COOKING TIME FOR MEDIUM WHITE SAUCE PREPARED FROM A MIX

by

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INTRODUCTION

Because of the shortage and high cost of labor, various types of mixes are used in food services. Mixes not only save labor and time, but are easy to employ and may be handled effectively by unskilled workers. They may be either manufactured commercially or made during slack work periods in individual kitchens, resulting in reduced or more efficient use of preparation time. Other advantages of mixes are decreased number of utensils needed, elimination of dangers of failure, assured standardization of quality and nutritive value, and cost comparable to products made on the premises.

White sauces are part of many recipes. They may be utilized several times in a given day's menus, as in cream soups, croquettes, souffles, and scalloped dishes. Therefore, use of a white sauce mix should be both convenient and time-saving, as well as helpful in emergency situations.

Criteria for doneness in white sauce are degree of thickness of the sauce and absence of raw starch taste. Maximum thickness occurs at approximately 90° C and raw starch taste disappears after about 45 min of cooking time. The general practice in most food services is to cook the sauce just until thick. When additional cooking is required as in casserole dishes, such procedures are adequate. However, when this is not the case, white sauce which must be cooked 45 min is not always practicable, especially when speed of preparation is a factor.

The objective of this study was to determine raw starch taste, nonfat dry milk flavor, viscosity, and acceptability of medium white sauces made from nonfat dry milk white sauce mix and cooked 5, 10, 20, or 45 min.

REVIEW OF LITERATURE

Effect of Heat on Milk

Heating is the most important step employed in milk processing. The main objective for applying heat to milk is preservation, reported Jenness (1959, p. 322), who also noted that dry milk gains its identity through heat treatment. Ling (1957, p. 123) observed that the effects of heat on milk depend upon 3 factors; temperature, time of holding, and pH.

When milk is heated to the boiling point, skin appears on the surface. Composition of this material, concluded Ling (1957, p. 123, 124), is protein, tricalcium phosphate, and fat.

Milk Proteins. Rowland (1933) indicated that heat coagulation consists of 2 distinct processes: (a) denaturation or alteration of protein by heat, which precedes (b) flocculation, the rapid separation of denatured protein in the presence of a suitable electrolyte. According to Lowe (1955, p. 23), a third process is coagulation.

Denaturation. Casein is not considered to be a denaturable protein, asserted Jenness (1959, p. 340), in the sense that the milk serum and many other proteins are. Destabilization of the caseinate particles by heat treatment causes them to aggregate to form a three-dimensional network that entraps some of the milk serum. The process is first manifested by an increase in viscosity. With more drastic heat treatment, actual coagulation of the caseinate and a separation of the system occurs. The only known direct effect of heat on casein is degradation with the release of esterified phosphate and hydrolysis of peptide linkages (Jenness, 1959, p. 340, 341).

After caseins have been precipitated by acid or rennin, emphasized Jenness (1954), the remaining proteins are serum or whey proteins. These have been separated as B-lactoglobulin, an albumin, and a-lactalbumin. B-lactoglobulin is the most important concerning heat effects on milk. Heat denaturation of milk serum proteins was attributed by Ling (1957, p. 125, 126, 127) to application of heat. Two manifestations are decreased solubility and precipitation of the protein.

A result of heat denaturation is flocculation of serum proteins. Curd-forming properties of milk as a result of heating are development of soft curd characteristics and impairment of milk protein clotting. According to Jenness (1959, p. 336, 338), 2 additional phenomena of milk resulting from heat treatment of serum proteins are loss of capacity to form a normal cream layer and an increase in the reflectance or whitening of milk. The sulfhydryl (SH) groups of milk serum proteins are reactivated by heat.

In a study by Rowland (1937), samples of milk were heated to temperatures above 75° C and denaturation of albumin and globulin took place rapidly. In milk heated as high as 115 and 120° C, the denaturation of albumin and globulin was followed by appreciable hydrolysis of protein, which resulted in increases in protease and in nonprotein-nitrogen.

Heating of milk causes denaturation of lactalbumin and lactoglobulin to an extent depending on both the temperature and the time of heating, related Rowland (1933). Temperatures from 63 to 80° C, for periods of from 2½ to 60 min, were used.

Harland and Ashworth (1945) disclosed that a time-temperature relationship exists in the denaturation of proteins in skim milk. The rate increases regularly as the temperature raised from 68 to 80° C.

Coagulation. Coagulation of milk by heat may be ascribed to proteins, principally casein and albumin, explained Eckles *et al*. (1943, p. 69). Casein is more stable of the two. Slightly acid milk will curdle or coagulate when boiled. With increasing acidity, proteins coagulate at lower temperatures.

Closely associated with coagulation by heat is the mineral balance in milk. When combined with a definite amount of calcium, casein is most resistant to heat coagulation (Eckles et al., 1943, p. 69).

Calcium-ion concentration and colloidal phosphate content, declared Pyne (1955), are chief factors determining tendency of milk to coagulate on heating. The heated caseinate-phosphate complex has capacity to bind additional colloidal phosphate, stated Pyne (1958). Principal changes which become evident with heat treatment, observed Jenness (1959, p. 346), are an increase in casein nitrogen with a decrease in albumin-globulin nitrogen and an increase in the proteose-peptone and nonprotein-nitrogen functions.

Milk Salts. Loss of carbon dioxide from milk is accelerated by heating and agitation. Removal of carbon dioxide raises the pH and reduces titratable acidity. A decrease in dissolved calcium and phosphate occurs when milk is heated, liberating hydrogen ions. This counteracts the increased pH and decreased titratable acidity caused by carbon dioxide removal (Jenness, 1959, p. 330, 333, 334). Heat has almost no effect on the amount of dissolved citrate in milk.

Browning. Browning results from the prolonged heat treatment of milk. Three main types of browning were listed by Patton (1955) as: (1) caramelization or non-amino browning of sugars, (2) amino-sugar or Maillard-type browning, and (3) oxidative browning. Amino-sugar type browning is the interaction of amino compounds with sugars and is the type that prevails in milk. Two main reactants in browning of milk and milk systems are lactose and casein.

Burton (1943) noted that before browning, milk shows increased whiteness, because of heat flocculation of serum proteins, changes in the state of casein aggregation, and conversion of soluble calcium to insoluble salts. The lactose-casein complex is unstable to heat, revealed Ling (1957, p. 128), and gives rise to the browning effect and production of acids, such as lactic and formic, by degradation of lactose.

Milk Fat. Influence of heat on fat was recognized by Eckles *et al*. (1943, p. 70) to be physical. Fat globules are formed in clusters. These clusters are broken up by heat.

Flavor. Jenness (1959, p. 361) mentioned that basic components, olfactory, gustatory, and tactual are concerned respectively with odor, taste, and feel of a flavor stimulus. Milk has a faint, characteristic odor, reported Davis (1939, p. 293, 294, 351). Pronounced flavor of any kind is abnormal to milk. Normal milk is smooth feeling in the mouth. The odor of heated milk is more apparent, especially that of boiled milk. Eckles *et al*. (1943, p. 70) stated that cooked taste and odor are the result of the influence of heat on proteins and lactose of milk. Sulphide or sulfhydryl compounds are formed.

The appearance of cooked flavor in heated milk follows closely the activation of the -SH groups, said Jenness (1959, p. 385). Hydrogen sulfide is partly responsible for cooked flavor. The amino acid cysteine, the principal site of -SH groups in the milk serum proteins, liberates hydrogen sulfide when heated in aqueous solution.

Heated milk imparts a tactual flavor defect, suggested Jenness (1959, p. 387, 388), caused by insoluble aggregates of calcium and magnesium with the milk proteins. This defect is marked in dry milk products.

Enzymes. Normal milk, stated Griswold (1962, p. 89), contains several enzymes. Principal ones natural to milk are catalase, peroxidase, xanthine oxidase, phosphatase, amylase, protease, lipase, aldolase, and lactase.

All known enzymes are proteins and are inactivated by heat. Milk enzymes are important to milk technology, commented Griswold (1962, p. 35, 89). Lipases are known for the production of hydrolytic rancidity in milk. Destruction of phosphatase is used as a test for the adequacy of pasteurization.

Bacteria. Pasteurization, as specified by Davis (1939, p. 349, 350), is used to destroy all pathogenic bacteria and many non-pathogenic organisms. Two basic methods used in industry are the holder process and the high temperature, short time process.

Nutritive Value. Griswold (1962, p. 85, 88) pointed out that milk proteins supply all essential amino acids. Their nutritive value is not decreased by heat. Except for ascorbic acid, vitamin content of reconstituted instant nonfat dry milk is comparable to that of fresh skim milk.

Pasteurized milk, noted Jenness (1959, p. 408), contains about one-half of the original vitamin C content of fresh raw milk. Variable amounts of vitamin B1 are lost by heat treatment.

Effect of Heat on Starch

Effect of heat on starch is related to such factors as temperature, concentration of starch to and solubility in water, length of storage time after cooking, and amount of agitation. These will be discussed under gelatinization, retrogradation, agitation, and viscosity.

Gelatinization. The starch granule is insoluble at room temperature, reported Pyler (1952, p. 15). When a starch suspension in water is heated slowly, the granules begin to swell when the temperature reaches 60° C. Maximum swelling occurs at 90° C, according to Miller and Barnhart (1947, p. 50).

Leach (1965, p. 292) observed that changes taking place in heated starch suspensions are loss of birefringence, increase in optical transmittancy and swelling. Temperature at which all granules have lost birefringence is designated as gelatinization temperature, declared MacMasters (1959, p. 576). As the temperature of the starch suspension rises above gelatinization temperature, granules swell greatly and lose ability to return to the birefringent condition (MacMasters, 1959, p. 578).

When heated with water a series of changes occurs in starch, pointed out Hofstee and DeWilligen (1953, p. 2), the most important being: increase in conductivity, change in translucence, swelling of the grain, loss of birefringence, change in x-ray diagram and abrupt increase in viscosity. These changes do not occur at the same time, nor at a sharply defined temperature.

Retrogradation. Clarity of starch paste increases as the granules swell and become translucent. The paste becomes opaque resulting from side by side alignment of amylose molecules through hydrogen bonding to give either a precipitate or a gel network. This condition is termed retrogradation (Elder and Schock, 1959).

Retrogradation tendencies, thought Matz (1962, p. 253), are promoted by high concentrations of starch. Retrogradation of starch was explained by Matz (1962, p. 252) as a kind of limited crystallization phenomenon causing texture changes in foodstuffs that must be stored for some time after their starch fraction has been cooked or gelatinized.

Agitation. Loss of solubles, chiefly amylose, from granules into surrounding water increases viscosity, reported MacMasters (1959, p. 581). Starch granules remain unbroken unless jostled by other granules or mechanically agitated, pointed out Elder and Schock (1959). The starch granule is held together by micelles formed from the linear molecules or linear segments of branched molecules. If the granules do not disintegrate, a suspension results; if they do disintegrate, a colloidal state exists. Griswold (1962, p. 290) maintained that further heating or vigorous stirring causes granules to rupture and disintegrate, giving a colloidal dispersion of greatly reduced viscosity.

Reaggregation may occur after prolonged heating when granules have disintegrated by stirring (MacMasters, 1959, p. 582). The aggregates, resulting from spontaneous formation of a fatty-acid amylose complex, influence viscosity. Fatty material in the presence of pasted starch in foods can increase the amount of the complex beyond that found in the starch paste alone. Some cases of granulation in sauces can be attributed to formation of this complex (MacMasters, 1959, p. 582).

Viscosity. St. John (1944, p. 19, 20) stated that viscosity has been defined as resistance of a system to flow or shear. It is measured in terms of poise, after Poiseville, who devised methods for its measurement. Poise is expressed in terms of force which is exerted on a unit area to produce a given rate of flow.

Swelling of starch granules, explained Meyer (1960, p. 106) causes an increase in viscosity. Elevation of temperature, said MacMasters (1959, p. 578), rather than duration of heating causes more swelling of the granules. Kesler (1947) found with increased rate of heating, greater rupturing of starch granules resulted in a thinner paste than when a slow rate of heating was used.

Viscosity of a starch paste is an important factor in its applicability to food uses, observed MacMasters (1959, p. 580). Viscosity of pasted starch leads to use of flour or starch as a thickener in sauces.

Charm (1962, p. 356, 357) noted that consistency of food materials is a complex quality to determine. Newton's mathematical concept of consistency is related to what is today called viscosity. Many instruments have been used to determine the viscosity of starch pastes. Least objectionable from the theoretical point of view, according to Matz (1962, p. 32), is the MacMichael viscosimeter. It records the torque transmitted from a rotating bowl containing the liquid to a disc suspended by a calibrated torsion wire. Provision is made for rotating the bowl at constant speed. MacMasters (1959, p. 581) emphasized that starch pastes are complex non-homogeneous systems and only "apparent viscosity" should be reported. Factors, cited by MacMasters (1959, p. 582), as affecting the viscosity of a starch paste are concentration of starch, kind of starch, temperature attained by starch-water system, duration of heating, degree of agitation, and pH of system.

If proportion of starch to water is too great to permit maximum gelatinization of starch granules, the cooked starch suspension may be sticky, asserted Miller and Barnhart (1947, p. 52). Stiffness of starch gels, commented Lowe (1955, p. 394), is reduced by heating to a temperature beyond that at which maximum swelling occurred.

As a cooked starch paste cools, it gels or becomes thicker in consistency. According to Miller and Barnhart (1947, p. 53), white sauce prepared in quantity and refrigerated for future use may be quite thick before heating but will become thinner when heated.

Cooking Times for White Sauces

Factors affecting length of cooking time for white sauces are size of batch, method of preparation, type of cooking utensils, and ingredients used. White sauce may be classified according to consistency as thin, medium, and thick (Justin, 1948, p. 129).

Thin White Sauce. Peterson (1961) cooked 6-qt batches of thin white sauce in stock pots on a gas range. Average cooking time for sauce made from a mix containing dry whole milk was 28.4 min; for sauce from a mix containing instant nonfat dry milk, 29.1 min; and for sauce from homogenized milk, 60.9 min. An additional 6 min were required to heat to 90° C tap water that was used to make sauces from the mixes (Peterson, 1961).

Medium White Sauce. Average length of cooking time, as reported by Longree (1953), was 47.5 min for a 1-gal. batch of medium white sauce made from homogenized milk and cooked in a bain-marie. This included the 19.5 min needed to heat the milk to 90° C. Average length of cooking time in a bain-marie for a 1-gal. batch of medium white sauce made from a mix was 36 min, and included 6 min needed to heat the water to 90° C (Longree, 1954).

Thick White Sauce. When thick white sauces were prepared and tested by Woodhams (1961), cooking time in 1-gal. electric trunnion kettles was set arbitrarily at 45 min, after preliminary work established that the raw starch taste disappeared by that time.

EXPERIMENTAL PROCEDURE

Preliminary Work

Preliminary work determined the ratio of mix to water required to prepare medium white sauce. Also during this period, techniques of preparation and testing were formulated and standardized.

Preparation. Basic formula for the mix was developed and tested by Peterson (1961) to use in making thin white sauce. Ingredients used were all-purpose flour, butter, hydrogenated vegetable shortening, salt, and instant nonfat dry milk. In the present study, salt was omitted from the mix because the amount of mix required for medium white sauce resulted in a product that was too salty. Instead, salt was added to the weighed mix, just prior to cooking. Various quantities of mix and water were tested before an acceptable product was obtained.

Evaluation. Woodhams cooked thick white sauces made from mix for 45 min. During preliminary work for the present study, when medium white sauces were cooked for less than

45 min, judges did not detect a raw starch taste.

The MacMichael viscosimeter was tested for use with medium white sauces. Size 30 gauge wire used by Woodhams (1961) proved to be satisfactory for recording viscosity. Techniques for preparation and presentation of the medium white sauces to the palatability committee were standardized and the score card developed (Form I, Appendix).

Statistical Design and Analyses

Statistical Design. Medium white sauce was prepared from instant nonfat dry milk mix and cooked in electronically controlled trunnion kettles. Thirty-six batches of sauce were prepared and tested in 12 periods. A period consisted of preparation and testing of 3 white sauces. Sauces were cooked for 5, 10, 20, or 45 min. The statistical design was an incomplete block design (Table 1).

Statistical Analyses. Data were collected for palatability factors of appearance, consistency, texture, and flavor, as well as for viscosity as measured by the MacMichael viscosimeter. The data were subjected to analysis of variance to study the effect of 4 cooking times upon palatability and viscosity of medium white sauces.

Procurement and Storage of Ingredients

Procurement. Ingredients needed were obtained in sufficient quantities for the entire study. Instant nonfat dry milk was purchased in vacuum-sealed cans, 6 cans to the

Table 1. Incomplete block design for cooking times for medium white sauces prepared from a mix.

Cooking period (block)	Kettle 1	Kettle 2	Kettle 3
	min	min	min
I	5	10	45
II	45	20	10
III	20	5	10
IV	20	10	45
V	10	5	45
VI	20	5	45
VII	10	5	20
VIII	20	45	5
IX	10	45	5
X	45	10	20
XI	10	20	5
XII	45	20	5

case. Each can contained 4 lb, 8 oz of dry milk. All-purpose flour was purchased by the 50-lb bag. Hydrogenated vegetable shortening was packed in 50-lb cans and noniodized table salt in 1-lb boxes. Butter was purchased in 1-lb packages.

Storage. Instant nonfat dry milk, hydrogenated vegetable shortening, and salt were stored in original containers and all-purpose flour in a covered stainless steel bin at room temperature in the laboratory. Butter was stored in the freezer at -20° F.

Preparation of Mix and Medium White Sauces

Preparation of Mix. Formula for the basic mix is given in Table 2. All ingredients were at room temperature when weighed and mixed. Butter was removed from the freezer 15 hr before weighing. An 80-qt mixer with a pastry blender attachment was used to prepare the mix. Dry milk solids and flour were placed in the mixing bowl; butter was added and mixed at low speed for 30 sec. The motor was stopped, mixing bowl lowered, and sides and bottom of bowl and paddle were scraped down with a rubber spatula. Hydrogenated vegetable shortening was added and blended for 30 sec at low speed. The scrape-down process was repeated. Mixing was continued at low speed for about 30 sec, or until the mix appeared yellow in color and crumbly in texture.

Table 2. Formula for medium white sauce mix.

Ingredients	Actual wt	Approx wt	
	g	lb	oz
Instant nonfat dry milk	2721	6	
All-purpose flour	1190	2	10
Hydrogenated vegetable shortening	1361	3	
Butter	1361	3	

Yield - 21 qt white sauce

The mix was placed in 1-gal. glass jars, covered with metal lids, and stored at 35-40 F until needed. The formula provided enough mix for 4 periods.

Preparation of Medium White Sauces. The formula for medium white sauce using instant nonfat dry milk mix is shown in Table 3. Sauces were prepared in 3 3-gal., electronically controlled trunnion kettles. Thermostats on kettles were set to maintain a temperature of about 90° C during cooking. For each gal. of white sauce, 1247.4 g (2 lb, 12 oz) of mix and 28.4 g (1 oz) salt were weighed and stored overnight at a temperature of 40° F. At the time of cooking, 3840.0 g (4 qt) of water were heated in a kettle to 90° C. The mix was added to hot water and stirred with a wire ship until all lumps were dispersed, after which it was stirred for 30 sec at intervals of 10 min. Cooking times were 5, 10, 20, or 45 min, as specified by the experimental design. Final cooking temperatures were recorded.

Table 3. Formula for medium white sauce.

Ingredients	Actual wt	Approx wt or meas		
	g	lb	oz	qt
Water	3840.0			4
Mix	1247.4	2	12	
Salt	28.4		1	

Yield - 1 gal. white sauce

Evaluation Procedures

Viscosity. At end of cooking period, triplicate measurements for viscosity of the sauces were made by a MacMichael viscosimeter. Hot water was poured into the outer cup until the cup plus water weighed 520 g. White sauce was placed in the inner cup for a combined weight of cup plus sauce of 260 g. A spindle plunger supported by a 30 gauge wire was immersed in the sauce, the inner cup rotated for 10 sec, and the viscosity reading recorded. High readings indicated viscous samples.

Organoleptic Test. Immediately following viscosity evaluation a palatability committee of 12 scored samples of the sauces. A 5-point scale was used; 5 points represented an excellent product and 1 point a poor product. Characteristics judged were appearance, consistency, texture, and flavor. Each judge was provided with a tray containing score card (Form I, Appendix), pencil, glass of water, 3 spoons, and 3-oz samples of sauce.

RESULTS AND DISCUSSION

Palatability Factors

Table 4 contains mean scores for palatability of appearance, consistency, texture, and flavor. Detailed data are in Tables 6, 7, 8, and 9 (Appendix).

Table 4. Average of mean values for palatability factors[1] and viscosity values[2] for medium white sauces made with instant nonfat dry milk.

Factors	lsd	Cooking time in min 5		10		20		45
Appearance								
Curdled	0.23	4.4	*	4.2	*	4.6	ns	4.5
Fat-separation	0.36	3.8	*	3.4	*	3.9	*	4.4
Consistency		4.2	ns	4.1	ns	4.1	ns	4.0
Texture		3.7	ns	3.7	ns	3.8	ns	3.8
Flavor								
Unpleasant milk		4.2	ns	4.0	ns	4.3	ns	4.1
Raw starch	0.21	4.2	ns	4.2	ns	4.3	ns	4.5
Viscosity		83.5	ns	78.9	ns	84.9	ns	82.9

1 Scoring range, 5 to 1.
2 MacMichael units.
* Significant at the 5% level.
ns Nonsignificant.
lsd Least significant difference.

Appearance. The first category under appearance was curdled or noncurdled sauce. Noncurdled sauces were scored 5 (Form I, Appendix). Mean scores for 5-min sauces ranged from 4.1 to 4.7; 10-min sauces, 3.6 to 4.6; 20-min sauces, 4.3 to 4.9; and 45-min sauces, 4.2 to 4.7 (Tables 6, 7, 8, and 9, Appendix). Mean scores were 4.4, 4.2, 4.6, and 4.5 for 5-, 10-, 20-, and 45-min sauces, respectively (Table 4).

Statistical analyses showed that the mean score of 10-min sauces varied significantly from those for 5-, 20-, and 45-min sauces. Significant differences in mean scores of 5-, 20-, and 45-min sauces were not evident. Curdling apparently was not an important factor, since all scores were above the median point of 3 for this characteristic.

Appearance was related also to separation or nonseparation of fat in the sauce. A score of 5 indicated no fat separation, and 1 the opposite condition (Form I, Appendix). The range of mean scores for 5-min sauces was 3.1 to 4.3; for 10-min sauces, 3.0 to 4.0; for 20-min sauces, 3.3 to 4.4; and 45-min sauces 4.0 to 4.7 (Tables 6, 7, 8, and 9, Appendix). Average scores for this characteristic were 3.8, 3.4, 3.9, and 4.4 for 5-, 10-, 20-, and 45-min sauces respectively (Table 4). A significant difference was apparent between mean scores for sauces cooked for 45 min and those cooked for 5, 10, or 20 min. A significant difference was found also for mean scores of sauces cooked for 10 min and those cooked for 5, 20, or 45 min. Differences for mean values between 5- and 20-min sauces were not significant. Sauces cooked for 10 min showed the greatest tendency to separate, whereas those cooked for 45 min, the least.

Consistency. Consistency scores for medium white sauces were described as like thick cream when rated 5. Scores below 3 might indicate a sauce either too thick or too thin (Form I, Appendix). Mean scores for 5-min sauces ranged from 3.8 to 4.3; 10-min sauces, 3.6 to 4.4; 20-min sauces, 3.8 to 4.6; and 45-min sauces, 3.3 to 4.7 (Tables 6, 7, 8, and 9, Appendix). Cooking times produced no detectable differences in consistency of sauces, which for that characteristic had mean scores of 4.2 for 5-min sauces, 4.1 for 10-min, 4.1 for 20-min, and 4.0 for 45-min sauces (Table 4).

Texture. Smooth sauces were rated 5 whereas scores below 5 were for sauces of varying degrees of either graininess and/or lumpiness (Form I, Appendix). Mean scores for 5-min sauces ranged from 3.2 to 4.2; for 10-min sauces, 3.0 to 3.9; for 20-min sauces, 3.2 to 4.3; and 45-min sauces, 3.1 to 4.3 (Tables 6, 7, 8, and 9, Appendix). No detectable treatment effects were found on mean texture scores of 3.7, 3.7, 3.8, and 3.8 for 5-, 10-, 20-, and 45-min sauces, respectively (Table 4). No differences in texture of sauces were produced by cooking times.

Flavor. Flavor was rated for qualities relating to both milk and starch. Scores ranged from 5 for free from unpleasant milk flavor to a low of 1 for the opposite condition (Form I, Appendix). The range of mean scores for 5-min sauces was 3.7 to 4.6; for 10-min sauces, 3.7 to 4.3; for 20-min sauces, 3.9 to 4.6; and 45-min sauces, 3.7 to 4.4 (Tables 6, 7, 8, and 9, Appendix). Mean scores relating to milk flavor of sauces were 4.2 for 5-min, 4.0, 10-min, 4.3, 20-min, and 4.1, 45-min sauces (Table 4). Significant differences were not apparent in average scores for this characteristic. No cooking effects on milk flavor of sauces could be detected.

Sauces free from raw starch flavor were given scores of 5, whereas lower scores indicated varying degrees of starch taste (Form I, Appendix). Range of mean scores for 5-min sauces was 3.9 to 4.6; for 10-min sauces, 3.9 to 4.6; for 20-min sauces, 4.0 to 4.7; for 45-min sauces, 4.1 to 4.7 (Tables 6, 7, 8, and 9, Appendix). Raw starch flavor average scores were 4.2 for 5-min, 4.2, 10-min, 4.3, 20-min, and 4.5, 45-min sauces. Flavor scores of raw starch were significantly higher for 45-min sauces than for 5- and 10-min sauces. No statistical differences were found in mean scores for the 5-, 10-, and 20-min sauces (Table 4). Showing least amount of raw starch flavor, 45-min sauces received highest scores.

Viscosity

High values, as measured by the MacMichael viscosimeter, indicated thicker sauces than did low values (Table 4). Mean scores for 5-min sauces ranged from 73.0 to 109.7; for 10-min sauces, 60.0 to 95.0; for 20-min sauces, 73.3 to 97.3; and 45-min sauces, 67.7 to 102.3 (Tables 6, 7, 8, and 9, Appendix). Average values for viscosity of medium white sauces were 83.5 for 5-min sauces, 78.9, 10-min, 84.9, 20-min, and 82.9, 45-min sauces. Treatment effects on the viscosity of sauces were not significantly evident.

Cost

Ingredient amounts and costs for medium white sauces are summarized in Table 5. Using actual market prices (Manhattan, Kansas, April, 1966), calculated cost of 1 gal. of medium white sauce was $1.22.

Table 5. Raw food costs[1] of medium white sauces prepared from a mix containing instant nonfat dry milk.

Ingredients	Amount	Cost
Flour, all-purpose	2 lb, 10 oz	$0.169
Milk, instant nonfat dry	6 lb	3.195
Shortening, hydrogenated vegetable	3 lb	.735
Butter	3 lb	2.280
Total cost of mix		6.379
Medium white sauce mix	2 lb, 12 oz	1.215
Salt	1 oz	.008
Total cost of 1 gal. of medium white sauce		1.223

[1] Manhattan, Kansas, April, 1966.

SUMMARY

This study was undertaken to determine raw starch taste, nonfat dry milk flavor, viscosity, and acceptability of medium white sauces made from nonfat dry milk white sauce mix and cooked 5, 10, 20, or 45 min.

Ingredients were at room temperature when weighed and combined. Mix was placed in 1-gal. glass jars, covered with metal lids, and stored at 35-40° F until needed. White sauces were cooked in electronically controlled trunnion kettles. After 3840.0 g of water were heated in a kettle to 90° C, mix was added and stirred with a wire whip until all lumps were dispersed. Sauces were cooked for 5, 10, 20, or 45 min, as specified by the experimental design. The incomplete block design included preparation and testing of 36 sauces in 12 periods. A period consisted of preparation and testing of 3 white sauces. End point temperatures were recorded.

Judges scored samples of white sauces for appearance, consistency, texture, and flavor. Viscosity of sauces was measured with a MacMichael viscosimeter. High readings indicated viscous samples. The data were subjected to analyses of variance. Where appropriate, least significant differences were determined.

Statistical analyses of data for appearance as related to curdled or noncurdled sauce showed that the mean score of 10-min sauces varied significantly from that for 5-, 20-, and 45-min sauces. Sauces cooked for 10 min received lowest scores, indicating more curdling than for other sauces. However, curdling was slight for all sauces. A significant difference regarding appearance as related to separation or nonseparation of fat was apparent between the sauces cooked for 45 min and those cooked for 5, 10, or 20 min. A significant difference was found also for mean score of sauces cooked for 10 min and those cooked for 5, 20, or 45 min. Highest score was received by sauces cooked for 45 min denoting small amount of fat separation, whereas 10-min sauces received lowest score indicating increased amount of fat separation. Flavor of raw starch was significantly higher for 45-min sauces than for 5- and 10-min sauces. Sauces cooked for 45 min received the highest score, indicating least amount of raw starch flavor. Using actual market prices (Manhattan, Kansas, April, 1966), calculated cost of 1 gal. of medium white sauce was $1.22.

CONCLUSIONS

Under the conditions of this study the following statements may be made:

1. Sauces cooked for 45 min demonstrated less fat separation than did sauces cooked for 5, 10, or 20 min.
2. Curdling did not appear to be a problem.
3. Sauces cooked for 45 min had the least raw starch flavor.

4. Length of cooking time did not affect consistency, texture, milk flavor, or viscosity of sauces.

RECOMMENDATIONS

1. Sauces to be used in a prepared dish need to be cooked initially no longer than 5 min.
2. Although 45-min sauce had the highest score, indicating the least raw starch flavor, no sauce had a lower score than 4 (with 2 exceptions of 3.9). In all probability sauces do not need to be cooked for longer than 5 or 10 min to be an acceptable product.

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APPENDIX

FORM I
SCORE CARD FOR MEDIUM WHITE SAUCE

NAME________________ SERIES________________

DATE________________

CHARACTERISTIC	SCORE RANGE 1	3 ... 5	PRODUCTS 1	2	3	COMMENTS
APPEARANCE	Curdled	Not curdled				
	Fat separation	No fat separation				
CONSISTENCY	Too thin Too thick	Like thick cream				
TEXTURE	Grainy Lumpy	Smooth				
FLAVOR	Unpleasant milk flavor	Free from unpleasant milk flavor				
	Raw starch flavor	Free from raw starch flavor				

Key -- 5 - Excellent
4 - Good
3 - Average
2 - Fair
1 - Poor

FORM II

Instructions for palatability committee.

1. The committee will meet Tuesday, Thursday, and Saturday from 9:30 to 10:00 a.m.
2. At the start of the scoring period, a tray with samples for testing, cold water, scorecard and pencil will be given to each member.
3. Scoring will be done at work tables at the north end of the laboratory.
4. Please do not talk before, during or after scoring, in order to avoid influencing other members' scores.
5. Place your name and date on the scorecard.
6. Additional comments are encouraged.
7. Colds and hay fever may affect the senses of taste and smell. These conditions should be noted on scorecard.
8. Please refrain from eating or drinking 30 minutes prior to tasting.
9. Do not stir sauces excessively while scoring, as this causes them to become thinner.

Table 6. Mean palatability scores[1] for medium white sauces made with instant nonfat dry milk mix and cooked for 5 min.

Testing period	Appearance		Consistency	Texture	Flavor		Viscosity[2]
	Curdled	Fat-separation			Milk	Starch	
1	4.5	3.9	4.1	3.9	4.0	3.9	73.0
3	4.3	3.8	4.1	3.3	4.3	4.1	60.7
5	4.1	3.1	4.1	4.0	4.4	4.0	63.3
6	4.1	3.3	4.2	3.3	3.7	4.1	90.0
7	4.6	3.7	3.8	3.2	4.6	4.1	81.7
8	4.6	4.3	4.2	3.7	4.3	4.5	78.0
9	4.7	4.1	4.2	4.2	4.4	4.2	89.3
11	4.4	4.1	4.3	3.7	4.3	4.6	76.3
12	4.3	3.8	4.2	4.1	4.1	4.2	109.7
Average	4.4	3.8	4.2	3.7	4.2	4.2	83.5

1 Scoring range, 5 to 1.

2 MacMichael units.

Table 7. Mean palatability scores[1] for medium white sauces made with instant nonfat dry milk mix and cooked for 10 min.

Testing period	Appearance		Consistency	Texture	Flavor		Viscosity[2]
	Curdled	Fat-separation			Milk	Starch	
1	4.5	3.7	4.2	3.5	4.1	3.9	95.0
2	4.0	3.1	3.6	3.4	4.0	4.2	77.3
3	4.4	3.9	4.3	3.9	4.2	4.3	81.3
4	4.3	3.6	3.9	3.0	4.1	4.2	91.0
5	4.1	3.0	4.3	3.9	4.0	4.4	53.3
7	4.0	3.4	4.1	3.6	3.9	4.6	85.0
9	4.2	3.3	3.9	3.7	4.2	4.3	81.0
10	4.6	4.0	4.1	3.9	4.3	4.3	78.7
11	3.6	3.1	4.4	3.8	3.7	4.1	60.0
Average	4.2	3.4	4.1	3.7	4.0	4.2	78.9

1 Scoring range, 5 to 1.

2 MacMichael units.

Table 8. Mean palatability scores[1] for medium white sauces made with instant nonfat dry milk mix and cooked for 20 min.

Testing period	Appearance		Consistency	Texture	Flavor		Viscosity[2]
	Curdled	Fat-separation			Milk	Starch	
2	4.6	3.9	4.3	3.2	4.0	4.2	85.0
3	4.4	4.0	3.8	3.5	4.2	4.3	82.0
4	4.5	3.9	4.2	3.5	4.2	4.2	79.0
6	4.3	3.9	4.1	3.4	4.0	4.0	96.7
7	4.7	4.1	3.9	4.3	4.6	4.4	86.7
8	4.6	3.3	4.1	4.1	3.9	4.2	75.0
10	4.9	4.4	4.1	4.0	4.6	4.7	94.3
11	4.9	4.3	4.6	4.1	4.6	4.6	73.3
12	4.5	3.9	4.1	4.0	4.4	4.2	97.3
Average	4.6	3.9	4.1	3.8	4.3	4.3	84.9

1 Scoring range, 5 to 1.

2 MacMichael units.

Table 9. Mean palatability scores[1] for medium white sauces made with instant nonfat dry milk mix and cooked for 45 min.

Testing period	Appearance		Consistency	Texture	Flavor		Viscosity[2]
	Curdled	Fat-separation			Milk	Starch	
1	4.2	4.0	3.3	3.1	3.8	4.5	95.0
2	4.7	4.5	4.0	3.3	3.7	4.1	93.3
4	4.4	4.1	4.1	3.5	4.2	4.4	102.3
5	4.4	4.7	3.7	3.9	4.0	4.5	78.3
6	4.5	4.6	4.3	4.1	4.4	4.7	81.7
8	4.6	4.4	4.1	4.2	4.2	4.4	70.3
9	4.6	4.1	4.1	3.7	4.1	4.6	90.7
10	4.7	4.6	4.7	4.3	3.9	4.7	67.7
12	4.4	4.2	4.0	4.1	4.0	4.1	78.3
Average	4.5	4.4	4.0	3.8	4.1	4.5	82.9

1 Scoring range, 5 to 1.

2 MacMichael units.

COOKING TIME FOR MEDIUM WHITE SAUCE PREPARED FROM A MIX

by

FRANCES LUCILE DAVITT

B. S., Kansas State University, 1949

AN ABSTRACT OF A MASTERS THESIS

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ABSTRACT

Because of the shortage and high cost of labor, various types of mixes are used in food services. Mixes not only save labor and time, but are easy to employ. They may be either commercially manufactured or made during slack work periods in individual kitchens resulting in reduced or more efficient use of preparation time. Other advantages of mixes are decreased number of utensils needed, elimination of dangers of failure, assured standardization of quality and nutritive value, and cost comparable to those products made on the premises. White sauces are part of many recipes. Therefore, use of a white sauce mix would be both convenient and time-saving, as well as helpful in emergency situations.

This study was undertaken to determine raw starch taste, nonfat dry milk flavor, viscosity, and acceptability of medium white sauces made from nonfat dry milk white sauce mix and cooked 5, 10, 20, or 45 min.

Ingredients were at room temperature when weighed and combined. Mix was placed in 1-gal. glass jars, covered with metal lids, and stored at 35-40° F until needed. White sauces were cooked in electronically controlled trunnion kettles. After 3840.0 g of water were heated in a kettle to 90° C, mix was added and stirred with a wire whip until all lumps were dispersed. Sauces were cooked for 5, 10, 20, or 45 min, as specified by the experimental design. The incomplete block design included preparation and testing of 36 sauces in 12

periods. A period consisted of preparation and testing of 3 white sauces. End point temperatures were recorded.

Judges scored samples of white sauces for appearance, consistency, texture, and flavor. Viscosity of sauces was measured with a MacMichael viscosimeter. High readings indicated viscous samples. The data were subjected to analyses of variance. Where appropriate, least significant differences were determined.

Statistical analyses of data for appearance as related to curdled or noncurdled sauce showed that the mean score of 10-min sauces varied significantly from that for 4-, 20-, and 45-min sauces. Sauces cooked for 10 min received lowest scores, indicating more curdling than for other sauces. However, curdling was slight for all sauces. A significant difference regarding appearance as related to separation or nonseparation of fat was apparent between the sauces cooked for 45 min and those cooked for 5, 10, or 20 min. A significant difference was found also for mean score of sauces cooked for 10 min and those cooked for 5, 20, or 45 min. Highest score was received by sauces cooked for 45 min denoting small amount of fat separation, whereas 10-min sauces received lowest score indicating increased amount of fat separation. Flavor of raw starch was significantly higher for 45-min sauces than for 5- and 10-min sauces. Sauces cooked for 45 min received highest score, indicating least amount of raw starch flavor. Using actual market prices

(Manhattan, Kansas, April, 1966), calculated cost of 1 gal. of medium white sauce was $1.22.