CURED MEATS WITH REDUCED NITRITE PRESERVED BY RADAPPERTIZATION

EUGEN WIERBICKI AND FRED HEILIGMAN

U. S. Army Natick Laboratories
Natick, Massachusetts 01760 U.S.A.

and

AARON E. WASSERMAN

U. S. Department of Agriculture
Philadelphia, Pa. U.S.A.

A series of experiments were conducted using deboned, smoked, "fully cooked" ham, and cured, smoked bacon as the experimental material to determine the minimal amounts of nitrite and nitrate needed to produce the characteristic color, flavor, texture, and overall acceptance of the products, while providing the necessary control of C. botulinum by radappertization (radiation sterilization).

Initial research on ham of this series has been reported.* The new information includes: chemical and organoleptic determinations of the ham samples after 14 months of non-refrigerated (23-28°C) storage; minimum radiation sterilizing dose (MRD) for the low nitrite/nitrate (25/100 ppp) ham; and confirmatory results obtained on irradiated (2.3 Mrad at ambient temp.) and non-irradiated bacon.

The results showed that: (1) nitrite, which is needed for the characteristic color, flavor, and overall acceptance of cured ham and bacon can be reduced from 156 ppm (the USDA maximum allowed and commonly used by the meat industry) to 25 ppm in the radappertized products; (2) a small amount of nitrate (100 ppm) and the USDA allowed amounts of ascorbate/erythorbate (500-550 ppm) are needed to prevent fading of the cured meat color in radappertized cured meats; (3) complete elimination of nitrite in ham caused a slight reduction in texture scores as determined by a taste panel but not by Kramer Shear Press; (4) the MRD under the 12-D concept for the ham cured with the reduced additions of nitrite/nitrate is 3.3 Mrad when the product temperature during irradiation is -30° ± 10°C; (5) an increase of sodium ascorbate/erythorbate from 500 to 1000 ppm was effective in controlling the increase of TBA-values during storage of low nitrite/nitrate (25/100 ppm) bacon samples stored in unsealed packages in 2-4°C refrigerator for 3 months after processing.

No nitrosamines (dimethylnitrosamine, methylethylnitrosamine, diethylnitrosamine, nitrosomorpholine, nitrosopyrrolidine (NO-Pyr) and nitrosopiperidine) were found in irradiated and non-irradiated ham samples shortly after processing. Determination of nitrosamines is in progress in the regular and low nitrite/nitrate irradiated ham after 14 months of non-refrigerated storage and in the bacon samples (with emphasis on NO-Pyr).

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VIANDES SALÉES A NITRITE RÉDUITE CONSERVÉES PAR RADAPPERTISATION

(EUGEN WIERBICKI et FRED HEILIGMAN, U.S. Army Natick Laboratories, Natick, Massachusetts, 01760, U.S.A.;
et
AARON E. WASSERMAN, Département de l'Agriculture des E.-U. Philadelphie, Pa. U.S.A.)

On a fait une série d'expériences sur du jambon désossé, fumé, "bien cuit" et du bacon fumé pour déterminer les quantités minima de nitrite et nitrate nécessaires à produire la couleur, le goût et la texture caractéristiques et l'accueil généralement favorable du public tout en assurant le contrôle nécessaire de C. botulinum par radappertisation (stérilisation p.radiation).

Un rapport a déjà été présenté sur les recherches initiales de cette série sur le jambon.* Les indications nouvelles comprennent: détermination chimique et organoleptique des spécimens de jambon après 14 mois de magasinage non-réfrigéré (23-28°C); dose minimum de stérilisation par radiation (MRD) pour le jambon à bas nitrite/nitrate (25/100 ppm); et résultats confirmatifs obtenus sur du bacon irradié (2,3 Mrad à température ambiante) et non-irradié.

Les résultats ont indiqué que: (1) la nitrite --nécessaire pour la couleur, le goût caractéristiques et le bon accueil général de jambons salés et bacon-- peut, dans les produits radappertisés, être réduite de 156 à 25 ppm; (2) une petite quantité de nitrate (100 ppm) et les quantités admises par le Département de l'Agriculture des E.-U. d'ascorbat/erythorbat (500-550 ppm) sont nécessaires pour prévenir la perte de couleur salaison dans les viandes salées radappertisées; (3) l'élimination complète de nitrite dans le jambon a causé une légère réduction dans la texture des stries, de l'avis d'une commission de dégustateurs mais pas à la "Kramer Shear Press"; (4) le MRD au-dessous du concept de moins de 12-D pour le jambon salé avec addition de quantités réduites de nitrite/nitrate est de 3,3 Mrad lorsque la température du produit pendant l'irradiation est -30°C±10°C; (5) une augmentation de l'ascorbat/erythorbat de sodium de 500 à 1000 ppm a été efficace dans le contrôle de l'accroissement des valeurs TBA pendant le magasinage d'échantillons de bacon à bas nitrite/nitrate (25/100 ppm) en emballage non scellé dans un réfrigérateur à 2-4°C pendant trois mois après salaison.

On n'a pas trouvé de nitrosamines (dimethylnitrosamine, methylethylnitrosamine, diethylnitrosamine, nitrosomorpholine, nitrosopyrrolidine (NO-pyr) et nitrosopiperidine) dans des échantillons de jambon irradié et non-irradié peu de temps après traitement. La détermination de nitrosamines est en cours dans le jambon régulier et à bas nitrite/nitrate irradié après 14 mois de magasinage non-réfrigéré et dans les spécimens de bacon (en particulier pour le NO-pyr).

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GEPOEKELTES FLEISCH MIT REDUZIERTEM NITRITGEHALT HALTBAR GEMACHT DURCH BESTRAHLUNG.

EUGEN WIERBICKI UND FRED HEILIGMAN

U. S. Army Natick Laboratories
Natick, Massachusetts 01760 U.S.A.

und

AARON E. WASSERMAN

U. S. Department of Agriculture
Philadelphia, Pa. U.S.A.

Eine Serie von Versuchen wurde durchgefuehrt mit entknoechertem, geraeuchertem, "voellig gekochtem" Schinken und geraeuchertem Bacon, um die minimalen Zugaben von Nitrit und Nitrat, die fuer die typische Farbe, Aroma, Struktur und Geschmack von gepoekelten Fleischprodukten noetig sind, zu bestimmen und die verlangte Kontrolle von C. botulinum durch Radappertisation (Bestrahlungs-Sterilisierung) zu verschaffen.

Die ersten Versuche mit Schinken dieser Serie sind bereits publiziert.* Die neuen Informationen geben einschliesslich: chemische und sensorische Bewertungen von bestrahltem Schinken, der 14 Monate in Zimmertemperatur (23-28 C) aufbewahrt wurde; die minimale sterilisierende Bestrahlungsdose (MRD) fuer den Schinken mit dem reduzierten Nitrit/Nitrat- (25/100 ppm) Gehalt; und die affirmativen Resultate, die mit dem bestrahlten (2.3 Mrad) und unbestrahlten Bacon gewonnen wurden.

Die Versuchsergebnisse haben erwiesen: (1) die Nitritzugabe beim Poekeln von Schinken und Bacon kann von 156 ppm auf 25 ppm reduziert werden, ohne typische Farbe, Aroma und Geschmack von diesen gepoekelten Fleischprodukten zu beeintraechtigen; (2) die kleine Zugabe von Nitrat (100 ppm) und die erlaubte Menge von Ascorbat/Erythorbat (500-550 ppm) sind noetig fuer die Farbhaltung in den bestrahlten Produkten; (3) die vollkommene Eliminierung von Nitrit in Schinken hat eine Erniedrigung von Strukturnoten verursacht, wenn sensorisch bewertet, aber nicht wenn bestimmt mit der "Kramer Shear"-Presse; (4) die MRD fuer den Schinken mit dem reduzierten Nitrit/Nitrat-Gehalt, wenn bestrahlt bei einer Produkttemperatur von 30° ± 10°C, ist 3.3 Mrad; und (5) eine Erhoehung der Ascorbat/Erythorbat-Zugabe von 500 auf 1000 ppm in Bacon mit dem reduzierten Nitrit/Nitrat-Gehalt (25/100 ppm) war wirksam in der Kontrolle der TBS-Werterhoehung in nicht luftdicht verpackten Baconproben, die im Kuehlschrank (2-4°C) fuer eine Zeit von 3 Monaten gehalten wurden.

Keine Nitrosoverbindungen (DMNA, MÄNA, DÄNA, NO-Mor, NO-Pip und NO-Pyr) wurden in bestrahltem und unbestrahltem Schinken kurz nach dem Herstellungsprozess nachgewiesen. Die Bestimmung der Nitrosoverbindungen in bestrahltem Schinken mit normalen und reduzierten Nitrit/Nitrat-Zugaben nach 14-monatiger Aufbewahrung und in den Baconproben (mit besonderer Beruecksichtigung von Nitrosopyrrolidin (NO-Pyr)) ist noch im Gange.

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Е.Вербицкий, Б.Гейликман, А.Е.Вассерман (США).

КОНСЕРВИРОВАНИЕ СОЛЕНО-КОПЧЕНЫХ МЯСОПРОДУКТОВ РАДАППЕРТИЗАЦИЕЙ ПРИ УМЕНЬШЕНИИ ДОБАВОК НИТРИТА.

Была проведена серия опытов по приготовлению солено-копченого окорока и бекона при минимальном содержании в рассоле нитрита и нитрата. Эти добавки нужны для получения присущих этим продуктам окраски, запаха, структуры и вкуса. В то же время, чтобы избежать появления ботулизма, продукты подвергаются радаппертизации (стерилизации высокими дозами ионизирующего облучения).

Первые результаты этой серии опытов уже опубликованы* В данной статье описываются химические и органолептические свойства облученного окорока после хранения в течение I4 месяцев вне холодильника при температуре 23-28°C; приводятся оценки минимальной стерилизующей дозы облучения (в Мрад) для окорока с пониженным добавлением нитрита/нитрата (25/I00мг/кг); проверка результатов опытов путем сравнения облученного со всех сторон дозой 2,3 Мрад и необлученного бекона.

Результаты опытов показывают, что:
(I) Количество нитрита, нужное для придания окороку и бекону характерного запаха, вкуса и цвета может быть уменьшено со I56мг/кг (максимум, допускаемый Министерством Сельского Хозяйства США и используемый промышленностью) до 25мг/кг для продуктов подвергшихся радаппертизации;
(2) Необходимо добавлять некоторое количество нитрата (I00мг/кг) и допускаемые МСХ США количества аскорбата или изоаскорбата (500 или 550мг/кг), чтобы сохранить окраску облученных продуктов;
(3) Отсутствие нитрита в окороке несколько ухудшало его органолептическую структуру. Вместе с тем испытания, проведенные с использованием пресса „Kramer Shear" не обнаружили никакого снижения оценок.
(4) Минимальная доза облучения для окорока с пониженным содержанием нитрита/нитрата составляет 3,3 Мрад при температуре во время облучения -30±I0°C;
(5) Увеличение содержания аскорбата (или изоаскорбата) с 500 до I000мг/кг оказывало влияние на значение ТБК во время трехмесячного хранения бекона с пониженным содержанием нитрита/нитрата (25/I00мг/кг) в открытой упаковке в холодильнике при температуре 2-4°C.

При исследовании как облученного, так и необлученного окорока через короткое время после обработки не было обнаружено нитрозаминов (ДМНА, МЭНА, ДЭНА, НО-Мор, НО-Пип, НО-Пир). В настоящее время работы по определению нитрозаминов для облученного окорока с обычным и пониженным содержанием нитрита/нитрата после I4-месячного хранения вне холодильника и в образцах бекона (особенно на НО-Пир) еще не завершены.

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NITRITES AND NITROSAMINES IN PROCESSED MEATS

CURED MEATS WITH REDUCED NITRITE PRESERVED BY RADAPPERTIZATION.

EUGEN WIERBICKI AND FRED HEILIGMAN
U. S. Army Natick Laboratories, Natick, Mass. 01760, U. S. A.
and
AARON E. WASSERMAN
U. S. Department of Agriculture, Philadelphia, Pa. 19118, U. S. A.

INTRODUCTION

Nitrite and nitrate benefit the organoleptic qualities of cured meats and nitrite, in combination with other curing agents, also inhibits toxin production by C. botulinum in thermally processed meats. The use of these curing agents, however, has been under reappraisal by the meat industry and the health regulatory agencies because under certain conditions nitrite may react with free amines in food forming nitrosamines, which are carcinogenic (4, 5, 6, 8).

The experiments reported in this paper were designed to reduce the additions of nitrite, $NaNO_2(NO_2)$ and nitrate $NaNO_3(NO_3)$ during curing to the minimal amounts needed for the characteristic color, flavor and overall acceptance of cured meats, while eliminating the possible hazards from C. botulinum by radappertization (radiation sterilization). Smoked ham and bacon were used as the experimental cured meats.

Initial research on ham of this series of experiments has been reported (7). Using smoked ham it was shown that NO_2 can be reduced from 156 mg/kg, the U. S. Department of Agriculture (USDA) allowed and commonly used by the meat industry, to 25 mg/kg in irradiated and non-irradiated ham without affecting the characteristic color, odor, flavor and overall acceptance of the product. The information given in this paper includes (a) organoleptic evaluation of the low NO_2/NO_3 (25/100 mg/kg) and the high NO_2/NO_3 (150/600 mg/kg) irradiated (3.7-4.4 Mrad at -30±10°C) ham after 14 months non-refrigerated (23-28°C) storage; (b) residual NO_2 and NO_3 in the ham; (c) effect of NO_2 and NO_3 on the ham texture; and (d) the minimum irradiation sterilizing dose (MRD) of the low NO_2/NO_3 ham under the 12-D concept. The study has also been extended to irradiated and non-irradiated bacon, cured with the low and high NO_2/NO_3 and Na-ascorbate (A) and Na-erythorbate (E) 1:1 mixture of 500 or 1000 mg/kg.

Limited data are provided also for the determinations of nitrosamines in the irradiated and non-irradiated ham and bacon, with emphasis on the nitrosopyrrolidine (NO-Pyr) in bacon.

EXPERIMENTAL

Ham. - The product was cured and processed as sectioned-and-formed, boneless, "fully-cooked", smoke ham (7). The curing ingredients were non-iodized salt (NaCl), sodium tripolyphosphate (TPP), $NaNO_2$, $NaNO_3$ and 1:1 mixture of A/E. The resulting product was in the form of rectangular rolls, 10.8 x 17.8 cm cross section. The rolls were cut into 12 mm thick slices (115 ± 5 g. per slice), vacuum packed in flexible pouches and irradiated with a dose of 3.7-4.4 Mrad at -30±10°C at the 1,250,000 curie Cobalt-60 irradiation facilities at the NLABS (U. S. Army Natick Laboratories) with a dose rate of about 30,000 rads/sec. After irradiation, the ham samples were stored at room temperature (23-28°C) until evaluation. The non-irradiated controls were stored at -29°C.

Bacon. - Six lots of bacon, ten 12/14 lb. bellies per lot, were stitch pumped with six different cures to the 12.5% level. Assuming 11% retention of the cures, the cure compositions were formulated to result in the finished product with the added curing ingredients specified in Table 4. The pumped bellies were placed in polyethylene bags and cured for 3 days at 0 - 1.6°C. The smokehouse processing was for 22 hours to internal temperature of 53.3°C and the yield-to-green of 100%. The chilled (-4 to -3°C) bellies were sliced (2.5 mm/slice) and packed into 1-pound commercial bacon boards. Several representative slices from each lot were removed for the proximate analysis at the time of slicing (3 days after smokehouse processing).

For irradiation one-pound bacon samples were packed into 303x509 size metal cans with "C" enamel lining and sealed under vacuum of not less than 125 mm. Hg. The bacon was given 2.3-2.7 Mrad at ambient temp. (the 12-D dose) (3-4°C starting temperature and 15-18°C after completion of the irradiation). After irradiation, the irradiated samples were stored at 23-28°C. Non-irradiated, vacuum packed samples were stored at -29°C.

Evaluation - The bacon (and ham) samples were evaluated by an 8-12 member expert panel for color, odor, flavor, texture and appearance using the 9-point intensity scale (1 - extremely poor, 5 - fair, 9 = excellent).

The overall quality was determined by testing for preference using the 9-point hedonic scale (1 - dislike extremely, 5 = neither like nor dislike, 9 = like extremely), using the 8-12 member expert panel and 32-member consumer type panel. Scores of 5 indicate marginal quality characteristics and scores of 6 to 9 indicate products of acceptable quality.

The samples were analyzed chemically for proximate composition and pH, residual NO_2 and NO_3, added TPP, Na-Asc. and Na-Eryth. and TBA values. Details on the methodology used have been reported previously (7).

Nitrosamines were determined using gas-liquid chromatography and high resolution mass spectrometry.

RESULTS AND DISCUSSION

Ham.- In the initial research on ham of this series it was shown that the additions of $NaNO_2$ and $NaNO_3$ can be reduced from 150/600 to 25/100 mg/kg and that 25 mg/kg $NaNO_2$ is definitely needed to get the characteristic color, odor and flavor of the ham (7). The study has been extended to determine the need, if any, of $NaNO_2$ on the texture of ham. Table 1 gives the results. The cures appear to have no definite effect on the texture of ham. The lower scores given cures D and E are a result of a bias by the panelist when the texture evaluation was made under incandescent light. By repeating the test under red light, the differences in the texture scores disappeared. The texture sensory data were confirmed by the Kramer Shear Press data.

The effect of the added NO_2 and NO_3 on the sensory quality of irradiated ham after 14 month storage at 23-28°C is given in Table 2. The data indicate that the low additions of NO_2 and NO_3 (25/100 mg/kg) are sufficient to get a high quality irradiated product that is stable without refrigeration for a long period of time.

The effect of the added NO_2 and NO_3 on their residual amounts in the irradiated and non-irradiated ham is given in Table 3. The data indicate that the residual nitrite approaches the analytical "zero" line (0.9 to 1.9 mg/kg) after 10 days storage in both the high and low nitrite ham. The amount of nitrate in the ham shows an interesting relationship in the addition of NO_2/NO_3 to the hams during curing. Whereas the amount of the residual NO_3 in the high nitrite ham (Cure 01) is close to the amount added during curing, in the low nitrite ham (Cure 02) and no-nitrite hams (Cures 03 and 04), the amounts of the residual NO_3 is significantly greater than the amounts added during curing. Even the no-nitrate ham (Cure 05) contained 51 to 78 mg/kg residual free nitrate. It appears that the ban of nitrate from cured meats, if attempted, will be impossible to enforce since free nitrate is present in meats cured without nitrate. The inoculated pack study (using the most radiation resistant spores of C. botulinum, types A and B) on the low nitrite/nitrate (25/100 mg/kg) ham to determine the MRD has been conducted by the Microbiology Division of NLABS during the period July 1973 through March 1974 and was established to be 3.3 Mrad at -30±10°C.

There was no indication of the presence of the nitrosamines, DMNA, MENA, DENA, NO-Mor, NO-Pip, and nitrosopyrrolidine (NO-Pyr), in any of the irradiated and non-irradiated ham shortly after processing. The determination of the nitrosamines in the 14 month stored samples is still in progress.

Bacon. The intended additions of the curing ingredients to the six experimental bacon lots are given in Table 4. Table 5 gives the proximate analytical composition of the six lots of bacon at the time of slicing. As the data for NaCl indicate, the additions of the curing ingredients to the bacon samples were excellent in meeting the intended additions specified in Table 4.

The data given in Table 5 are averages of the determinations in three different samples per lot. It is apparent that added $NaNO_3$ was only partially recovered as residual $NaNO_3$ in the low nitrate (100 mg/kg) bacon (lots IV, V, VI), whereas practically full recovery of $NaNO_3$ was made on high nitrate (500 mg/kg) bacon (lots I, II). About 65-70% Na-Asc. was recovered after the processing. The residual $NaNO_2$ was twice as high in the high NO_2/NO_3 bacon with added sucrose (lot I) than in high NO_2/NO_3 bacon cured without sucrose(lot II). The individual data for the three samples were 54, 45 and 45 for lot I and 24, 21 and 19 mg/kg of $NaNO_2$ for lot II. Similar data were obtained previously on non-irradiated ham (7). It appears that the elimination of sucrose from the ham and bacon cures will decrease the residual nitrite in the finished products by over 50%. This factor should be investigated further, using also other sugars, such as glucose and dextrose.

Table 6 gives the sensory color scores for raw (not fried) irradiated and non irradiated bacon samples of the six lots. Among the non-irradiated

Table 1. Ham 73/30: Effect of nitrite and nitrate on texture. Technological panel: n = 8; samples (a)1/

Cure	Variables (mg/kg) Added	Incandescent Light, Days after Processing: 7	14	21	Red Light, Days after Processing: 7	14	21
A	150 NO_2, 600 NO_3	7.5	6.8	7.1	6.4	7.5	6.7
B	25 NO_2, 100 NO_3	7.0	6.1	6.3	6.3	6.8	6.9
C	25 NO_2, 0 NO_3	6.6	6.6	5.6	6.8	6.4	7.0
D	0 NO_2, 100 NO_3	5.4*	5.6	5.5	6.0	6.3	6.9
E	0 NO_2, 0 NO_3	5.5*	5.4	5.0*	6.1	6.6	6.6

1/ Non-irrad., no-vacuum, stored at 2° to 3°C.
* Significant difference (5%) from Cure A.

Table 2. Effect of the added nitrite and nitrate on sensory characteristics of irradiated ham after 14 months non-refrigerated storage.

Sensory Characteristic	Ham 73/17 High1/ NO_2/NO_3 Cold	Hot	Low2/ NO_2/NO_3 Cold	Hot	Ham 73/46 High NO_2/NO_3 Cold	Hot	Low NO_2/NO_3 Cold	Hot
Technological Panel (n = 2 x 12)								
Color	7.0	6.8	7.0	6.9	7.1	6.8	7.0	6.7
Odor	6.6	6.7	6.8	6.8	7.1	6.7	7.0	6.8
Flavor	6.1	6.4	6.3	6.4	6.7	6.3	6.6	6.5
Texture	6.5	6.3	6.7	6.5	6.9	6.3	7.0	6.7
Appearance	6.8	6.6	7.1	6.8	7.0	6.7	7.2	6.9
Preference	6.2	6.2	6.5	6.4	6.9	6.7	6.8	6.5
Consumer Type Panel (n = 32)								
Preference	6.2	--	6.2	--	6.6	--	6.5	--

1/ 150 (mg/kg) $NaNO_2$, 600 $NaNO_3$ 2/ 25 $NaNO_2$, 100 $NaNO_3$

Table 3. Ham 72/111: Added and residual nitrite and nitrate in ham.

	Variables mg/kg added	Residual mg/kg $NaNO_2$ Irradiated 10*	90	420	$NaNO_2$ Control 10	$NaNO_3$ Irradiated 10	90	420	$NaNO_3$ Control 10
01	150 NO_2, 600 NO_3	2.4	2.2	1.9	4.1	477	515	535	572
02	25 NO_2, 100 NO_3	1.6	2.4	1.6	1.1	140	141	122	145
03	0 NO_2, 600 NO_3	1.8	1.6	1.5	1.4	737	728	433	871
04	0 NO_2, 100 NO_3	1.0	1.4	1.5	1.1	118	137	93	128
05	0 NO_2, 0 NO_3	0.9	1.7	1.7	1.0	58	69	78	51

*Days of storage.

Table 4. Experimental bacon samples (amounts added during curing).

Lot No.	NaCl %	Sucrose %	TPP %	$NaNO_2$ mg/kg	$NaNO_3$ mg/kg	A/E mg/kg
I	1.5	0.75	0.3	150	500	500
II	1.5	--	--	150	500	500
III	1.5	--	--	25	--	500
IV	1.5	--	--	25	100	500
V	1.5	--	--	25	100	1000
VI	1.5	0.75	0.3	25	100	1000

Table 5. Effect of cures (Lot No.) on analytical composition of raw non-irradiated bacon.*

Lot No.	H_2O	Fat %	Protein %	NaCl %	Sucrose %	TPP added %	Residual, mg/kg			pH
							$NaNO_2$	$NaNO_3$	Na-Asc	
I	30.3	58.7	8.5	1.49	0.82	0.29	48	487	294	6.6
II	34.2	53.4	9.5	1.64	T	--	21	571	291	6.1
III	30.4	58.7	8.7	1.48	--	T	7	--	347	6.2
IV	37.4	51.6	9.7	1.57	--	--	6	55	355	6.1
V	31.5	56.6	9.3	1.64	T	T	7	24	728	5.9
VI	31.5	55.9	9.2	1.58	0.73	0.31	8	17	698	6.2

*3 days after smokehouse processing; T = Trace

samples, the lots I, II and VI showed slightly higher scores, but the differences from the other lots were not significant. Irradiation decreased the color ratings, but the differences for the "0"-hour exposed samples were significant only for lots I and III. All irradiated samples suffered fading of color when exposed to light for 2 hours and the most severely affected were low nitrite (25 mg/kg) bacon samples which contained no added nitrate (Lot III). These results confirmed our previous finding with irradiated ham (7). The data in Table 6 indicate also that an increase of A/E from 500 to 1000 mg/kg (Lot IV vs. Lot V) might be beneficial for the color stability in the raw low NO_2/NO_3 bacon.

Table 7 gives the results for sensory quality characteristics, including overall preference, for the six lots of bacon fried in an electric oven at 205°C until crisp. There were no significant differences between the scores of the six lots of irradiated bacon of any of the sensory quality investigated. The non-irradiated control samples showed significantly lower rating only for the color of the bacon of lot V. Surprisingly, the bacon samples of lot III (low NO_2, no-NO_3) received as high scores for all the sensory characteristics and higher scores for preference than other samples. Additional data are being collected during 2-year storage period to substantiate these data.

Consistantly low TBA values (0.06-0.21 malonaldehyde per 1000g) were found for bacon samples of lots I, II and VI (Table 9). Increase of A/E from 500 to 1000 mg/kg in the low NO_2/NO_3 bacon (Lot IV vs. Lot V) had a slight beneficial effect on preventing the increase in the TBA values during storage at 3-4°C of the raw non-irradiated bacon up to 49 days. Irradiation

Table 6. Effect of cures (Lot No.) on the color ratings of raw bacon (n = 12).

Lot No.	Non-irradiated 0	Non-irradiated 2	2.3 Mrad 0	2.3 Mrad 2 1/
I	7.2	7.4	5.8	5.3*
II	7.1	7.3	6.5	6.1*
III	7.0	6.7	5.1 2/	4.1 2/
IV	7.0	6.8	6.3	5.9*
V	6.9	6.7	6.8	6.4*
VI	7.2	6.9	6.8	6.3*

1/ Exposure to light at 25°C in hours; 2/ Sig. dif. from other samples at the same exposure time; *Sig. dif. from the 0-hour exposed samples.

Table 7. Effect of cures (Lot No.) on sensory characteristics of fried bacon.

Sensory Characteristic	Lot No. I	II	III	IV	V	VI	Sig. Dif.
Non-Irradiated Controls							
Color	7.5	7.3	7.8	7.1	5.9*	7.3	5%*
Odor	7.4	7.3	7.6	7.4	7.5	7.4	NS
Flavor	7.5	6.9	7.9	7.3	7.1	6.5	NS
Texture	7.3	7.1	7.9	7.1	6.9	7.1	NS
Appearance	7.4	7.3	8.1	7.3	7.8	7.3	NS
Preference	7.5	7.3	8.1	7.1	6.5	6.8	NS
Irradiated (2.3 Mrad at amb. temp.) samples							
Color	5.7	6.9	6.6	6.8	7.0	6.5	NS
Odor	6.1	6.9	6.6	6.7	6.5	6.5	NS
Flavor	5.8	6.6	6.6	6.5	6.9	6.4	NS
Texture	5.6	6.5	6.5	6.8	6.6	6.5	NS
Appearance	6.0	6.6	6.5	6.8	6.9	6.5	NS
Preference	5.4	6.3	6.5	6.1	5.6	6.1	NS

Technological panel: n = 8, samples I, III, V, and VI; n = 2 x 8, samples II and IV; *Sig. Dif. from samples I and III; NS = no sig. dif.

has little, if any, effect on the TBA values of vacuum packed raw bacon.

Nitrosamines, particularly NO-Pyr, has been found in the majority of the commercial bacon samples (1). One of the possible precursors is nitrosopro-line which is apparently formed from the connective tissue of the bacon fatty tissue (2). It is interesting to note that NO-Pyr was found in the drippings

Table 8. Bacon 73/59: Nitrosopyrrolidine (NO-Pyr) in raw and prefried bacon.

Samples	Variables: Bacon	Variables: Treatment	NO-Pyr, ppb: Pan-fried	NO-Pyr, ppb: Drippings
1A	Raw	Irrad.	n.d.	6*
2A	"	"	7*	7*
1B	Raw	Control	n.d.	6*
2B	"	"	9*	15*
1C	Pre-fried	Irrad.	n.d.	n.d.
2C	"	"	17*	n.d.
1D	Pre-fried	Control	12*	2*
2D	"	"	18*	2

*Confirmed by mass spectrometric analysis; n.d. = not detected.

and in the fatty portion of fried bacon but not in the lean portion of the same bacon samples (3). Therefore, of particular interest was to find whether irradiation has any effect on the NO-Pyr content of bacon. One-pound samples of commercial bacon were obtained from the local supermarket. They were subdivided into raw and pre-fried irradiated and non-irradiated samples. Frying was made in an electric oven, pre-heated to 205°C, until reduction in-weight-to raw was 60% (1 lb. pre-fried = 2½ lbs. raw). Irradiated samples received 2.3-2.8 Mrad at ambient temperature. The irradiated samples were frozen stored until the NO-Pyr determination to eliminate the storage effect, if any. Table 8 shows the results. The data indicate that the raw bacon samples after frying contain more NO-Pyr in the fat drippings than in the fried bacon itself, while the reverse is true for the pre-fried bacon samples. The results further indicate that the irradiation has no effect on the NO-Pyr content.

To obtain more definite data relating to the cures and the residual nitrite, nitrate and ascorbate in bacon, the bacon samples listed in Table 4 are being investigated for the presence of NO-Pyr in the fat drippings and the bacon residues after frying. Some data will be available for discussion at the time of the meeting.

CONCLUSIONS AND RECOMMENDATIONS

1. Radappertization (radiation sterilization) destroys C. botulinum thus eliminating the need for nitrite to control C. botulinum in cured meats.

2. In the radappertized ham and bacon the addition of nitrite can be reduced from 156 to 25 mg/kg without affecting significantly the color, odor, flavor, texture and overall acceptance of the products.

3. Small additions of nitrate (100 mg/kg) and A/E (500 mg/kg) are needed to prevent fading of the cured meat color, formed by nitrite, in radappertized ham and bacon.

4. In non-irradiated ham and bacon the elimination of sucrose from the cures reduces the amount of the residual nitrite in the finished products by over 50 percent.

5. Based on the results obtained on ham and bacon, reduction of nitrite in other non-irradiated cured meats below the presently used level of 156 mg/kg seems to be possible, without affecting the quality of the products, in which the danger of botulism is minimal. These are the cured meat products which are not hermetically packed and are distributed under refrigeration. The nitrite reduction in such cured meats to the level of 75 mg/kg. or less seems feasible. This possibility should be investigated.

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Table 9. Effect of cures (Lot No.) on TBA of raw, non-irradiated bacon stored in open packages at 3°-4°C (samples 1, 2 and 3) and vacuum packed irradiated (Ir) and non-irradiated (C) bacon.

Lot No.	Sample 1 21*	Sample 2 35*	Sample 2 49*	Sample 3 63*	Sample 3 77*	Sample 4** Ir.	Sample 4** C
I	0.09	0.06	0.12	0.06	0.13	0.29	0.10
II	0.07	0.05	0.12	0.13	0.15	0.27	0.16
III	0.35	0.54	0.62	0.26	0.24	0.34	0.40
IV	0.35	0.25	0.65	0.45	0.58	0.33	0.40
V	0.23	0.17	0.28	0.50	0.66	0.36	0.35
VI	0.10	0.21	0.21	0.14	0.12	0.25	0.13

TBA = Malonaldehyde per 1000 g.

* Days after smokehouse processing

** 21 days after smokehouse processing.

INDUSTRIAL APPLICATION OF STRAIN P_4 IN THE PRODUCTION OF RAW-DRIED SAUSAGES IN THE PEOPLE'S REPUBLIC OF BULGARIA

Stoyan Djevizov

Summary

Observations have been made for two years on the application of the strain P_4 starter on an industrial scale. As a result of the technology applied in four different items it has been observed that the drying period is reduced by 40-45% compared to the production where the starter was not applied. Moisture loss, pH, microflora, and organoleptic indices have been followed in the process of drying. The application of strain P_4 as a starter results in the reduction of technological processing, the elimination of a number of technological processes, and the unification of production in terms of organoleptic indices, pH, and microflora.

L'APPLICATION INDUSTRIELLE DE LA SOUCHE P_4 DANS LA FABRICATION DE SAUCISSONS SECS EN BULGARIE

St. Djevizov

Résumé

Pendant deux années ont été effectuées des observations sur l'application d'une culture starter de la souche P_4 à l'échelle industrielle. Par suite de la technologie, appliquée sur quatre assortiments différents, on peut observer un raccourcissement du délai de séchage de 40-45% par rapport à la fabrication, à laquelle on n'a pas appliquée de culture starter. Lors du procès de séchage on étudie la perte d'humidité, le pH, la microflore et les indices organoleptiques. Par suite de l'application de la souche P_4 en tant qu'une culture starter, on observe une réduction du traitement technologique, une élimination de toute une série de procès technologiques, une égalisation de la production en ce qui concerne les indices organoleptiques, le pH et la microflore.

ANWENDUNG DES STAMMES P_4 BEI DER INDUSTRIELLEN HERSTELLUNG VON ROHWURST IN DER VR BULGARIEN

Stojan Dshevisov

Zusammenfassung

Im Laufe von zwei Jahren wurden Beobachtungen über die Anwendung von Starterkulturen des Stammes P_4 in der Industrie durchgeführt. Als Ergebnis der bei vier verschiedenen Produkten angewandten Technologie wird eine Verkürzung der Trocknungszeit um 40 - 45 % im Vergleich zur Herstellung ohne Anwendung von Starterkulturen beobachtet. Während des Trocknungsprozesses werden der Feuchteverlust, der pH-Wert, die Mikroflora und die sensorischen Eigenschaften überprüft.

Bei der Anwendung des Stammes P_4 als Starterkultur wird die technologische Verarbeitung verkürzt infolge des Ausfalls einer Anzahl technologischer Prozesse, indem eine Vereinheitlichung der Produktion hinsichtlich der sensorischen Merkmale, des pH-Wertes und der Mikroflora erreicht wird.

ПРОМЫШЛЕННОЕ ПРИМЕНЕНИЕ ШТАММА P_4 ПРИ ПРОИЗВОДСТВЕ СЫРО-ВЯЛЕНЫХ КОЛБАС В НРБ

Ст.Хр.Джевизов

Аннотация

В течение два года проводятся наблюдения при применении закваски из штамма P_4 в промышленном масштабе. В результате примененной технологии в четырех различных ассортиментах наблюдается сокращение срока сушки на 40-45% по сравнению с производством, которому не применена закваска. В процессе сушки прослеживают потерю влаги, pH, микрофлору и органолептические показатели. В результате применения штамма P_4 в качестве закваски, сокращается технологическая обработка, выходит из состава ряд технологических процессов, унифицируется продукция по органолептическим показателям, pH, микрофлоре.

INDUSTRIAL APPLICATION OF STRAIN P_4 IN THE PRODUCTION OF RAW-DRIED SAUSAGES IN THE PEOPLE'S REPUBLIC OF BULGARIA

Stoyan Djevizov

Meat Technology Research Institute, Sofia

The application of strain P_4 as a starter in the industrial production of raw-dried sausages imposed some changes in the accepted technological processes. The latter had to be adjusted so that to provide optimum conditions for the growth and action of the starter culture introduced, without having a negative effect on ready product quality. The preliminary experimental work (2, 3, 4, 5) with strain P_4 in laboratory, semi-industrial and industrial conditions allowed us to apply such a technology, which was used for two years in daily industrial production. Observations during that period aimed at ascertaining, on industrial basis, the expediency of the technological parameters applied and their impact on the growth of the introduced strain P_4, the drying period, and the organoleptic indices of the ready product.

METHODS

1. Technological methods

1.1. Assortment. The following article types of raw-dried sausages were covered in the experimental work:

Article 1.- Beef and pork Loukanka, BDS (Bulgarian State Standard) 2589. Composition: beef, 60%, and pork, 40%.

Article 2. Pork Loukanka, BDS 2589. Composition: 100% pork.

Article 3. Ambaritsa sausage, BDS 1851907. Composition: pork, 80%, and beef, 20%.

Article 4. Moussala sausage, BDS 10690. Composition: 100% pork.

Articles 1 and 2 are typical national products, they are not smoked and, during drying, they are subjected to repeated pressing. The casing diameter is 47 mm. Articles 3 and 4 are round smoked sausages with a casing diameter of 58 mm.

1.2. Preparation of raw materials. After slaughter, products are cooled for 24-48 hours, with a view to temperatures below 10°C deep into the ham. The deboned and sorted meat is cooled: beef and red pork, down to -1°C or -1,5°C (usually in 20 hours). Fatty pork meat, and the fat are cooled down to minus 5°C (usually in 36-48 hours).

1.3. Machine processing. Machine processing was effected on the Krämer-Grebe line. Fatty pork or the fat are cut at several revolutions in a cutter, then beef or red pork, spices, salting materials and the starter, in the form of broth culture, are added. Cutting is continued till the desired particle size is obtained. Vacuumizing and filling is effected immediately according to the Krämer-Grebe line. "Fibros" artificial casings were used.

1.4. Drying. The whole production cycle was accomplished in Italian type climatic driers that provided for the realization of the straining, smoking, and drying processes.

1.4.1. Straining. It took place in the straining chambers, with an automatic regime, to the stage of semi-drying of casings (for about 48 hours). Straining was applied for articles 1 and 2. The following parameters were applied: temperature, 13°-15°C, and relative humidity, 75-80%.

1.4.2. Smoking. It took place in the straining chambers. It was applied for articles 3 and 4. Filled production strained in those chambers for about 20 hours. Then the chamber was amply satiated with smoke obtained directly in the chamber. During the straining and smoking process, an automatic regime was maintained, with the following parameters: temperature, 15°-20°C, and relative humidity, 80-85%. The smoking process was realized in 6 or 7 days.

1.4.3. Drying. It took place in the drying chambers. An automatic regime with parameters of temperature, 13°-15°C, and relative humidity, 78-82%, was maintained for articles 1 and 2 in the first twenty days. Then, to the state of ready product, the ranges were 16°-18°C for temperature and 74-78% for humidity. During drying, the product was pressed periodically: on the 10th or 12th day, on the 17th or 18th day, on the 23rd or 24th day after filling.

With article 3: temperature, 12-14°C, humidity, 80-82%; during the last week of drying: temperature, 16°-18°C, and humidity, 74-78%.

With article 4: temperature, 12°-14°C, humidity, 80-85%; during the last fortnight of drying: temperature, 13°-15°C, and humidity, 78-82%.

2. Preparation of starters

Strain P_4 (1, 6) was used as a starter. Preparation was made in the plant laboratory, according to an official instruction (6). 20-hour broth culture (5, 6) was used at the rate of 5 ccm per kg of filling, according to the instruction (6, 7).

3. Laboratory observations

Observations were made on production lots. Analyses were made: immediately after filling, after straining, after smoking and in the process of drying, at 7-day intervals. The following observations and analyses were carried out.

3.1. Moisture loss. After filling the lots, some 10 pieces were set aside and weight loss was followed by weighing during the whole technological process and was expressed in %.

3.2. Determination of pH. This was done using an electric pH-meter SP.

3.3. Microbiological investigations. From each lot, a contact preparation was made on yeast-glucose agar (2, 3, 7). The presence of strain P_4 colonies was determined visually, and using the small magnification of a microscope.

3.4. Organoleptic evaluation. Organoleptic evaluation was made of each sample during its analysis for other indices by the laboratory staff. Each lot of ready product was evaluated in the organoleptic laboratory of the plant.

RESULTS

Data about production without a starter (Table 1) refer to 1971, when no starter was used in the same plant. Technological processing and adopted parameters were in accordance with existing official instructions. The data indicate that the drying period varies considerably in each article. An explanation to that can be sought for predominatingly in the ununified microbiological processes during the drying and ageing period (3, 4). The absence or the retardation in the growth of a microflora capable of reducing product pH, delay drying processes.

Data about production with a starter (Table 1) refer to 1972-73, when the whole production in the same plant was processed using strain P_4 according to a technology indicated under "Methods". Conditions and the casings used were the same as those in the production without a starter. The data point to a considerable reduction in the drying period: by 43 to 45% in comparison with the production without a starter; with no significant variation in the individual lots of articles produced. That speaks of a correct, unified ageing process, with appropriate technological parameters confirmed by the results obtained for moisture loss (Table 2). The insignificant diversions from M confirm a unified drying process. Microbiological results indicate that strain P_4 gains a preponderance over the remaining microflora already in the first days after its introduction and is retained during the whole drying process. As a result, product pH is rapidly reduced, while diversions in M are insignificant (Table 3). Further, organoleptic indices followed periodically through the drying process, are characteristic. The improvement in sausage binding progresses parallel to pH reduction. Binding is pronounced already within 4 or 5 days after filling, and it is retained during the whole drying period. Also, colouring processes begin on the 4th or 5th day. Filling acquires intensive colouring with a raspberry tint, which after the 10th or 12th day acquires the typical rosy colour that does not change on cutting, for 4 or 5 days. Changes in flavour and aroma are detectable on the 7th or 8th day, a manifest smack of ready product appearing after the 10th or 12th day. Recurrent organoleptic indices in every lot point to a correct, unified ageing process on the basis of the introduces cultures of strain P_4. The data obtained from industrial production confirm the results of other observations of ours (2, 3, 4).

DISCUSSION

The technological processes after the filling of raw-dried sausages are essential in the technology of the latter. Two basic processes take place here: preservation by moisture release (drying), and ageing predominatingly on microbiological basis. Those two processes are interdependent: thus the set parameters (temperature, humidity and velocity of the air), apart from having virtually the task to take away moisture from the product, must also provide the most favourable conditions for microflora growth in the sausage. On the other hand, microbiological processes, apart from being the basis of ageing itself, must reduce product pH and create good binding, so that to favour drying processes. In the processes of drying, modern technique provides for a correct and guiding intervention of the technologist. In the ageing process, however, in the presence of most varied microflora, the technologist is inefficient. Hence the failures with the parameters applied, the poor and varied quality of production. This basic problem in the production of raw-dried sausages can be solved by the application of suitable pure cultures. In this country, the problem was solved by the application of strain P_4 (2). An expedient technology for the industrial application of strain P_4 was arrived at in the course of a series of laboratory, semi-industrial, and industrial observations (1, 2, 3, 4, 6, 7). The two years' application of that technology in four basic enterprises gave good results in two respects: curtailing the period of technological processes, and the unification and sharp improvement of quality. Curtailing the period of technological processes by 43-45% is obtained for two reasons. In the first place, a number of technological processes are eliminated: straining of raw materials, preliminary ageing of the filling, the period of obligatory green mould coating, etc., and the pressing of Loukanka sausages is reduced to 2 or 3 times, instead of 5 or 7 times. In the second place, due to the starter introduced, the growth of other saprophytic microflora stops (3, 4), and production pH falls rapidly. This makes it possible to apply such drying parameters, as would favour that process (a higher temperature, a lower humidity, a higher air velocity).

Parallel to the reduction of technological terms in the manufacture of raw-dried sausages, the production obtained has stable unified quality indices, expressed in the whole yearly production. Binding and colour formation begin already after the 4th or 5th day, and the formation of flavour and aroma qualities, on the 10th or 12th day. Ready production has well formed quality indices, stable colour on cutting, and a long storage life, what makes it a product with good commercial indices.

The application of a starter in raw-dried sausages, with well selected technological parameters, offers possibilities for a wide industrial manufacture of raw-dried sausages with unified and stable quality indices.

CONCLUSIONS

1. The application of strain P_4 as a starter contributes to the reduction of the period of technological processing, by eliminating a number of technological processes and using such parameters as will accelerate drying processes.

2. The application of strain P_4 as a starter in raw-dried sausages unifies and improves the quality of ready production.

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Table 1.

Article	Production with starters: Number of Lots n	Amount in tons	Drying period, days M	±m	Production without starters: Number of Lots	Amount in tons	Drying period, days M	±m
Article 1	172	163,1	25	1,1	39	48,3	44	4,3
Article 2	114	63,2	26	1,13	22	26,3	45	4,2
Article 3	118	169,3	27	1,2	43	64,4	55	5,1
Article 4	15	18,2	43	2,05	8	12,3	72	5,8

Table 2.

Article	n	Weight loss, %, by days: 7 M	7 ±m	14 M	14 ±m	21 M	21 ±m	28 M	28 ±m	35 M	35 ±m	42 M	42 ±m	49 M	49 ±m
Article 1	11	19,6	1,14	30,2	1,26	37,3	1,47	41,1	1,21	-	-	-	-	-	-
Article 2	11	17,5	1,15	29,1	1,02	34,5	1,36	38,8	1,34	-	-	-	-	-	-
Article 3	11	17,2	0,9	22,1	0,96	25,5	0,69	31,2	1,04	-	-	-	-	-	-
Article 4	7	15,1	1,04	24,1	1,01	27,3	1,07	31,1	1,10	34,7	1,04	37,3	1,34	39,5	1,70

Table 3.

Article	n	Change in pH, by days: 0 M	0 ±m	7 M	7 ±m	14 M	14 ±m	21 M	21 ±m	28 M	28 ±m	35 M	35 ±m	42 M	42 ±m	49 M	49 ±m
Article 1	11	5,9	0,13	5,35	0,12	5,3	0,11	5,35	0,08	5,45	0,13	-	-	-	-	-	-
Article 2	11	5,86	0,14	5,35	0,11	5,25	0,10	5,35	0,07	5,4	0,12	-	-	-	-	-	-
Article 3	11	5,8	0,10	5,3	0,09	5,2	0,09	5,3	0,09	5,35	0,10	-	-	-	-	-	-
Article 4	7	5,85	0,11	5,3	0,08	5,2	0,09	5,15	0,07	5,1	0,09	5,25	0,08	5,3	0,09	5,3	0,08