Effect of Inclusion of Salmon Roe on Characteristics of Salmon Baby Food Products

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Running head: Salmon baby food containing salmon roe

ABSTRACT: Baby food was formulated from sockeye salmon (puree alone, puree + chunks, puree + pink row, puree + pink row + chunks, puree + red row, puree + red roe + chunks). In the first study physical (pH, instrumental color, water activity) and descriptive sensory (odor, flavor, texture, visual color) characteristics of the products were determined. Descriptive results indicated that samples containing roe were lighter than formulations without roe regardless of the type of roe added. Products containing roe were also less red (by approximately 3 to 4 a* units) than formulations without roe regardless of roe type. Visual pink color followed the same trend. Formulations with roe, both pink and sockeye, were almost twice as fibrous as formulations without roe. Salmon flavor was stronger in samples containing roe from sockeye salmon. In a second study, retort processed samples were stored at room temperature for 6 months. Storage time (6 mo) affected sweaty, cooked egg, earthy, and ocean odors, and pink and yellow visual scores. L* and a* values of samples without roe appeared to be most stable over the storage period. The best correlations between visual and instrumental color occurred between visual cream-brown and L*, a*, b* and chroma values (r = -0.80, 0.75, 0.80 and 0.84, respectively). TBARS values ranged between 0.1 and 0.35 mg MDA/kg. TBARS values of all samples declined after month 2 then stayed fairly constant over the remainder of the storage period.

Keywords: salmon roe, baby food, sensory, acceptability, color

Introduction

The salmon industry in Alaska is in transition due to increasing the availability of cheaper farm-raised salmon. This has resulted in a loss of market share for Alaskan salmon and a large decrease in total harvest value. In 2007, nearly 500,000 metric tons of Alaskan salmon valued at 420 million dollars was harvested (Alaska Department of Fish and Game, 2007).

For producers of agricultural commodities to profit, outlets through direct distribution of fresh products (fish, chicken, etc.) or demand for these raw materials for further processing by food companies must be continuous. When other new products enter the market taking away market share, it becomes necessary for individual commodities to become actively engaged in market expansion. For raw materials demand to increase, food companies must grow continue to profit, by: (1) expanding into new geographic markets, (2) taking market share from competitors by increasing market penetration, or (3) developing new products that can replace those whose profitability is waning. The current project targets all three in addition to offering a potential new use for salmon roe.

A specific "market need" is a prerequisite to new product success. Salmon is a good source of the omega-3 fatty acid, docosahexaenoic acid (DHA). The newborn infant's brain is 50% DHA, however it is unable to synthesize this compound from alpha-linolenic acid in sufficient amounts to ensure an adequate supply to the developing neural tissues. The World Health Organization recommends that infant diets (formulas) provide 40 mg of DHA / kg body weight to provide for the needs of the developing brain provides additional impetus for developing infant foods from roe from cold water fish such as salmon (FAO, 1994).

Salmon roe contain approximately 50-3000 IU/g Vitamin A, 5-25 IU/g Vitamin D, 10-80 UI/100g of Vitamins B1, B2, and B12, and 10-30 IU/100g Vitamin C (Bledsoe and others, 2004). Salmon roe contain significantly more DHA and EPA than fish oils from tuna and sardines and are more oxidatively stable, most likely because of the phospholipid content (Moriya and others, 2007). Salmon roe can offers a natural source of Vitamin D which enhances bone development and prevents rickets. Vitamin D is found naturally in significant quantities only in fatty fish and fish oils, liver and fat from aquatic mammals, and chicken eggs fed Vitamin D. The American Academy of Pediatrics has recently doubled the recommended dietary intake of Vitamin D for infants, children, and adolescents to 400 UI/day (Wagner and Greer, 2008). Further, fish roe provide high quality protein (Bledsoe and others, 2003) and are a rich source of amino acids such as glutamic acid, lysine, serine, and aspartic acid (Mol and Turan, 2008).

While incorporating roe into baby food products could potentially increase the nutritive value of these products, retort processing can be expected to alter salmon-based food products (Kristinsson and others, 2009; Ramamoorthi and others, 2009). Similar to salmon flesh, roe are heat labile and also undergo irreversible protein denaturation at 70-80°C resulting in loss or dulling of the characteristic color. The feasibility of roe inclusion hinges on the sensory quality and stability (shelf life) of the product. The suitability of roe from red and pink salmon for this application is unknown. This study examines 6 combinations of retort processed salmon and roe baby food products designed to meet the FDA definition of a toddler "high meat dinner" (at least 26% salmon; 9 CFR

381.117[d]) in terms of sensory characteristics, visually and instrumentally measured color, pH and water activity.

Materials and Methods

This experiment was designed as a randomized complete block with six treatment combinations and four replications. Treatment combinations included baby food formulations from sockeye salmon (purée, puree + chunks, puree + red row, puree + red row + chunks, puree + pink row, puree + pink roe + chunks). Physical and sensory characteristics of the products were determined within 48 h of product manufacture for the descriptive study. In a second study, storage stability (6 months) based on quality characteristics was determined

Sample manufacture

Sockeye salmon was chosen for formulation of the base purée to remove the undesirable characteristics (excessive lightening, off flavor development) found in pink salmon formulations in an earlier study (DeSantos and others, 2009). Wild sockeye ("red") salmon (*Oncorhynchus nerka*) were processed by Ocean Beauty Seafoods LLC (Seattle,WA, U.S.A.). Bone-in fillets (400-600 g) were individually quick-frozen, shipped (frozen) to the University of Illinois (Urbana-Champaign, IL), and stored at -28°C until use. Frozen salmon was thawed under controlled conditions (4-6°C in the dark) for 2 days prior to baby food manufacture. Baby food was manufactured by combining salmon, water and starch, and roe from red or pink salmon (*Oncorhynchus gorbuscha*) such that 8% of the purée was comprised of salmon roe (Table 1).

Thinly-sliced fillets (2-3cm) and salmon roe were cooked for 3 min in boiling water, and homogenized with a KitchenAid blender (Pro-line, KitchenAide Counter Top Products, St. Joseph, MO) at “high” setting for 90 s. Organic Corn Starch (National Starch-Food Innovation, Bridgewater, NJ, U.S.A.) was added during the last 30 s of blending. The product was hot-filled into glass containers (180 mL; 100 mm height, 65 mm width—Jarden Home Brands, Daleville, Indiana) and closed using two-piece metal vacuum-sealable lids to yield approximately 170 g of product per container. For chunked formulations, pre-weighed raw salmon chunks (40-70 mm) were added to base purée at a ratio of 25% chunks / 75% puree (by wt).

Heat penetration studies were conducted with the target of a 12 D reduction of *Clostridium botulinum*. The temperature distribution during thermal processing was assessed using temperature proves inserted into the middle and at the bottom of the containers. The temperature was measured at one min intervals and temperature distribution was plotted. Based on the heat penetration results and known times to inactivated *Clostridium sporogenes SC220-4,* the thermal process time was calculated for the baby food (Lut and others, 1981; Myset, 1985; BAM, 2001: Ocasio, 2008). To build sufficient pressure in the retort to reach 121 C took 5 min

The time was calculated to produce a five log reduction of *C. sporogenes* based on the time required for samples to attain the required temperature (118-121C) at the cold point (based on heat penetration studies) plus known times to achieve a 1 log reduction (BAM, 2001; Ocasio, 2008). Pressure was released over a 13 min. period. Containers of baby food products were thermally processed at 118-121°C for 55 min in a steam-jacketed vertical still retort (Model # AA3152, Food Machinery and Chemical Corp., Hoopeston, IL) then cooled to room temperature by pumping potable water (25°C) through the retort for 10 min after steam was released.

Descriptive analysis

Sensory panelists (21-55 yr; n = 8) who had previous experience with sensory evaluation of salmon products were trained over four 2-hr sessions. A reference set of descriptors was provided (Prell and Sawyer 1988) then characteristics of interest were selected and reference standards determined. Salmon samples and standards were evaluated such that standards could be assigned locations on the 15-point intensity rating scale (0 = none; 15 = extreme) for each characteristic (Table 2). Judges evaluated the visual color of samples using standards shown in Table 3. Unsalted crackers and water were provided for cleansing the palate between samples. Standards were provided at all sessions. Samples were capped in 60 mL portion cups, labeled with 3-digit random numbers, at least one hour before evaluation and heated to an internal temperature of 45°C in a water bath (60°C).

All treatment combinations (purée, puree + chunks, puree + red row, puree + red row + chunks, puree + pink row, puree + pink roe + chunks) were first evaluated for odor and taste characteristics. Samples were then presented under fluorescent light (GE warm white, 3013 lux, General Electric, Fairfield, CT, U.S.A.) against a white background. Visual color was evaluated following odor, taste, and texture evaluations so as to prevent bias due to visual appearance.

Water activity, pH, viscosity and instrumental color

Water activity (a_w) was determined using an AquaLab CX2 meter (Decagon, Pullman, WA, U.S.A.). The pH was determined by placing the electrode of an Accumet pH meter (Accumet model 15, Fisher Scientific, Pittsburgh, PA, U.S.A.) directly into baby food samples (22 °C). Viscosity was determined on the red salmon puree used as the base for all the babyfood products at 20 rpm using spindle 4 in a Brookfield Viscometer (Brookfield SP Model LR 99102, Brookfield Engineering Laboratories Inc., Middleboro, MA). Instrumental color was determined using a LabScan 6000 spectrocolorimeter (Hunter Labs, Reston, VA, U.S.A.) Reflectance was determined over the 400 to 700 nm range using illminant D65 in order to calculate CIE L*, a*, and b* values, hue angle (arctan (b*/a*) and chroma ($[a^{*2} + b^{*2}]^{1/2}$) (CIE 1978).

Storage study

Samples were formulated and processed as previously described then stored at room temperature (22°C) in the dark for 6 months. Samples were removed from storage monthly and evaluated by instrumental, chemical, and sensory means. These samples were then discarded. Water activity, pH and instrumental color were determined. Sensory judges were trained as previously described to evaluate odor using the designated sensory terms in Table 2 and the visual color scale shown in Table 3.

Thiobarbituric acid reactive substances (TBARS): TBARS were determined after each month of storage using the cold extraction method described by Miller (1998) based on the method developed by Witte, Krause, & Bailey (1970). Absorbance was determined spectrophotometrically (Beckman Coulter DU® 640, Inc., Fullerton, CA, U.S.A.) at 530 nm.   Concentration of malondialdehyde (MDA) was calculated from a standard curve using solutions of tetraethoxypropane (TEP; 0-10 nm MDA/ml). The equation obtained from the curve was y=0.0819 x + 0.0055 (r^2=0.999) where y is the absorbance of the sample extract and x is the concentration of MDA. Malondialdehye recovery was computed using the TEP-spiked samples. Each sample was analyzed in duplicate. Results are expressed as mg malondialdehyde / kg sample.

Descriptive data from the first part of the study were treated as a 2 (purée or chunk) by 3 (no roe, with pink roe, or with sockeye roe) factorial design, and analyzed using the Mixed Models procedure (SAS, 2002) to determine main effects and interactions. Effects were considered significant at $p < 0.05$. Separation of least square means (LSM) was achieved using the Tukey-Kramer *post hoc* test for multiple comparisons. For sensory data, judges were included as a random effect and experiment replication as a repeated measure. Correlations between instrumental and visual color, and among sensory odor and flavor scores were made using PROC CORR (SAS 2002). All results from the Mixed Models are reported as least squares means of the fixed effects.

Instrumental data and TBARS for the storage study were treated as a 2 (puree or chunk) by 3 (no roe, sockeye or pink roe) by 7 (storage time) factorial design, and analyzed using the Mixed Models procedure (SAS, 2002) to determine main effects and interactions. Effects were considered significant at $p < 0.05$. Separation of least square means (LSM) was achieved using the Tukey-Kramer *post hoc* test for multiple comparisons. Sensory data were analyzed as described for instrumental data with the inclusion of judges as a repeated measure. Correlations between instrumental and visual color were made using PROC CORR (SAS 2002). All results from the Mixed Models are reported as least squares means (LSMeans) of the fixed effects, and standard errors of the mean (SEM) reported for significant measures.

Results

Characteristics of raw materials

Raw bone-in salmon was 73 - 73.6% moisture, about 1.7% fat, had an L* value of 67.4, an a* value of 34.8, b* value of 36.2, and chroma of 50.2 (data not shown). .

Descriptive study results

The pH ranged from 6.47 to 6.84 among the six products formulated (data not shown). Formulations containing pink roe were similar in pH to those without roe (6.7; SEM=0.02), and were slightly higher than those formulated with sockeye salmon roe (6.5). The water activity of all treatment combinations was 0.99. The viscosity of the red salmon puree that was used as the baby food base for all treatments was 3800 cP. Viscosity of roe-containing samples was above the upper limit of measurement of the viscometer.

There was a significant roe type (red vs pink) by product type (chunk vs puree) interaction for L* and a* values, hue angle, bitter, metallic and mouth-drying flavors and visual pink color (Table 4). The addition of roe had a direct effect on L* values of the puréed baby foods. Samples containing roe had higher L* values (lighter) than those without roe (Table 4), regardless of the type of roe added. This lightening may result from the increase in fat content of the formulation. The fat content of the sockeye salmon puree was about 0.85 g/100g (Brewer 2008) while that of roe-containing samples contained 1.4 to 2.69 g/100g. Fat content has been shown to affect the color of salmon products (Christiansen and others, 1995).

Products containing roe were also less red (by approximately 3 to 4 a* units) than formulations without roe, with no clear difference due to roe source (red versus sockeye). Visual pink color followed the same trend; judges scored salmon products with roe as less pink than those without roe, and visual pink scores for base purée (without roe) averaged at least one unit (on the 15-cm line) higher (pinker) than the chunked product without roe. Hue angles were lowest (closer to the true red axis of the color scale) for sockeye salmon purée with neither roe nor chunks, and were similar for all other products. There was an interaction between roe addition and chunk inclusion for mouth-drying mouth feel (Table 4). Pureed samples without roe had the lowest mouth-drying scores scores (2.47-3.48) while the puree with pink roe had the highest (6.05). Metallic flavor was most prominent in the chunked product containing roe from pink salmon and lowest in chunked product containing roe from sockeye salmon (Table 4). While the presence of roe appeared to attenuate the bitter taste, it did not have the same effect on metallic flavor.

Samples without roe were perceived to be more bitter (Table 4). Lawless, Rapacki and Hayes (2003) reported that tastes associated with calcium chloride were largely suppressed when calcium was combined with larger organic ions such as lactate, gluconate or glycerophosphate. It is possible that the addition of roe to the base formulation moderated the bitter taste detected either through an association of bitter components with calcium or by attenuating the taste response due to an increase in lipid compounds from the roe (Lawless, Rapacki and Hayes, 2003). Not unexpectedly, bitter flavor was negatively correlated with sweet flavor (r^2 = -0.82; Table 5).

Roe from pink salmon is yellow while that from sockeye salmon is a very vivid, dark orange-red color. The effects of inclusion of roe from various sources were apparent in the instrumental data, especially in the b* values (yellowness) and chroma (color saturation) of the products (Table 6). The b* value of samples (both puree and chunk) with sockeye roe (25.8) was lower than that of samples with pink roe (28.2), and both were lower than that of the control (29.9). Chroma followed a similar trend.

The sensory panel's perception of yellowness and cream-brown color also varied due to the inclusion of roe; samples with roe were scored significantly lower on the visual yellow intensity scale (Table 6). However, the panel did not differentiate between samples with pink versus sockeye roe with respect to visual yellow or cream-brown colors. L* value and hue angle were inversely correlated with visual pink, yellow and cream brown colors, while a* and b* values were positively correlated with all visual characteristics (Table 6). The pigments in salmon eggs are heat-labile. The proteins denature at 70-80°C (Bledsoe and others, 2003). However, from these color observations, it is evident that their characteristic colors are apparent even after the disruption of cells that occurs during homogenization and the protein denaturation that occurs during thermal processing. Fibrousness differed due to the presence of roe; formulations with roe, both pink and sockeye, were almost twice as fibrous as formulations without roe (Table 6) but only about half as fibrous as the horseradish sauce used as a reference standard. The chunks contained in the formulations with pink salmon roe had higher chewiness scores (3.2) than those with sockeye roe or no roe (2.3-2.6)

(Table 6) but these were still very low relative to the reference standard used (baked salmon; scale location = 10).

Salmon flavor was stronger in samples containing roe from sockeye salmon (Table 6). Samples without roe were perceived to be more bitter. Although cooked egg odor did not differ significantly among samples, those with roe had nominally higher scores than those without roe. Samples that were scored higher for cooked egg odor had low scores for bitterness (r=-0.94; Table 7).

Inclusion of chunks reduced a* (redness) and b* values (yellowness), which reduced chromaticity and increased hue angles (Table 8). Inclusion of chunks or roe shifted the color away from the 'true red' character of the product. This is noteworthy since consumer evaluation during the previous study revealed that chunked products were less visually acceptable than puréed formulations (Desantos and others, 2009).

Salmon flavor was more intense in chunked products (Table 8). It was correlated with savory flavor (r=0.89; Table 7), and, to a lesser extent, with chunk chewiness (r=0.74). Chunked products were more savory than puréed products and had higher salmon flavor scores (Table 8). This outcome is supported by strong linear correlations between the scores for these characteristics (Table 7). Since chunked formulations contained more salmon than the puréed base, addition of chunks would be expected to impact the intensity of salmon odor or flavor.

Storage study results

There were no two- or three-way interactions (chunk inclusion, presence of roe, and storage time) for sensory characteristics. Salmon and sweetness odor scores were non-significant (7.3 ± 0.2, and 2.9 ± 0.2, respectively; data not shown). All visual color measures differed among samples due to the presence and type of roe in the formulation.

Sweaty odor was most intense in fresh samples (prior to storage) and generally decreased during storage (Table 9). This sweaty odor may be due to 2, 4-heptadienal, a compound identified by Girard and Durance (2000) described as having “fishy” and “catfood” aromas. Cooked egg odor declined after two months of storage (from >5 to <3) then remained constant. It was surprising that cooked egg odor was unaffected by inclusion of salmon roe. Earthy odor remained constant during the first 2 months of the study (>3.6) then decreased to a constant level throughout the remainder of the study. The ocean odor was an attribute measured for the first time in this series of studies of salmon quality characteristics. This characteristic followed the same trend as earthy odor. Visual pink and yellow color scores were also affected by storage time. In general, visual pink color did not change until after the fifth month of storage when there was a significant increase (from 4-5 to >8; Table 9). Visual yellow color scores increased slightly over time, but after 6 months, were still comparable with scores at the scores at the initiation of the study.

Storage time appeared to have the least effect on instrumentally measured color of these products (Figure 1). L* and a* values of samples without roe appeared to be most stable over time, while those of samples containing chunks fluctuated slightly (Figure 1). L* values of all samples remained between 67 and 70 throughout the storage period. The a* values of all samples remained between 15 and 18 throughout the storage period. The b* value of samples without roe were higher at all time periods than those of samples containing roe. In addition, the b* values of samples without roe appeared to fluctuate more (29 to 32) than those with roe (red roe, 33 to 35; pink roe, 36 to 37).

Correlations between visual color and instrumental color were moderate (Table 10). The best correlations were observed between visual cream-brown and L*, a*, b* and chroma values (r = -0.80, 0.75, 0.80 and 0.84, respectively).

TBARS values ranged between 0.1 and 0.35 mg MDA/kg. Averaging values across storage time, products made with sockeye roe had the highest TBARS values and those with pink salmon roe had the lowest (Figure 2). Chunked formulations generally had higher TBARS values (~0.35) initially but these declined over storage time. TBARS values of all samples declined after month 2 then stayed fairly constant over the remainder of the storage period. This may be because the initial cooking and retort processing of the product initiated oxidation and production of MDA which subsequently broke down to lower molecular weight compounds over time. Ortiz and others (2009) reported that TBARS of cooked, farm-raised Coho salmon (*O. kisutch*) that had been supplemented with dietary antioxidants varied from 0.5 to 0.8. They did not change significantly in the first six months of frozen storage, nor did a trained panel detect oxidized flavor.

Conclusions

Adding roe to salmon baby food resulted in a lighter, less red product regardless of roe type (pink or sockeye). Formulations with roe were almost twice as fibrous as formulations without roe. Salmon flavor was stronger in samples containing roe from sockeye salmon than in that containing roe from pink salmon. Storage time had small effects on sweaty, cooked egg, earthy, and ocean odors, and pink and yellow visual scores. Visual cream-brown color was well correlated with instrumental color measures. TBARS values remained low (0.1 to 0.35 mg MDA/kg) throughout 6 months of storage.

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Table 1--Composition of salmon baby food formulations containing salmon roe

% weight in formulation (wet basis)	**Ingredients**						**Total**
	Salmon muscle	Salmon roe	Water	Corn Starch	Purée formulation	Salmon muscle chunks	
Base puree	32	8	58	2	100	0	**100**
Chunked variations					75	25	**100**

Table 2--Sensory standards and scale locations used for salmon baby food products

Sensory	Standard
Odor	
Salmon	*Member's Mark*® (Sam's West, Inc., Bentonville AR) Canned Atlantic Salmon fillets (sl
Sweaty	0.1% w/v *Special Kitty* Premium Cat Food(Walmart, Bentonville AR, ground and dispers
Cooked egg	Freshly boiled white (chicken) egg
Sweet[1]	10 ml Pepsi
Ocean[1]	Live sand under water from marine fish tank, Leisure Time, Champaign IL.
Earthy[1]	5 g fresh shiitake mushroom
Flavor	
Salmon[2]	Salmon chunks baked at 375°C (10 min.) and 200°F for 10 min.
Bitter[2]	*Schweppes* (Dr Pepper/Seven Up Inc., Plano TX) Tonic Water diluted to 25%
Savory[2]	Broth from salmon chunks cooked in aqueous solution of NaCl (1%) and monosodium g
Metallic[2]	0.01 % ferrous sulfate (Walgreen Co., Deerfield IL) dispersed in dH_2O (coating removed
Sweet[2]	Boiled (chicken) egg albumin
Texture	
Mouth-drying[2]	0.08% aqueous solution of grape seed extract (ActiVin, SJVC, San Joaquin Valley, Calif
Fibrous[2]	Horseradish sauce
Chunk chewiness[2]	Salmon chunks baked at 375°C (10 min.) and 200°F for 10 min.
Viscosity[2]	Gulden's Spicy brown mustard (ConAgra Foods, Omaha NE)

[1] Used for storage study only
[2] Used for descriptive study only

Table 3--Visual color standards used for evaluating salmon baby food products

Color chip	Scale position	L* value	a* value	b* value
Pink Scale				
Baby's Breath 93101[1]	1	91.53	-0.54	9.68
Pink Thread 93102[1]	5	89.59	2.37	11.44
Mermaid 93103[1]	10	85.14	7.11	15.19
Salmon A27-3[3]	15	80.85	14.46	22.30
Yellow Scale				
Orange Sparkle 2007-4C[2]	1	93.26	-4.36	18.73
Almond Whip 2008-4C[2]	3	92.03	-3.81	26.33
Honey Pecan 2008-4B[2]	8	87.34	-0.48	36.42
Almond Butter 3001-4A[2]	15	83.68	2.92	40.31
Cream-Brown Scale				
Sand Dune 267-1[4]	3	88.73	0.38	19.15
Vanilla Tan 267-2[4]	7	83.30	4.43	24.78
Boulder Buff 267-3[4]	10	77.69	8.23	29.36
Sunstone 267-4[4]	14	69.32	13.39	33.66

[1]Lowe's Companies Inc. *American Tradition*, North Wilkesboro, NC
[2]Walmart *ColorPlace*, Bentonville, AR
[3]Lowe's Companies Inc. *Olympic Paints*, North Wilkesboro, NC
[4]Lowe's Companies Inc. *Valspar*, North Wilkesboro, NC

Table 4—Effect of roe and chunks on characteristics of salmon baby food

Characteristic	Purée			Chunk			SE
	No roe	***Pink roe***	***Sockeye roe***	***No roe***	***Pink roe***	***Sockeye roe***	
Instrumental							
L* value	61.30^{b}	68.39^{a}	68.67^{a}	63.90^{b}	67.08^{a}	68.32^{a}	0.59
a* value	19.57^{a}	15.16^{c}	13.44^{cd}	15.53^{bc}	14.86^{c}	12.67^{d}	0.43
Hue angle	57.36^{b}	62.18^{a}	63.16^{a}	61.98^{a}	61.73^{a}	63.16^{a}	0.70
Sensory							
Bitter flavor	1.79^{b}	1.69^{b}	1.16^{b}	3.18^{a}	2.09^{ab}	1.08^{b}	0.56
Metallic flavor	1.91^{ab}	2.13^{ab}	1.93^{ab}	2.74^{ab}	2.86^{a}	1.21^{b}	0.58
Mouth-drying	2.47^{c}	6.05^{a}	4.28^{b}	3.48^{c}	4.31^{b}	3.69^{c}	0.64
Visual pink color	10.03^{a}	6.11^{b}	5.78^{b}	8.72^{a}	7.02^{b}	6.13^{b}	1.07

[1] Scale: 0= none, 15 = extremely intense

[abcd] Means (in rows) with like superscript letters do not differ ($p \leq 0.05$)

Table 5--Correlations between instrumental and sensory color of baby foods with and without salmon chunks and roe

Visual color	Instrumental Color				
	L* value	***a* value***	***b* value***	***Hue angle***	***Chroma***
Pink	-0.99 *(<0.01)*[*]	0.88 *(0.02)*	0.81 *(0.05)*	-0.86 *(0.03)*	0.86 *(0.03)*
Yellow	-0.96 *(0.02)*	0.88 *(0.02)*	0.89 *(0.02)*	-0.79 *(0.06)*	0.90 *(0.01)*
Cream-brown	-0.91 *(0.01)*	0.92 *(0.01)*	0.94 *(<0.01)*	-0.83 *(0.04)*	0.96 *(<0.01)*

[*] p-values

Table 6—Effect of roe on characteristics of salmon baby food

Characteristic	Control (no roe)	With pink roe	With sockeye roe	SEM
Instrumental				
b* value	29.87[a]	28.15[b]	25.81[c]	0.24
Chroma	34.67[a]	31.91[b]	28.93[c]	0.29
Sensory				
Salmon flavor	4.37[b]	4.42[b]	5.38[a]	0.63
Sweet taste	3.35[b]	3.12[b]	4.82[a]	0.73
Fibrousness	2.33[b]	4.81[a]	4.21[a]	0.45
Chunk chewiness	2.32[b]	3.19 [a]	2.55[b]	0.47
Yellow color	9.05[a]	6.15[b]	5.21[b]	0.95
Cream-brown color	8.07[a]	6.25[b]	5.54[b]	0.51

[1] Scale: 0= none, 15 = extremely intense

[abcd] Means (in rows) with like superscript letters do not differ ($p \leq 0.05$)

Table 7--Correlations among sensory characteristics of salmon baby food with and without salmon chunks and roe

Sensory characteristics	Savory flavor	Bitter flavor	Metallic taste
Salmon odor	0.89 (0.02)*	ns	ns
Cooked egg odor	ns	-0.94 (<0.01)	ns
Sweet taste	ns	-0.82 (0.04)	-0.92 (0.01)
Chunk chewiness	0.87 (0.02)	ns	ns

* p-values

Table 8—Effect of inclusion of chunks on characteristics of salmon baby food

Characteristic	**Baby food samples**		SEM
	Puree only	***Puree + chunks***	
Instrumental			
b* value	28.61[a]	27.24[b]	0.20
Chroma	32.84[a]	30.83[b]	0.24
Sensory			
Salmon flavor	4.31[b]	5.14[a]	0.61
Savory flavor	4.80[b]	5.91[a]	0.84
Fibrousness	3.41[b]	4.16[a]	0.39
Chunk chewiness	0.78[b]	4.60 [a]	0.45
Cream-brown color	7.00 [a]	6.24 [b]	0.30

[1] Scale: 0= none, 15 = extremely intense
[abcd] Means (in rows) with like superscript letters do not differ ($p \leq 0.05$) Pooled across samples with and without roe

Table 9--Effect of storage time on baby food containing roe

Sensory	**Storage time (months)**							
parameter	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**SEM**
Sweaty	4.45^{a}	3.90^{ab}	2.38^{b}	3.68^{ab}	3.35^{ab}	2.77^{b}	2.71^{b}	0.41
Cooked egg	5.82^{a}	5.03^{a}	2.57^{b}	3.42^{b}	2.62^{b}	2.58^{b}	2.71^{b}	0.38
Earthy	3.64^{a}	4.45^{a}	2.69^{b}	2.55^{b}	2.76^{b}	2.73^{b}	3.09^{ab}	0.34
Ocean	0.98^{b}	3.70^{a}	2.12^{ab}	2.61^{b}	1.47^{b}	1.92^{b}	2.41^{ab}	0.39
Pink color	4.81^{b}	4.13^{b}	4.31^{b}	4.84^{b}	5.44^{b}	4.89^{b}	8.31^{a}	0.40
Yellow color	2.80^{b}	3.14^{b}	3.44^{ab}	3.94^{ab}	4.91^{a}	4.96^{a}	3.10^{b}	0.41
TBARS	0.23^{a}	0.14^{b}	0.13^{b}	0.14^{b}	0.13^{b}	0.13^{b}	0.10^{b}	0.00

Main effects pooled over chunked or puree forms and presence of roe
SEM, standard error of mean
[1] Scale: 0= none, 15 = extremely intense

Table 10--Pearson correlations between instrumental and visual color of stored baby food

Visual Color	**Instrumental Color**				
	L*	***a****	***b****	***Hue angle***	***Chroma***
Pink	-0.54	0.58	0.47	ns	0.54
Yellow	-0.60	0.55	0.59	ns	0.62
Cream-brown	-0.80	0.75	0.80	ns	0.84

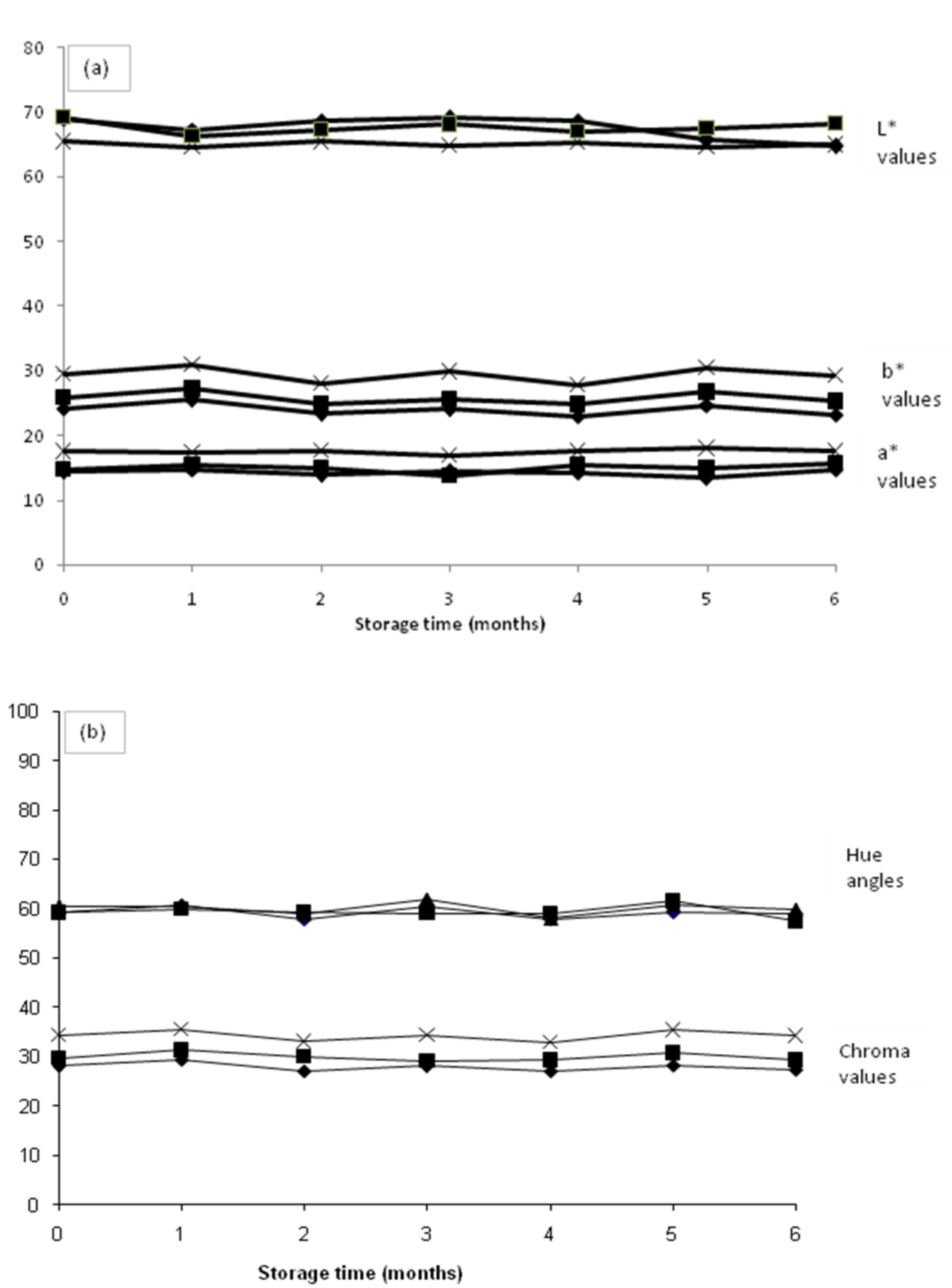

FIGURE 1--INSTRUMENTAL (A) L*, a* AND b* VALUES AND, (B) HUE ANGLES AND CHROMA WITH ROE OVER STORAGE; LEGEND: -X- SAMPLES WITHOUT ROE, -■- SAMPLES WITH PINK SALMON ROE, -◆- SAMPLES WITH SOCKEYE ROE

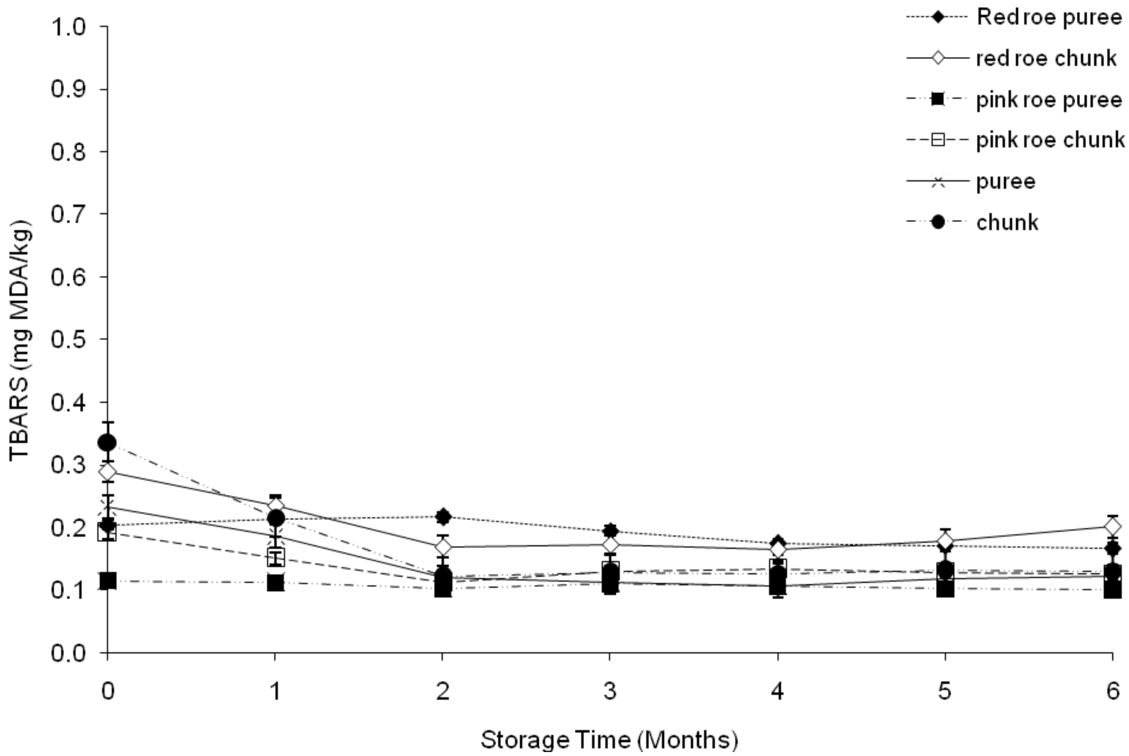

FIGURE 2--EFFECT OF STORAGE (AT ROOM TEMPERATURE) ON TBARS (MG MDA/KG) OF PUREED SALMON BABY FOOD WITH ROE