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The skinny on tuna fat: health implications

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Abstract

Objective—Dietary omega (ω) 3 (n-3) and ω6 (n-6) polyunsaturated fatty acids (PUFA) have significant implications in health and disease prevention. Marine life is rich in long chain n-3 PUFA. Children and adults in North America are reluctant fish eaters; canned tuna is a common fish in children's diets. While a multitude of tuna products are available, their respective PUFA contents have not been well described. The aims of this study were to compare the fatty acid profiles of different commercially available U.S. tuna products.

Design—Fat and fatty acid composition of eight products randomly selected from two US suppliers were analyzed with capillary gas chromatography after lipid extraction.

Setting—Large northeastern United States grocery store chain

Subjects—Canned tuna

Results—Energy from fat varied from 3 to 33% and the essential fatty acids linoleic (18:2n-6) and alpha-linolenic (18:3n-3) acids varied 10 fold. Docosahexaenoic acid (DHA) varied between 90 to 770 mg/serving. The n-6:n-3 ratio was 3:1 to 4:1 in oil-packaged products, 2:1 to 7:1 in the packaged tuna salads and 1:3 to 1:7 in water packaged products. A similar magnitude of differences was seen in the ratio between arachidonic acid (20:4n-6) and DHA.

Conclusions—Light tuna canned in water may be a better choice to supply n-3 PUFA for individuals in a healthy population, while the oil-packed products may be preferable for those individuals with need for increased essential fatty acids, such as for patients with cystic fibrosis. Awareness regarding PUFA content may aid in consumer product choices and health care provider advice.

Keywords

n-3 fatty acids; DHA; EPA; chronic cisease

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Authorship: AM obtained the commercial tuna products for analyses; BS performed the fatty acid analyses. All three authors conceived of the study, contributed to the statistical analyses, to the writing of the manuscript and have read and approved the manuscript.

Introduction

The modern Western diet has been characterized by marked changes in the polyunsaturated fatty acid (PUFA) content, with an increase in omega ω6 (n-6) fatty acids (FA) coupled to a decrease in ω3 (n-3) FA. Lower intakes of the biologically important long chain n-3 PUFA are observed in the modern Western diet as compared to the human diet from the hunter-gatherer periods, and to traditional diets globally(1). The observed lower intakes of n-3 PUFAs and changes to the dietary ω6: ω3 (n-6:n-3) ratios have been implicated as a risk factor for common, chronic noncommunicable conditions - particularly for cardiovascular disease, inflammatory bowel disease, obesity and diabetes(1-2).The incidence and prevalence of these chronic diseases has increased in parallel to this specific aspect of the global nutrition transition in progress (1-5). Fatty fish are a good source of long chain n-3 FA, which are believed to have health benefits for the prevention and treatment of these non-communicable diseases. With disease prevention and risk reduction and key considerations, modifications of risk factors for these diseases need to be considered starting in childhood. Children in North America in particular are reluctant fish eaters, with canned tuna one of the most common types of fish consumed (6). While differences in PUFA profiles have been described for animal products by species and agricultural practices (7-10), less is known regarding PUFA characteristics of commercial tuna products. Consumers may consider all tuna products as being equally beneficial to human health, which may be inaccurate. The purpose of this analysis was to describe the PUFA characteristics of some common commercially available products in order to increase awareness of potential product differences in the context of the diet and health of children and adults.

Materials and Methods

Two cans each of eight commercially available US canned tuna products were obtained in duplicate from two of the three major US suppliers from a major Northeast grocery store chain in November of 2007. These included chunk white, light and albacore tuna varieties, packaged in either water or oil. Two tuna salad products, (named “regular” and “fat free”) were also obtained. The total fat content and fatty acid composition of the canned contents (tuna products plus respective packaging medium- water or oil) were analyzed by lipid extraction and analysis of FA methyl esters by capillary gas chromatography as previously described (7). Each sample was analyzed in duplicate, giving four analyses of each product and the average values are reported. Serving size, total fat content, and calorie information was obtained from the respective Food and Drug Administration (FDA) Nutrition Facts labels. Complete fatty acid profiles, including the n-3 FA alpha-linolenic (18.3n-3, ALA), eicosapentaenoic (20:5n-3, EPA) and docosahexaenoic (22:6n-3, DHA) acids, and the n-6 FA linoleic (18:2n-6, LA) and arachidonic acids (20:4n-6, ARA) were expressed as mg per gram of the product and per the manufacturer suggested serving size.

Results

Serving sizes ranged from 56 to 82 grams. The total energy per serving ranged from 50 to 190 kcal. Percentage of energy as fat varied from 3 to 33%. The major fat classes and select PUFAs analyzed are reported in Table 1. The n-6:n-3 ratios ranged 1:3 to1:7 for tuna products in water, 3:1 to 4:1 for products in oil, and 2:1 to 7:1 for the salad products. DHA content varied between 1.1 to 13.6 mg/g between the different tuna products (106 and 930 mg/serving). As shown in Table 1 the long chain PUFA of the n-3 series (EPA+DHA) varied more than 10-fold per (mg/g). The n-6 content also varied considerably across products, most likely related to the packaging medium (such as added vegetable oil), with a resulting ARA/DHA ratio varying between 1:1 to 1:9. Complete fatty acid profiles for these different tuna products are in Table 2.

Discussion

In the current study, there was considerable variation across products with respect to PUFA profiles, DHA content and the n-6: n-3 ratio. The linoleic acid (LA; 18:2n-6) content (mg/g) was highest in the tuna salad, with a >170 fold difference between LA in the salad as compared to a chunk light product packaged in water. Tuna products packaged in water had higher EPA + DHA content and lower n-6: n-3 ratios as compared to tuna products packed in oil. This may have significant implications for dietary counseling and consumer knowledge and choices in the context of health and disease.

Humans cannot synthesize essential fatty acids (EFA) and are dependent on dietary sources to prevent deficiency. LA (18:2n-6) and (18:3n-3) are the n-6 and n-3 EFA, respectively. Dietary EFA are enzymatically converted to longer chain PUFAs; ALA (n-3) is converted to EPA and DHA and LA (n-6) to ARA. These long chain PUFAs have many structural and functional roles throughout the life cycle via several well-described mechanisms, including effects on cell membrane fluidity, gene expression and modulation of the inflammatory response (11-12).

The Dietary Reference Intakes (DRI) for PUFA recommend dietary LA (n-6) and ALA (n-3) intake specifically to meet adequacy and to prevent EFA deficiency in the general population (13).The DRI further stipulate that up to 10% of the Adequate Intake for ALA can be in the form of DHA and EPA to support normal neural development and growth; this translates to 90 to160 mg daily of EPA + DHA for children > 4 years of age (13). While ALA supplementation has been demonstrated to increase red blood cell DHA content (14), the conversion of ALA to long chain PUFA is minimal, between 0.5 % to DHA and 5% to EPA (15-16). Therefore, the dietary intake of long chain PUFAs are an important determinant of serum and tissue PUFA status.

How much dietary n-3 PUFA intake is required to promote health and prevent disease is an important question. There are two components by which to address dietary n-3 PUFAs: in relationship to the n-6 PUFAs (the n-6: n-3 ratio), and as total n-3 PUFA (especially DHA + EPA). The epidemiological and anthropological data suggest increased risk of some chronic noncommunicable diseases associated with changes of the n-6: n-3 ratio from historical and

traditional diets to the modern western diet, i.e., from about 1:1-2 to the current 15-20:1 (1; 4; 17-18). The n-6: n-3 PUFA ratio influences many key biological functions including the immune response and may be important for several chronic diseases. A dietary n-6: n-3 ratio of approximately 4-5:1 may be desirable in this context (2; 19).

In terms of n-3 intake, DHA and EPA intake recommendations are available for pregnant women and lactating mothers to support normal neural growth, development and health in their offspring (20-21). Currently, the pediatric data regarding the impact of dietary n-3 PUFAs as a preventative health strategy are not available to provide for specific guidelines for children. However, the published recommendations for adults for both primary and secondary disease risk reduction are available and informative. Consensus committee statements regarding cardiovascular disease and dyslipidemia for adults published from the American Heart Association and other committees provide some guidance for children as well (3; 22). The tuna PUFA profile data reported here are relevant in the consideration of food choices to promote n-3 fatty acid intake and a favorable n-6: n-3 ratio.

Fish and seafood are rich in n-3 FA and particularly the long chain n-3 FA (EPA and DHA), and have an n-6: n-3 ratio <1. Fatty fish in particular are rich in long chain n-3 PUFAs. Several factors influence the nutrient composition of animals that are common in the human diet. There are many levels and stages during which these factors influence nutrient content-while these animals are alive and after they are killed. Many studies have highlighted that the manner in which cultured fish and livestock are fed influence their total fat, PUFA profiles and pollutant content differently than their free-range or wild counterparts, with data from studies in cattle and salmon serving as an excellent example (8-10). Processing and packaging of food products also alter total fat and fatty acid profiles of foods; a recent study has shown more than 50-fold changes of the n-6/n-3 ratio during food processing (7).

There are commercial supplier and consumer factors which influence the changes that occur in nutrient content from tuna, between the time it is captured and when it is purchased as a commercial tuna product. Tuna PUFA content varies by species; canned tuna is a *product*, and individual canned products may contain more than one species of tuna. The nomenclature used to described tuna products includes “white tuna”, which refers to albacore, northern and southern bluefin tuna species; “light tuna” which includes skipjack (the most common), yellowfin and bigeye tuna species (23). While distinct differences in PUFA profiles were noted across the range of products in the current study, some of the differences between similar products may have been related to differences in the tuna species present in individual cans. Consumer choices also influence the tuna products that are commercially made available and promoted. Packaging of tuna products in vegetable oil to diminish the fishy odor and enhance palatability is a good example of consumer driven modification. Similarly, tuna salad products enhance consumer convenience. Some of these modifications, such as packaging in vegetable oils and in the salads alter the energy content and the DHA, EPA and LA content (24). Mayonnaise is a good source of ALA, and the tuna salad product had the greatest ALA content per serving amongst the tested products; mayonnaise was the second major ingredient listed on the Nutrition Facts label (after tuna). This provides insight into some of the changes in nutrient content that occur between

capture and eventual consumption. The data we present in this study provides complete fatty acid profiles of the tested products to allow for comparison.

Consumption of marine life also has associated health risks for humans that have to be considered. Fatty fish may be contaminated with methyl mercury, polychlorinated biphenyls (PCB) and dioxans. These are linked to adverse health risks which may offset some of the benefits of n-3 PUFA, and result in more complex dietary counseling for children and women who are either pregnant or planning to be pregnant (10; 25-26). The FDA currently recommends dietary intake of up to 12 ounces of fish per week. While albacore tuna has the highest DHA content of all tuna species, it also has more methylmercury than other tuna, and the FDA recommends that no more than 6 ounces per week of albacore. Furthermore, women of childbearing age and children under the age of 5 years are advised not to consume albacore tuna. If more than one type of fish is consumed regularly, the total amount of fish per week may need to be reduced in order to limit mercury intake (6; 27-28). While tuna contaminant content was not assessed in the current study, findings from the literature suggest that chunk light tuna in water has relatively lower mercury content than other tuna products (29-30), and as this product provides relatively high n-3 PUFA (DHA + EPA) content, a lower n-6: n-3 ratio, these findings suggest that chunk light tuna in water may be the better choice of tuna product for the healthy population.

Another health consideration of the choice of tuna products and health benefits is in reference to groups of the patients at risk for EFA deficiency and PUFA abnormalities, such as children with cystic fibrosis; the most common abnormalities reported in these children are low LA and DHA status (31-32). For these children, tuna canned in oil may be preferable, in order to provide both LA and DHA.

PUFA intake and status need to be considered in two important ways: to ensure EFA adequacy and prevention of deficiency (particularly in at risk populations), and for primary disease risk reduction by promotion of n-3 PUFA intake. The tuna data presented here can support dietary counseling for our patients and for consumers in making informed decisions, in the context of practical strategies to promote improved dietary intake of n-3 fatty acids and decrease the n-6: n-3 ratio (31-32). Substitution of cooking oils with more favorable ALA content and PUFA profiles (such as walnut and canola oils), and the use of n-3 fortified foods also support healthful fat intake. Increased awareness regarding these considerations may lead consumers to favoring foods richer in n-3 PUFAs and lower in contaminants, and may also influence animal rearing practices and effect change in the food supply.

Conclusions

We provide information of the variability of PUFA profiles and ω3 FA across tuna products and to support consumer choices and health education useful in promoting healthier diets. Tuna products are a good source of DHA and EPA with favorable PUFA profiles, and our data suggest that amongst these products, light canned tuna packaged in water may be a better choice for children and adults to increase ω3 PUFA intake.

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Table 1

Major fat content and select polyunsaturated fatty acid (PUFA) content and profiles of common available tuna products, mean (SD[1])

	TUNA PRODUCTS							
	Fat Free	**Regular**	**Chunk Light**	**Chunk Light**	**Chunk White Albacore**	**Chunk White Albacore**	**Solid White Albacore**	**Chunk Light**
Medium	Salad[2]	Salad[3]	Water	Water	Water	Water	Oil	Oil
Serving Size* g, oz	82, 2.9	82, 2.9	56, 2.0	56, 2.0	56, 2.0	56, 2.0	56, 2.0	56, 2.0
Calories**	70	190	60	50	60	70	90	90

	mean	**SD**	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**
Total fat, g/serving, (mean)	6.4	0.0	27.1	0.2	1.8	0.0	1.6	0.0	2.0	0.0	1.5	0.0	3.5	0.0	2.8	0.0
Saturated fat, g/serving†	1.8	0.1	4.1	0.0	0.5	0.0	0.5	0.0	0.5	0.0	0.4	0.0	0.6	0.0	0.5	0.1
Monounsaturated fat, g/serving†	1.2	0.1	5.5	0.0	0.3	0.0	0.2	0.0	0.4	0.0	0.2	0.0	0.7	0.0	0.5	0.0
Polyunsaturated fat, g/serving†	3.4	0.1	17.5	0.0	0.9	0.0	0.9	0.0	1.1	0.0	0.9	0.0	2.2	0.0	1.7	0.0

Select PUFAs	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**	**mean**	**SD**
Docosahexaenoic acid (DHA; 22:6n-3) mg/serving*	780.0	176.0	90.2	10.7	707.8	61.6	657.4	20.2	762.2	10.6	600.3	17.4	221.8	45.4	255.9	87.4
Eicosapentaenoic acid (EPA; 20:5n-3) mg/serving*	123	32.8	16.4	0.8	95.2	10.1	95.8	2.2	170.2	5.6	64.4	3.4	29.7	14.6	36.4	15.1
Arachidonic acid (ARA; 20:4n-6) mg/serving	139.4	32.8	16.4	0.8	75.6	10.1	71.1	4.5	60.5	3.9	87.4	3.9	29.7	7.8	26.3	5.0
Linoleic acid[a] (LA; 18:2n-6),, g/serving*	2.0	0.3	15.3	0.0	0.1	0.1	0.1	0.0	0.6	0.0	0.1	0.0	1.7	0.1	1.2	0.1
Alpha Linolenic acid[b] (ALA; 18:3n-3) g/serving*	0.3	0.1	2.1	0.0	0.00	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	0.0

Select PUFA profiles	**mean**							
EPA+DHA[c], mg/serving	893	106	801	750	930	666	252	292
ARA:DHA ratio	1:5	1:5	1:1	1:9	1:1	1:7	1:8	1:9
ω6:ω3 ratio (n-6:n-3)‡	2: 1	7: 1	1: 4	1: 6	1: 7	1: 3	4: 1	3: 1

[a] Adequate Intake for linoleic acid is between 7-16 grams for children from ≥4-18 years of age[13]

[b] Adequate Intake for alpha linolenic acid is between 0.9-1.6 mg for children from 4-18 years of age[13]

[c] DHA + EPA intake of 90-160 milligrams (10% of ALA intake) per day to met the Adequate Intake for children 4-18 and adults[13]

[*] Serving size information as per FDA Nutrition Facts label

[**] Calories per serving as per FDA Nutrition Facts label

[†] saturated fats: (12:0 + 14:0 + 16:0 + 20:0 + 22:0 + 24:0); monounsaturated fats: (14:1n-5 + 16:1n-7 + 18:1n-9 + 24:1n-9; polyunsaturated fats: (18:2n-6 + 18:3n-3 + 18:3n-6 + 20:2n-6 + 20:3n-9 + 20:3n-6 + 20:4n-6 + 20:5n-3 + 22:6n-3.

[‡] (18:2 n-6 + 18:3n-6 + 20:2n-6 + 20:3n-6 + 20:4n-6) / (18:3n-3 + 20:5n-3 + 22:6n-3)

[1] SD obtained from sample of n=4 for each canned tuna product category.

[2] ingredients (per FDA Nutrition Facts label): tuna (light tuna, water, vegetable broth, salt), salad dressing (water, vinegar, sugar, modified food starch, polydextrose, microcrystalline cellulose, salt, whey protein concentrate, egg yolk, xanthan gum, titanium dioxide, natural flavor, sodium benzoate and potassium sorbate (preservatives), phosphoric acid, onion powder, lactic acid, garlic powder, spice extractives, fd&c yellow #6 and #5), celery, textured soy flour, fructose, water chestnuts, carrots, water, glucono delta lactone, dextrose, salt, onion, spices, xanthan gum.

[3] ingredients (per FDA Nutrition Facts label) : tuna (light tuna, water, vegetable broth, salt), heat stable mayonnaise (soybean oil, water, whole eggs, egg yolks, vinegar, salt, sugar, potassium sorbate (as a preservative), natural flavors, natural color), celery, textured soy flour, carrots, fructose, water chestnuts, water, glucono delta lactone, dextrose, salt, onion, gum arabic or xanthan gum.

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Table 2

Fatty acid content of common commercially available tuna products, in mg/g product; mean (SD*).

	Fat Free	Regular	Chunk Light	Chunk Light	Chunk White Albacore	Chunk White Albacore	Solid White Albacore	Chunk Light
Fats	Salad[1†]	Salad[1‡]	Water[2]	Water[2]	Water[2]	Water[2]	Oil[2]	Oil[2]
Total saturated fat (mean)	22.3	50.5	9.7	9.1	9.7	7.4	10.6	9.3

	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Lauric Acid (12:0)	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Myristic Acid (14:0)	0.6	0.1	0.2	0.0	0.4	0.0	0.3	0.0	0.7	0.0	0.2	0.0	0.1	0.1	0.2	0.1
Palmitic Acid (16:0)	15.9	0.5	34.3	0.1	6.4	0.3	6.0	0.1	6.6	0.0	5.0	0.1	7.2	0.3	6.3	0.7
Stearic Acid (18:0)	5.1	0.4	13.8	0.1	2.7	0.2	2.4	0.0	2.1	0.0	2.2	0.0	2.8	0.1	2.6	0.1
Arachidic Acid (20:0)	0.1	0.0	0.9	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.2	0.0	0.1	0.0
Behenic Acid (22:0)	0.2	0.0	1.0	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.2	0.0	0.1	0.0
Lignoceric acid (24:0)	0.2	0.0	0.4	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0
Total monounsaturated Fat (mean)	14.8		67.3		5.0		4.0		6.2		3.8		12.2		9.7	

	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Myristoleic acid (14:1n-5)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Palmitoleic acid (16:1n-7)	1.0	0.2	0.4	0.0	0.6	0.0	0.6	0.0	1.0	0.0	0.3	0.0	0.2	0.2	0.3	0.2
Oleic Acid (18:1n-9)	13.4	0.5	66.9	0.0	4.0	0.4	3.0	0.0	4.8	0.2	3.0	0.2	11.9	0.2	9.3	0.4
Nervonic Acid (24:1n-9)	0.4	0.1	0.1	0.0	0.4	0.1	0.4	0.0	0.5	0.0	0.6	0.0	0.2	0.1	0.2	0.0
Total polyunsaturated fat (mean)	41.0		213.2		15.8		16.1		19.2		15.7		39.2		30.9	

	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Linoleic acid, (LA; 18:2n-6)	24.9	3.7	186.4	0.1	2.1	1.2	1.1	0.4	1.1	0.4	2.0	0.1	30.3	1.3	22.2	2.3
γ-linolenic acid, (18:3n-6)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
α-linolenic acid, (ALA; 18:3n-3)	3.2	0.6	25.0	0.2	0.3	0.2	0.2	0.1	0.2	0.1	0.2	0.0	3.8	0.1	3.0	0.3
Icosadienoic acid (20:2n-6)	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.0
Mead acid (20:3n-9)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dihomo-y-linolenic acid (20:3n-6)	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Arachidonic acid (ARA; 20:4n-6)	1.7	0.4	0.2	0.0	1.4	0.2	1.3	0.1	1.1	0.1	1.6	0.1	0.5	0.1	0.5	0.1
Eicosapentaenoic acid(EPA; 20:5n-3)	1.5	0.4	0.2	0.01	1.7	0.2	1.7	0.0	3.0	0.1	1.2	0.1	0.5	0.3	0.7	0.3

	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Docosahexaenoic acid (DHA; 22:6n-3)	9.5	2.2	1.1	0.1	12.6	1.1	11.7	0.4	13.6	0.2	10.7	0.3	4	0.8	4.6	1.6

*SD obtained from sample of n=4 for each canned tuna product category.

*1*serving size: 82 gram

*2*serving size: 56 gram

†ingredients (per FDA Nutrition Facts label): tuna (light tuna, water, vegetable broth, salt), salad dressing (water, vinegar, sugar, modified food starch, polydextrose, microcrystalline cellulose, salt, whey protein concentrate, egg yolk, xanthan gum, titanium dioxide, natural flavor, sodium benzoate and potassium sorbate (preservatives), phosphoric acid, onion powder, lactic acid, garlic powder, spice extractives, fd&c yellow #6 and #5), celery, textured soy flour, fructose, water chestnuts, carrots, water, glucono delta lactone, dextrose, salt, onion, spices, xanthan gum.

‡ingredients: (per FDA Nutrition Facts label) : tuna (light tuna, water, vegetable broth, salt), heat stable mayonnaise (soybean oil, water, whole eggs, egg yolks, vinegar, salt, sugar, potassium sorbate (as a preservative), natural flavors, natural color), celery, textured soy flour, carrots, fructose, water chestnuts, water, glucono delta lactone, dextrose, salt, onion, gum arabic or xanthan gum.