



Research Report

Children's Preference
for Fish-Oil Supplements

**Research into the preference of different
administration methods of fish-oil supplements
across children of 4 to 12 years of age
in the Netherlands**

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Abstract

This randomized study investigated children's preference of four different delivery forms containing fish-oil. Preference is an importance factor to improve compliance. Compliance is primarily influenced by taste, flavor and texture, with taste being the most importance of these.

Four available delivery forms for fish oil supplementation were used to evaluate children's preference. Preference was investigated by performing hedonic sensory research using 5 point questionnaires and conducted according to Good Sensory Practice. Children were asked to rate size, color, smell, shape and overall appearance prior to ingestion and after consumption they were asked about the taste and mouth sensation of each delivery form. The delivery form with the highest scores was compared with the 3 other delivery forms using a t-test (significance level of 0.05), with taste being considered as the most important sensory characteristic

A total of 53 children aged between 4 and 12 years, enrolled this study and were recruited from primary schools in the Netherlands.

The ConCordix soft chew supplement was mostly preferred by children between 4 and 12 years of age. The soft chew was given the highest total score (1635 points) and the highest score on seven out of nine questionnaire items. The soft chew received the highest scores for taste and aftertaste and was 39% and 27%, respectively, higher than the least preferred delivery form: the chewable capsule (Weifa). The balance of flavors and sweeteners used for the soft chew resulted in exceptional overall taste that was highly preferred by the children. The mouthfeel of the soft chew received the highest score and was 39% higher than the chewable capsule which was rated lowest. The liquid form (Natures) received a total of 1436 points, which was a comparable score with the Holland & Barrett soft gel capsule (1485 points). The chewable capsule was not well accepted (total score of 1396) in this age category. The chewable capsule was indicated as 'not nice at all', which was in line with the high number of children (39%) who spat the supplement out.

The soft chew (ConCordix) was mostly preferred in a population between 4 and 12 years of age and scored statistically higher over other delivery forms at key factors that influence compliance: taste, aftertaste and texture.

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1 Introduction

Omega 3 fatty acids (FA) are essential for good health, however, humans are unable to produce omega 3 FAs and must acquire it through diet. Omega 3 FAs are considered as polyunsaturated fatty acids (PUFA) and consist of 3 important members: alpha-linolenic acid (ALA), eicosatetraenoic acid (EPA), and docosahexaenoic acid (DHA) [1]. ALA is found in plant sources. In humans ALA can be enzymatically converted to EPA and DHA, however only 2% to 10% is converted [2]. Fatty fish and shellfish are important sources of EPA and DHA. EPA plays an important role in the maintenance of a normal heart function, and regulates blood pressure and blood lipids, whereas DHA supports normal brain and eye function, development and reduces inflammation [3]. The health effects of EPA and DHA are acknowledged by the European Food Safety Association (EFSA) by approving several health claims for these omega 3 FAs [4-8].

Surveys conducted in the Netherlands reported that on average, 22.6 kg of fish per year is consumed which is approximately 435 g per week per adult [9]. However, only half of the Dutch children between 4 and 12 years of age consume a sufficient amount of fish [10]. According to the authorities this is concern since children in this age category are dependent on omega 3 FAs from fish for their growth and (cognitive) development [10, 11].

A possibility to meet sufficient amounts of omega 3 FAs in a children's diet is to supplement with fish oil. Fish oil is available in different delivery systems, including soft gel capsules, liquids and chewable tablets. However, only 3% to 6% of Dutch children use a fish oil supplement. This low number is due to several factors including the appearance, size and taste which negatively affect acceptance and compliance. The primary factor that influences compliance is taste, but also by volume, thickness of the delivery form, smell, and overall appearance are important to achieve long-term compliance [12-14]. Children are probably the most difficult population when it comes to taste preferences. the sensitivity of children's taste buds is much higher compared to an adult [14]. Therefore, a delivery form for a children's dietary supplement should be attractive and have specific characteristics to achieve long-term compliance. This research evaluated the preference of Dutch children between 4 and 12 years of age regarding fish oil supplementation delivered via various administration forms.

2 Methodology

2.1 Research Design

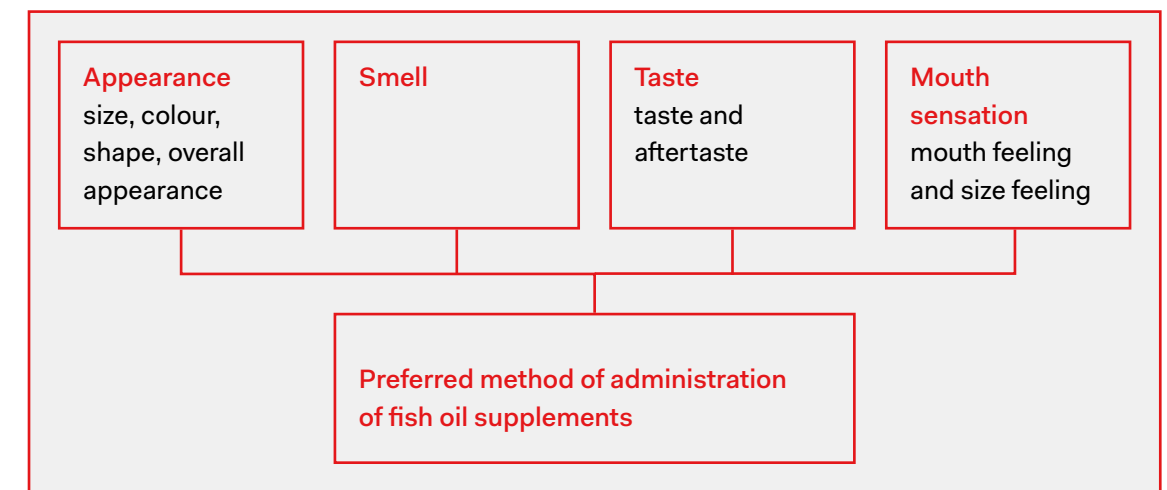
This was a randomized study evaluating the preference of fish oil supplementation using different delivery systems of children between 4 and 12 years of age. Four available delivery forms for fish oil supplementation were used to evaluate children's preference (Table 1). The order of supplementation was randomized.

Table 1 Delivery Forms

Brand	Dosage	EPA/DHA
Natures Aid Kids Omega-3 liquid (flavour: lemon)	One teaspoon (5 ml)	550 mg DHA 825 mg EPA
Holland & Barrett Softgel Capsule Omega-3-6 child (no flavour)	One capsule	53 mg DHA 80 mg EPA
ConCordix Soft Chew Mini Omega-3 (flavour: lemon)	One soft chew	250 mg DHA 50 mg EPA
Weifa Chewable Capsule Complete Omega-3 (flavour: orange)	One chewable capsule	60 mg DHA 85 mg EPA

Preference was investigated by performing hedonic sensory research and conducted according to Good Sensory Practice (Figure 1). Children were separated from other children to avoid any influence of others. Before the children consumed the fish oil supplements, they were asked 7 questions regarding appearance (size, color, smell, shape and overall appearance) of the different delivery forms. Thereafter they were asked to taste the supplements in the predetermined randomized order. Between the consumption of each supplement they received a cracker and water to neutralize their taste. After consumption of the supplement they were asked about the taste and mouth sensation.

Figure 1 Sensory Characteristics of Hedonic Research



The questionnaire used for the hedonic research had a 5-point scale, with 1 being most negative and 5 being most positive. The delivery form that was given the highest scores was statistically compared with the 3 other delivery forms using a t-test (significance level of 0.5%), with 'taste' being considered as the most important sensory characteristic.

2.2 Study Population

Dutch children were recruited from primary schools in the Netherlands. Parents were informed and had to sign an informed consent prior to enrollment of their child.

2.3 Inclusion Criteria

Children were eligible to participate in this investigation when:

- 1) Upon signing informed consent by the parents.
- 2) Male or female.
- 3) Aged between 4 and 12 years.

2.4 Exclusion Criteria

Children were excluded from this investigation when:

- 1) Children were vegan or vegetarian.
- 2) Children ate halal or kosher.
- 3) Children used medication that influenced taste.
- 4) Children who had disorders that influenced smell or taste, including, anosmia, hyposmia, hyperosmia, dysnomia, kakosmia or parosmia.
- 5) Children who were color blind.



3 Results

In total, 57 children were recruited of which 4 children were withdrawn from the study because their parents did not want to have their child swallow a soft gel capsule. Of the 53 children, 29 (54.7%) were male and 24 (45.3%) were female. The majority of children were 6 years of age (Table 2).

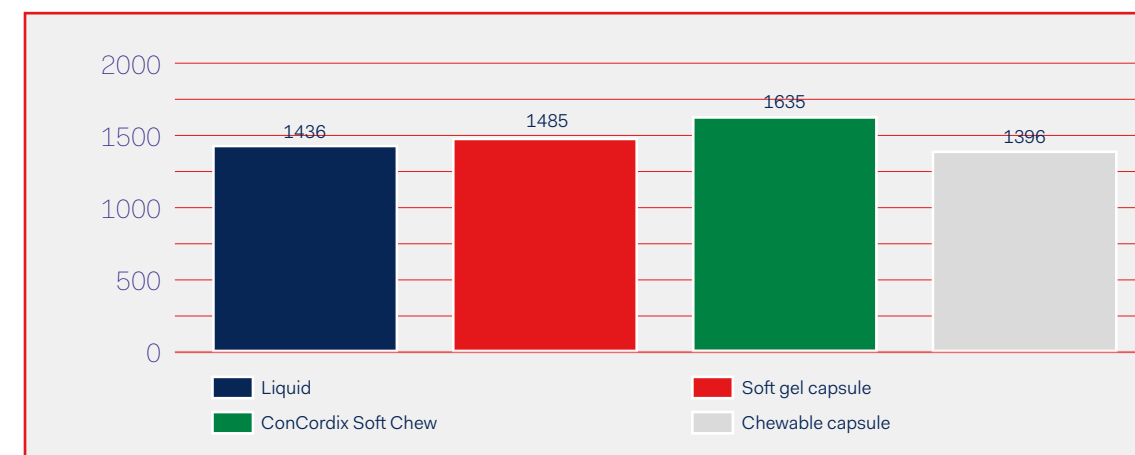
Table 2 Age and Gender of Enrolled Children

Age	Male	Female	Total
4 years old	2 (3.8%)	4 (7.5%)	6 (11.3%)
5 years old	3 (5.7%)	3 (5.7%)	6 (11.3%)
6 years old	5 (9.4%)	5 (9.4%)	10 (18.9%)
7 years old	1 (1.9%)	1 (1.9%)	2 (3.8%)
8 years old	4 (7.5%)	4 (7.5%)	8 (15.1%)
9 years old	1 (1.9%)	4 (7.5%)	5 (9.4%)
10 years old	3 (5.7%)	2 (3.8%)	5 (9.4%)
11 years old	2 (3.8%)	2 (3.8%)	4 (7.6%)
12 years old	5 (9.4%)	2 (3.8%)	7 (13.2%)
Total	26 (49.1%)	27 (50.9%)	53 (100%)

3.1 Total Scores

According to the total highest scores reported, the ConCordix soft chew was mostly preferred of the four delivery forms (Figure 2). Therefore, a statistical analysis with a significance level of 0.5% were performed by comparing the scores of the liquid, the chewable capsule and the capsule with the highest scores of the soft chew.

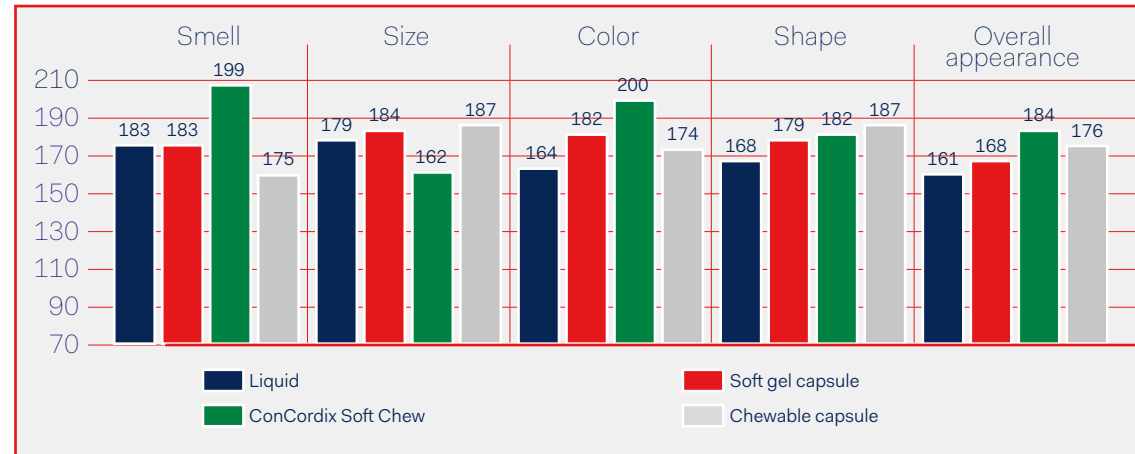
Figure 2 Total Scores



3.2 Results Prior to Consumption: Appearance

Prior to consuming each delivery form, the children were asked about the appearance, including size, smell, color, shape, and overall appearance as presented (Figure 3).

▷ Figure 3 Total Scores of Appearance (Size, Color, Shape, Smell and Overall Appearance)



The chewable capsule scored highest with regards to size and shape (187 scores; 61.1% of children). Color of the soft chew was given 200 scores (70.7% of children) and was statistically more preferred compared with the liquid ($p < 0.0001$), soft gel capsule ($p < 0.004$), and the chewable capsule ($p < 0.5$). For 'smell' 8.1% more points were given compared with the second-best scoring delivery systems (liquid and soft gel capsule) 58.5% of children reported they liked the lemon smell of the soft chew of which 22.0% reported the smell was 'very nice'. The chewable capsule was given the least points and was statistical different from the soft chew ($p = 0.0153$). Highest scores were also given for the overall appearance (184 scores; 61.0% of children) of the soft chew and was statistically different compared with the liquid ($p < 0.001$), soft gel capsule ($p < 0.004$), and the chewable capsule ($p < 0.05$).

3.3 Results After Consumption: Taste, Aftertaste, Mouth feel

Preference for a delivery system was measured by asking children what they thought about the smell, taste and aftertaste and mouth feel after consuming a supplement. The soft chew of ConCordix was given the highest scores compared with the three other delivery forms (Figure 4).

3.3.1 Taste and Aftertaste

The taste of the soft chew was statistically more preferred than the three other delivery forms with p-values of < 0.001 . The soft chew was given 182 points for taste which was 21.5% higher compared with the soft gel capsule, and even 39.0% higher than the least preferred delivery form; the chewable capsule. Also, the soft chew's aftertaste was highly preferred and was statistically different compared with the three other delivery forms (p-values < 0.02). A total of 21 points more were given for the soft chew supplement in comparison with the second-best scoring delivery form (soft gel capsule).

3.3.2 Mouthfeeling

Children reported that the mouthfeeling of the soft chew was 'strange', however it scored a total of 168 points which was the highest score (p-value of < 0.02) across delivery forms. The chewable capsule was preferred the least and 85.4% of children gave a score of 2 points or lower, and 39% of children spat the chewable supplement out.

Even though the soft chew was given the lowest score for size prior to consuming, the size feeling of the ConCordix soft chew was given the highest score compared with the three other delivery forms. The preference for size-feeling was statistically different between the chewable capsule ($p = 0.053$) and the soft gel capsule ($p = 0.0158$). A total of 75.6% children reported they thought the soft chew was 'nice'. The chewable capsule was favored the least in terms of mouthfeeling and scored 33.5% less than the soft chew.

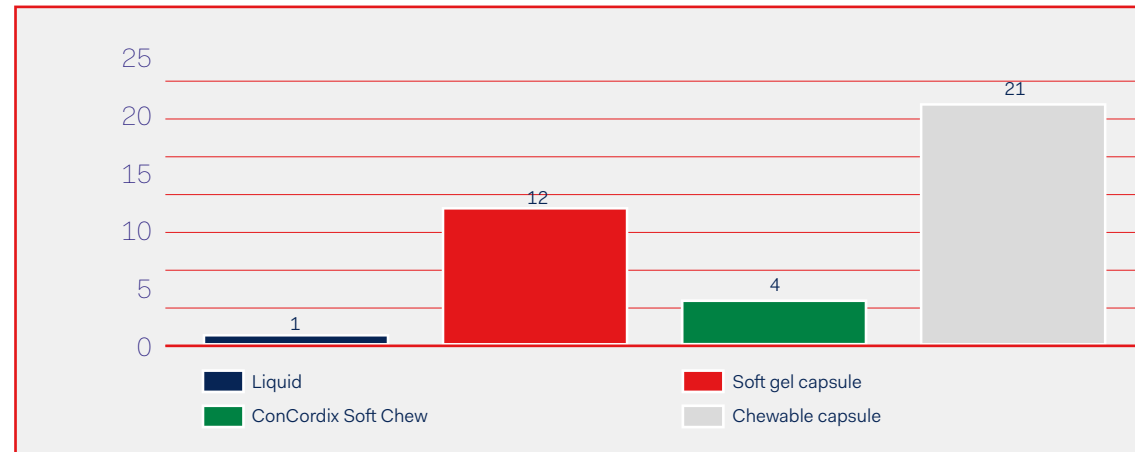
▷ Figure 4 Results after Supplement Consumption: Taste, Aftertaste, Mouth feel and size



3.3.3 Spitting Out the Supplement

The chewable capsule was spat out most often (39.0% of children), followed by 22.6% of children who spat out the soft gel capsule (Holland & Barrett) due to the size. The soft chew and the liquid were spat out by less than 2.2% of children (Figure 5).

Figure 5 Total of Children who Spat Out a Supplement



4 Discussion

This research investigated children's preference of four different delivery forms containing fish oil. Preference is an importance factor to improve compliance which is directly linked to health outcomes. Compliance of dietary supplements are primarily influenced by taste, flavor and texture, with taste being the most importance of these [12-14].

The results of the hedonic sensory research showed that fish oil delivered in a ConCordix soft chew supplement was mostly preferred by children between 4 and 12 years of age. The soft chew was given the highest total score (1635 points) and the highest score on seven out of nine questionnaire items. Prior to consumption the size and shape were less preferred compared with the three other delivery forms.

The liquid form (Natures) received a total of 1436 points, which was a comparable score with the Holland & Barrett soft gel capsule (1485 points). The chewable capsule (Weifa) was not well accepted (total score of 1396) in this age category, and mouth feeling and taste were the primary factors that children indicated as 'not nice at all', which was in line with the high number of children (39%) who spat the supplement out. Also, the soft gel capsule was spat out frequently (12%) and the reason children reported, was that it was too large to swallow.

Taste is a key factor to achieve long-term compliance [12, 15]. Chemical stimuli in foods and drinks activate chemoreceptors on the tongue and in the nose which are responsible for gustatory and olfactory perceptions. Impulses are then relayed to the brain where they join other information about the appearance and texture [14]. The ConCordix soft chew received the highest score for taste and was 39% higher than the least preferred taste: the chewable capsule. As taste, flavor is a key influencer of oral supplement compliance. When flavors and sweeteners are well balanced it results in a highly accepted taste. The soft chew was flavored with lemon while the least preferred supplement (chewable capsule) was flavored with orange. However, it seems that the flavor difference was not necessarily the cause for the large preference for the soft chew. The liquid delivery form was also flavored with lemon but was rated 33% lower than the soft chew. This indicates that the balance of flavors and sweeteners used for the soft chew resulted in exceptional overall taste that was highly preferred by the children. Moreover, children reported that the soft chew tasted similarly as fruity candy.

In addition, the aftertaste of the soft chew was 27% higher compared with the least preferred delivery form (chewable capsule). Aftertaste is as importance as the first taste when a supplement reaches the taste buds of the tongue. Especially when active ingredients have a distinct taste such as fish-oil. The statistical significant preference of the soft chew's taste and aftertaste over the three other delivery forms indicates an exceptional taste and remarkable taste-masking property, and could improve compliance for children's dietary supplements.

Texture of a delivery form may be a strong factor to improve compliance ^[14]. Low preference has been observed for supplements that are sticky or hard ^[12-14]. The mouthfeel of the soft chew received the highest score and was 39% higher than the chewable capsule which was rated lowest. Children reported that the chewable capsule ruptured during chewing and that the outer layer of the capsule was too tough. In contrast, the mouthfeel of the soft chew was comparable with a gummy candy. More than 75% of children rated the size feeling of soft chew as 'nice' and received the highest scores across the tested delivery forms. In contrast, children reported that before ingestion, the soft chew seemed too large. However, after ingestion, they felt that the delivery form was less big than they anticipated.

4.1 Conclusions

This research demonstrates that taste, flavor and texture are key to achieve acceptance of a delivery form, especially in children. The soft chew (ConCordix) was mostly preferred in a population between 4 and 12 years of age and scored statistically higher over other delivery forms at key factors that influence compliance: taste, aftertaste and texture. These results suggest that a delivery form with characteristics such as the soft chew has the potential to improve acceptance and compliance in young populations.



5 Acknowledgements

This research was established with Vitux A.S. which is a private label company that develops and produces dietary supplements for human and animal use. Vitux A.S. is the patent holder of the ConCordix Technology. The ConCordix soft Chew supplements are designed with a gelatin-based emulsification technique. The gelatin emulsion dissolves evenly in the intestinal liquids, there is a larger contact surface which provides better conditions for digestive enzymes, proved by an enhanced bioavailability ^[16]. The gelatin emulsion would also prevent reflux of lipids such as fish oil because it does not separate from the gastric contents. Additionally, they use natural fruit-extracts to mask distinct tastes and use sweeteners so that every supplement is sugar-free. The ConCordix Technology can be used for tailor-made supplements.

We would like to thank Dr. Merel Hazewindus in the preparation of this summary of report.

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