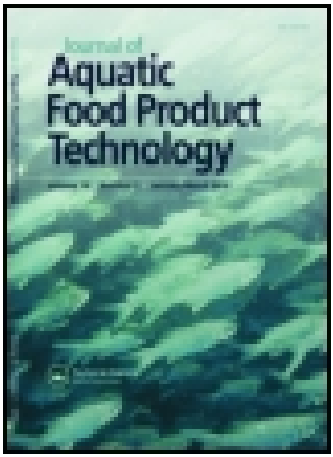


Journal of Aquatic Food Product Technology

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/wafp20

Influence of Water and Glycerol Contents on the a_w of Fish Pastes

Gabriela L. Sanchez Pascua [a] , Maria R. Casales & Maria I. Yeannes

[a] Departmento de Qutimica Facultad de Ciencias Exactas y Naturales , Universidad Nacional Mar del Plata, Funes 3350, 7600 Mar del Plata, Prov. Buenos Aires , Argentina

Published online: 11 Oct 2008.

To cite this article: Gabriela L. Sanchez Pascua , Maria R. Casales & Maria I. Yeannes (2001) Influence of Water and Glycerol Contents on the a_w of Fish Pastes, Journal of Aquatic Food Product Technology, 10:1, 89-100, DOI: 10.1300/J030v10n01_08

To link to this article: http://dx.doi.org/10.1300/J030v10n01_08

Influence of Water and Glycerol Contents on the a_w of Fish Pastes

Gabriela L. Sánchez Pascua
María R. Casales
María I. Yeannes

ABSTRACT. The influence of fish water content on the characteristics of water activity (a_w) of reduced paste was studied. Two fish species were used: a fat species, mackerel (*Scomber japonicus marplatensis*), and a lean species, Brazilian sandperch (*Pseudopercis semifasciata*). Glycerol (from 15 to 50%) was used to decrease a_w of the cooked fish paste.

The possible influence of sex on the water and lipid contents of mackerel was also studied.

According to the results of the statistical analyses there are not significant differences on water and lipid contents of male and female mackerel.

Relationships of a_w versus percent added glycerol were determined. Water content of raw materials was used as parameter as is common in products of reduced a_w. Due to the extreme values of water content

---

Gabriela L. Sánchez Pascua is affiliated with Comisión de Investigaciones Científicas de la Provincia de Buenos Aires (CIC), Departmento de Química Facultad de Ciencias Exactas y Naturales, Universidad Nacional Mar del Plata, Funes 3350, 7600 Mar del Plata, Prov. Buenos Aires, Argentina.

María R. Casales and María I. Yeannes are affiliated with Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Departmento de Química Facultad de Ciencias Exactas y Naturales, Universidad Nacional Mar del Plata, Funes 3350, 7600 Mar del Plata, Prov. Buenos Aries, Argentina (E-mail: mcasales@mdp.edu.ar or myeannes@mdp.edu.ar).

This research was sponsored by Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET) and by Comisión de Investigaciones Científicas de la Provincia de Buenos Aires.

The authors thank Dr. Montecchia and Dr. Roura for assistance in the sex differentiation of the specimens. They are also deeply grateful to Eng. Almandós assistance with statistical analyses.

(54.12% and 77.89%) in mackerel, two relationships of a_w versus percent added glycerol were obtained, and for Brazilian sandperch one relationship was obtained.

KEYWORDS. Fish paste, lean and fat species, a_w reduced, glycerol

INTRODUCTION

The use of low molecular weight solutes such as NaCl and sucrose and humectants such as glycerol and propylene glycol to reduce water activity (a_w) has been described by several authors (Brockmann, 1970; Kaplow, 1970). Pet foods were the first, successfully marketed products with intermediate moisture produced by infusion in equilibrium solutions (Brockmann, 1970; Kaplow, 1970). Glycerol has been used to formulate intermediate moisture foods either by blending or infusion (Dymsza and Sylverman, 1979; Favetto et al., 1981a,b; Che Man and Atan, 1984; Prabhakar and Ramamurthi, 1990; Sanchez Pascua et al., 1994). Nevertheless, depending on the achieved a_w level, the products were often not sufficiently palatable (Kaplow, 1970; Collins and Yu, 1975; Dymsza and Sylverman, 1979; Leistner, 1987).

Research about intermediate moisture fish products is limited. Collins et al. (1972) indicated that fish flesh might have utility for producing intermediate moisture fish products of excellent storage stability. Collins and Yu (1975) studied the stability and acceptance of deep-fried catfish, but the poor flavor of the product decreased the overall acceptability. Sanchez Pascua et al. (1994) developed intermediate moisture mackerel chunks using glycerol as humectant and obtained a product with a moderately sweet taste and a succulent texture.

The main constituents of fish flesh (protein, lipid, ash and water contents) vary among fish species and during the reproductive cycle. Among these constituents the lipid and water contents have the greatest variations along the reproductive cycle. These variations are more extensive in fat species (Love, 1970; Huss, 1988; Conell, 1990; Yeannes and Almandós, 1994) and there is an inverse relationship between water and lipid contents (Love, 1970; Conell, 1990; Yeannes and Almandós, 1994). These changes in chemical composition promote changes in process parameters.

The aim of this paper was to analyze the influence of fish water content on the characteristics of reduced a_w pastes using glycerol to depress the a_w by the direct mix method.

Two fish species with different proximate composition were used: a fat species, mackerel (*Scomber japonicus marplatensis*), and a lean species, Brazilian sandperch (*Pseudopercis semifasciata*) (some years ago sea salmon, *Pinguipes somnambula*).

Since mackerel is one species with large seasonal variations on lipid and water contents, two lots caught in two different months of the fishing season were used. The possible variation in lipids and water content of males and females was also studied.

To compare the influence of proximate composition of lean and fatty species on the formulation of reduced a_w fish pastes, only one lot of Brazilian sandperch was used, since it was determined that it is one species with low lipid content, high water content and without large seasonal variations (Yeannes and Filsinger, 1993).

Cooked fish was mixed with a constant percentage of sodium chloride and variable percentages of glycerol using the direct mix method (Labuza et al., 1972).

MATERIALS AND METHODS

Raw Materials

Two lots (each 40 Kg) of mackerel (*Scomber japonicus marplatensis*) were used. Lot A arrived at our institute in December in fresh condition and was frozen at $-18°C$ and stored two months at $-18°C$. Lot B was purchased frozen in March, with a month of frozen storage at $-18°C$ and stored one month in our institute at $-18°C$.

One lot of fillets of Brazilian sandperch (*Pseudopercis semifasciata*), a lean fish, with skin and bones, was purchased frozen and stored two months at $-18°C$.

Two runs for each lot were carried out.

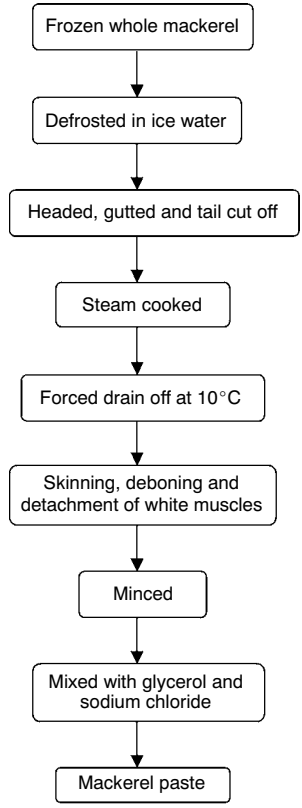
Processing

Figures 1 and 2 outline respectively the mackerel and Brazilian sandperch pastes processing used in the present study.

The mackerel was defrosted in ice water for 15 h. The specimens were headed and gutted and then steam cooked for 20 min and drained off for 3 h at 10°C by means of air forced convection. Mackerel was skinned and deboned and white muscle was detached.

The Brazilian sandperch fillets were defrosted in air at 10°C for 8 h. Deboned and skinned Brazilian sandperch fillets were steam cooked for 15 min. The samples were drained off for 1.30 h at 10°C.

FIGURE 1. Description of the mackerel paste process



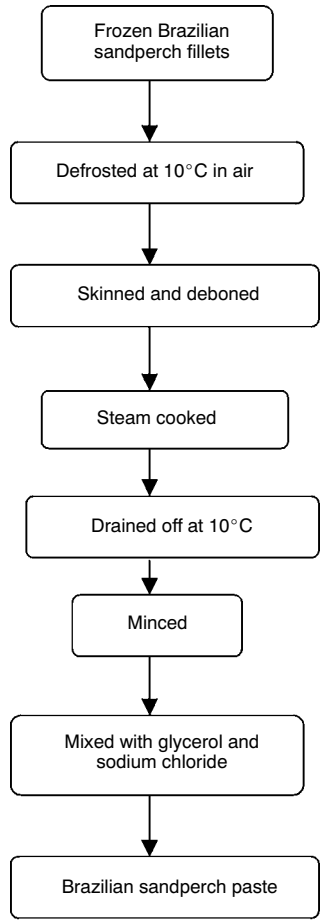
The mincing of mackerel white muscle and Brazilian sandperch fillets were performed separately in a kitchen mixer (Moulinex, type D56, 220 v, 50 Hz, 750 W, 13000 rpm). The mixing with 2% sodium chloride and different percentages of glycerol from 15% to 50%, was made in a Kenwood Chef mixer.

Chemical and Physical Analyses

The analyses were made by making up a minced batch.

In lots A and B of mackerel and in the Brazilian sandperch lot, 6 samples (4 specimens each) were taken and the following determinations were made: water content in quadruplicate and ash, lipid and protein contents in duplicate.

FIGURE 2. Description of the Brazilian sandperch paste process



The analyses were performed on the white muscle of these species.

Water content was determined by drying in an oven at 100 ± 2°C until constant weight (Pearson, 1976). Lipid content was determined by extraction in Twisselmann equipment with petroleum and ethyl ethers (1:1) (Lees, 1969). Ash was determined by calcination of the sample at 500 ± 10°C (Pearson, 1976). Protein content was obtained using the Lowry method (1951). To extract the whole protein the samples of fish were digested in 1 M sodium hydroxide solution in a boiling water-bath for 30 min (Martone et al., 1980).

Water activity was determined by a gravimetric technique on samples of pastes obtained from all lots of the species mentioned. Conway dishes with 1 g of sample and different saturated salt solutions of known a_w were equilibrated at a constant temperature of 25°C for 24 h. The a_w values were determined by means of the ratio between loss and gain of weight of the sample (ITP, 1991). All determinations were made in quadruplicate for each run.

Sensory Tests

In order to use raw materials of good and homogeneous quality sensory tests were carried out.

Sensory tests in defrosted mackerel were made by Casales and Yeannes (1987) (see Table 1), taking into account the following characteristics: external aspects (skin and physical damage), odor, flesh texture and abdominal cavity. The scores ranged from 0 for excellent quality to 3 for very poor quality.

To assess the sensory quality of Brazilian sandperch fillets, specific structured scales were devised to evaluate odor, color and texture. The scale for odor ranged from 10 "fresh and seaweedy" to 0 "strong off-odor." Interpolations on the scale are as follows: 8, fishy odor; 6, no odor; 4, slight off-odors; 2, off-odor.

The scale used to evaluate color ranges from 10 "white" to 0 "dark." Interpolations on the scale were: 8, grayish white; 6, grayish white with small dark spots; 4, spotted; 2, spotty. The scale for texture ranged from 10 "firm and springy" to 0 "soft and flaccid." Interpolations on the scale were: 8, slight loss of both firmness and springiness; 6, less firm without springiness; 4, little firm; 2, soft.

In the pastes the sweet and bitter tastes were individually evaluated using structured scales. The scale for sweetness ranges from 0 "not sweet" to 10 "extremely sweet." The scale for bitterness ranges from 0 "not bitter" to 10 "extremely bitter."

Statistical Analyses

The t-test with paired comparisons was used to evaluate possible influence of sex on the water and lipid contents in mackerel of lot B ($p < 0.05$) (Kume, 1992).

The t-test was used to compare the water and lipid contents of lots A and B of mackerel and lots A of mackerel and the lot of Brazilian sandperch.

A slope comparison test for the straight lines regression of a_w vs. percent added glycerol obtained with all lots was conducted (Volk, 1969).

TABLE 1

CHARACTERISTIC		P O I N T S			
		0	1	2	3
EXTERNAL ASPECT	A- Skin	Black drawing in zigzag and V form on greenish lively colors Silvered flanks with silvered and nacreous irisations. White and silvered belly.	Brilliance and reflected less lively. Light opacity. Lack of little areas of skin.	Lack of reflection. White-silvered areas with yellowish color. Drawing skin detaches.	Lack of brightness and reflection. White silvered areas very yellowish. Skin totally detached.
	B- Physical damage	Neither mutilation nor deformation.	Little mutilation or deformation. No physical damage.	Some physical damage. Fish lightly broken or smashed.	Strong broken or mutilated, and/or 20% of the flesh exposed.
ODOR		Fish odor.	No odor or undefined but no bad or off odors.	Lightly rancid, but neither acid nor putrid.	Acid, putrid, rancid or off odors.
FLESH TEXTURE		Firm flesh, enough springy, it sinks by mild digital pressure and it springs slowly right back.	Flesh little springy, it sinks by mild digital pressure and it springs partially.	Soft flesh, it doesn't spring to digital pressure.	Soft and flaccid flesh, it can break or collapses by soft digital pressure.
ABDOMINAL CAVITY ASPECT		Grizzly color, with some reflection, moist and brilliant aspect. Thin and transparent peritoneum.	Intense grizzly color, some sanguineous leakage. Ventral bones break the peritoneum.	Dark grizzly color, not uniform. Mucosity. Ventral muscular walls with laceration.	Dark grizzly color, uniform. Abundant mucosity. Projecting ventral bones. Ventral muscular zone very broken, digested, pasty.

RESULTS AND DISCUSSION

Sensory scores obtained for defrosted mackerel were 0 for all characteristics except for abdominal cavity aspect which generally was 0.5, thus corresponding to top quality. The sensory tests of Brazilian sandperch fillets indicate that the odor score was 8 and the color and the texture scores were 6, corresponding to good quality.

Table 2 shows the results for the proximate composition of mackerel and Brazilian sandperch lots. The statistical analysis on water and lipid contents of male and female for lot B of mackerel shows that these values are not significantly different ($p > 0.05$). According to the results all values of water and lipid content obtained for each sex were used together to analyze the influence of the reproductive cycle among the two lots of mackerel.

The statistical analyses on mackerel indicate that water and lipid content of the two lots are significantly different ($p < 0.01$). According the results of proximate composition and the gonad observation, lot A (caught in December) is in the period close to spawning time and lot B (caught in February) is in the gonad resting stage with high lipid content. These results agree with those obtained by Angelescu and Gneri (1965) and Chiodi (1966) for *Scomber japonicus marplatensis* in the different biological conditions.

The values of lipid of lot A (mackerel close to spawning time) are in the range of lean fish category. Although the water and lipid content of lot A of mackerel and the lot of Brazilian sandperch are significantly different, according to the results of the t-test both species belong to lean fish category.

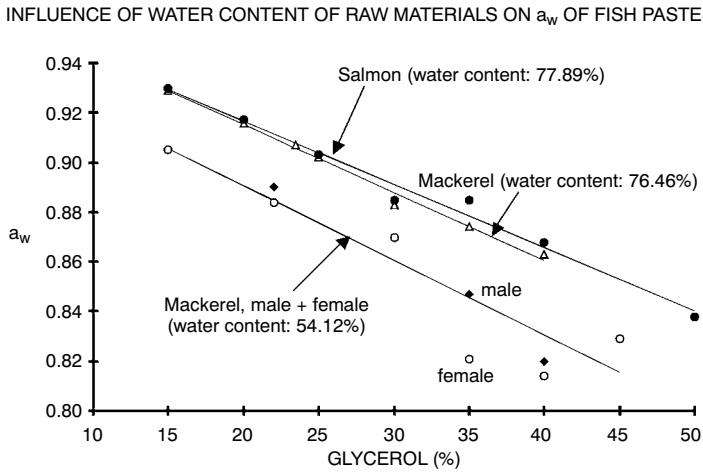
Figure 3 shows the relationships between a_w and percentage of glycerol with water content of the different raw materials as parameters. The regression equations and the correlation coefficients (r) are the following:

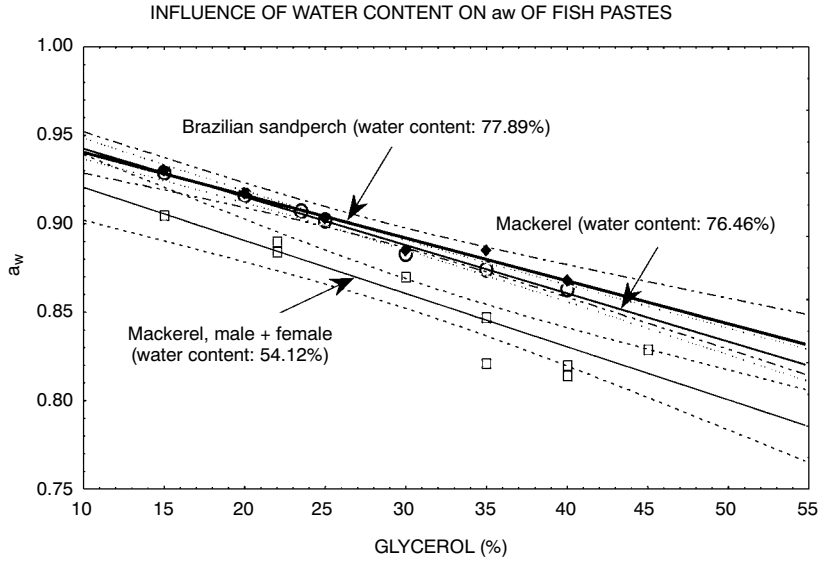
TABLE 2. Proximate composition of mackerel (*S. j. marplantensis*) and Brazilian sandperch (*P. semifasciate*)

SAMPLE	WATER CONTENT %	LIPIDS %	ASH %	PROTEINS %
Mackerel[1]	76.46 ± 1.01	1.35 ± 0.37	1.19 ± 0.12	20.95 ± 0.23
Mackerel[2]				
Male	54.92 ± 2.13	24.49 ± 3.53	1.19 ± 0.08	20.01 ± 0.42
Female	53.33 ± 3.04	25.65 ± 6.00	1.19 ± 0.14	19.98 ± 0.37
Brazilian sandperch	77.89 ± 0.11	0.67 ± 0.28	1.20 ± 0.07	20.52 ± 0.39

[1] Lot A, caught in December month
[2] Lot B, caught in February month

FIGURE 3


INFLUENCE OF WATER CONTENT OF RAW MATERIALS ON a_w OF FISH PASTES
Salmon (water content: 77.89%)
Mackerel (water content: 76.46%)
Mackerel, male + female
(water content: 54.12%)
male
female
a_w
0.94
0.92
0.90
0.88
0.86
0.84
0.82
0.80
10
15
20
25
30
35
40
45
50
GLYCEROL (%)


INFLUENCE OF WATER CONTENT ON aw OF FISH PASTES
Brazilian sandperch (water content: 77.89%)
Mackerel (water content: 76.46%)
Mackerel, male + female
(water content: 54.12%)
a_w
1.00
0.95
0.90
0.85
0.80
0.75
10
15
20
25
30
35
40
45
50
55
GLYCEROL (%)

For mackerel:

lot A (water content of raw materials: 76.46%)

$a_w = 0.970 - 0.727 \times 10^{-3} \times \%G$ r: -0.9952

lot B, male + female (water content of raw materials: 54.12%)

$a_w = 0.949 - 2.994 \times 10^{-3} \times \%G$ r: -0.9409

For brazilian sandperch:

(water content of raw materials: 77.89%)

$a_w = 0.968 - 2.544 \times 10^{-3} \times \%G$ r: -0.9838

G: % added glycerol

The results of the slope comparison test indicate that there are no significant differences between the slopes of the straight lines obtained for the three lots. These results indicate that for a determinate amount of glycerol added to the fish paste, the a_w decreases with the same rate independent of the raw materials used.

In Figure 3 it can be seen that there is no difference between ordinate values of lot A of mackerel and Brazilian sandperch, but an important difference was observed for a_w between ordinate values of these lots and lot B of mackerel. According to this, to obtain a fish paste with a determined a_w value a lower amount of glycerol must be used when the humectant is added to a fatty fish mince.

These results indicate that the amount of glycerol needs to obtain a desired a_w can be determined for Brazilian sandperch and mackerel based on the initial water content.

Since the selected species have an extended range of variation on the lipid and water content, this graph could be of great utility for fish species with water content between 77.89% and 54.12%.

The results of the sensory tests indicate that for percentages of glycerol higher than 20% the pastes are very sweet. The bitter taste was perceived only in pastes with more than 30% glycerol.

REFERENCES

Angelescu, F.S. and Gneri, F.S. 1965. Resultados preliminares de las investigaciones sobre biología y pesca de la caballa (*Scomber japonicus*) en el área de Mar del Plata. CARPAS/T3 FAO, Río de Janeiro, Brazil.

Brockmann, M.C. 1970. Development of intermediate moisture foods for military use. Food Technol. 24: 60-64.

Casales, M.R. and Yeannes, M.I. 1987. Evaluación sensorial de caballa. Influencia de la materia prima en el producto final. Revista de Ciencias Agrarias 8 (3-4):19-26.

Chiodi, O.R. 1966. La caballa del Atlántico Sud-Zona Mar del Plata. CARPAS/T5 FAO, Río de Janeiro, Brazil.

Collins, J.L., Chen, C.C., Park, J.R., Mundt, J.O., McCarty, I.E., and Johnston, M.R. 1972. Preliminary studies on some properties of intermediate moisture, deep-fried fish flesh. J. Food Sci. 37:189-190.

Collins, J.L. and Yu, K.A. 1975. Stability and acceptance of intermediate moisture, deep-fried catfish. J. Food Sci. 40:858-863.

Connell, J.J. 1990. *Control of Fish Quality.* Fishing News Books. U.K. Dymza, M.C. and Silverman G. 1979. Improving the acceptability of intermediate moisture fish. Food Tech. 33: 52-53.

Favetto, G., Chirife, J., and Bartholomai, G. 1981a. A study of water activity lowering in meat during immersion-cooking in sodium chloride-glycerol solutions. I. Equilibrium considerations and diffusional analysis of solute uptake. J. Food Tech. 16: 609-619.

Favetto, G., Chirife, J., and Bartholomai, G. 1981b. A study of water activity lowering in meat during immersion-cooking in sodium chloride-glycerol solutions. II. Kinetics of a_w lowering and effect of some process variables. J. Food Tech. 16: 621-628.

Huss, H.H. 1988. El pescado fresco: su calidad y cambios de calidad. Manual de capacitación preparado por el Programa de Capacitación FAO/DANIDA en Tecnología Pesquera y Control de Calidad. ROMA: FAO/DANIDA.

ITP (Instituto Tecnológico Pesquero del Perú). 1991. Productos Curados y en Conserva. En: *Curso de Tecnología de Productos Pesqueros*. Callao, Peru.

Kaplow, M. 1970. Commercial development of intermediate moisture foods. Food Tech. 24:889

Kume, H. 1992. Introducción a la inferencia estadística In: *Herramientas Estadísticas Básicas para el Mejoramiento de la Calidad*. Norma S A, pp. 191-194. Bogotá, Colombia.

Labuza, T.P., McNally, L., Gallagher, D., Hawjes, J., and Hurtado, F. 1972. Stability of intermediate moisture foods. 1- Lipid oxidation. J. Food Sci. 37:154-159.

Lees, R. 1969. *Manual de Análisis de Alimentos*. Ed. Acribia, Zaragoza, España.

Leistner, L. 1987. Shelf-stable products and intermediate moisture foods with respect to microorganisms. In: *Water Activity: Theory and Applications*. Rockland, L.B. and Beuchat, L.R. (Eds.) IFT/Marcel Dekker, Inc. New York, USA. pp. 295-323.

Love, M.R. 1970. *The Chemical Biology of Fishes*. pp. 225-226. Academic Press, London, U.K.

Lowry, O.H., Rosebrough, L., and Randall, R.J. 1951. Protein measurements with Folin phenol reagent. J. Biol. Chem. 193: 265.

Martone, C.B., Crupkin, M., Barassi, C.A., and Trucco, R. 1980. Determination of protein in fishmeal. J. Sci. Food Agric. 31:782-784.

Pearson, D. 1976. *Técnicas de Laboratorio para el Análisis de Alimentos*. Acribia, Zaragoza, España.

Prabhakar, K. and Ramamurthi, R. 1990. A study on the preparation of intermediate moisture meat. 27(3): 162-164.

Sanchez Pascua, G., Casales, M., and Yeannes, M. 1994. Preliminary development of intermediate moisture, pasteurized mackerel (*Scomber japonicus marplatensis*) chunks. J. Sci. Food Agric. 64: 199-204.

Volk, W. 1969. The t-test and Variance. In: *Applied statistics for Engineers*. 2nd ed, pp. 109-148. Mc Graw Hill, New York, USA.

Yeannes, M.I. and Filsinger, B.E. 1993. Proyecto de desarrollo de productos de salmón de mar ahumados. CITEP. Mar del Plata.

Yeannes, M.I. and Almandós, M.E. 1994. Ecuaciones para la estimación de la composición química proximal de pescado a partir de valores de humedad. Acta del VI Congreso Argentino de Ciencia y Tecnología de Alimentos. Primer Encuentro de Técnicos de Alimentos del Cono Sur. Bs As. Argentina, 6-9 de Abril. pp. 353-355.