removal of both protein and lipid led to greater stickiness, softness, and pastiness. Removal of gliadin (with 70% ethanol) had a less serious effect than removal of gluten with acetic acid solvents.

The data support the generally recognized fact that protein is an essential structural component of spaghetti and other pasta products. Without it, the strands tend to disintegrate and lose their form on cooking. The lipids supplement the function of protein and minimize other consequences of cooking such as stickiness. Removal of lipids with water-saturated butanol resulted in increased amounts of amylose in the cooking water. This may be due to a loss of the amylose-complexing properties of the polar lipids. However, this effect also may be due, at least in part, to alteration of the lipoprotein complex occurring in the spaghetti, which, in turn, affects amylose complexing. Removal of protein from spaghetti resulted in a release of amylose to cooking water, exceeding that incurred by removal of lipid.

An ideal approach to the study of any biological system is addition or

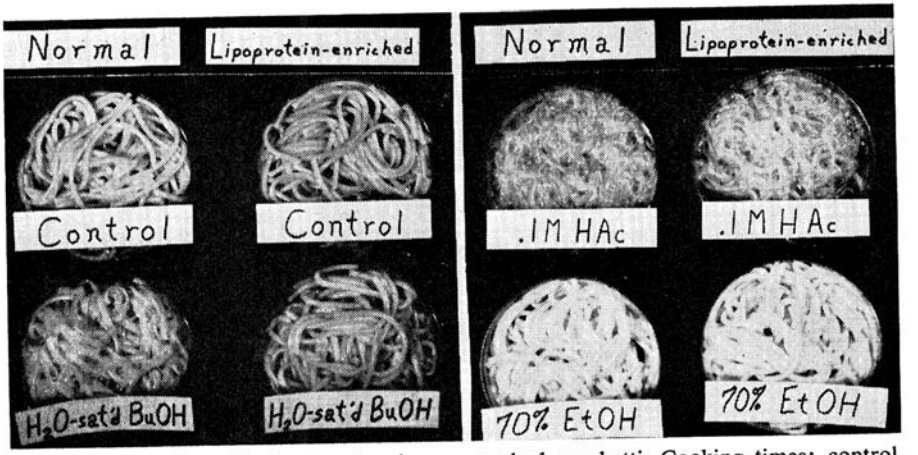


Fig. 4. Effect of solvent extraction on cooked spaghetti. Cooking times: control, 18 min., water-saturated butanol, 18 min.; 0.1*M* acetic acid, 10 min.; 70% ethanol, 15 min. Not shown in the figure are the spaghettis extracted with 70% acetic acid and glacial acetic acid which, after 15 min. of cooking, appeared similar to pictures shown for 0.1*M* acetic acid and 70% ethanol, respectively. Lipoprotein-enriched spaghettis are on the right.

removal of components without disturbance to the integrity of the rest of the system. Unfortunately, this ideal is rarely realized and usually is compromised. All of the solvents used in these experiments could be expected to alter the protein remaining in the spaghetti. This alteration would still be present if the semolina was extracted first and then formed into spaghetti. However, even with these reservations, some important observations may be drawn from these experiments regarding the function of lipid and protein in the quality of cooked spaghetti.

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[Received July 10, 1967. Accepted January 15, 1968]