Ref. Ares (2018)4843939 - 20/09/2018

Intelligent Fish feeding through Integration of ENabling technologies and Circular principle

Grant Agreement (GA) No: 818036

D17 - Assessment of organoleptic and nutritional quality of fish products from the demonstration tests

Version: 2.0

Date: 21-July-2023

Document type:	**Report**
Dissemination level:	**Public**

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 818036

Project data

Project Title:	Intelligent Fish feeding through Integration of ENabling technologies and Circular principle
Project Grant Agreement (GA) No:	818036
Project Acronym:	iFishIENCi
Duration:	57 months, 1 November 2018 – 31 July 2023
Type of action:	Innovation Action

Deliverable Administration and Summary

Status:	Draft0	**Due:**	28.02.2023	**Date:**	
Author (s)	Anneli Rost, TTZ				
Reviewer	Florian Nagel, AAR Juliana Kobolák, MATE Marie Shrestha Freya Robinson, ABT				
WP	3	**Relative No. in WP**	D3.6		
Comments					

Document change history

Version	Date	Author	Description
1	22.02.2023	Rost, Shrestha (TTZ)	
2	21-07-2023	Freya Robinson (ABT)	Final Review

Suggested reference to this deliverable: Deliverable D3.6, Assessment of organoleptic and nutritional quality of fish products from the demonstration tests, Intelligent Fish feeding through Integration of Enabling technologies and Circular principle (iFishIENCi) Horizon 2020 project under Grant Agreement (GA) No: 818036.

Contents

Executive Summary

The worldwide demand for protein has led to a rapid increase in global aquaculture production in recent years. A related challenge is the need for feed ingredients. The goal must be to produce feeds that promote fish health and lead to higher fish production. Fishmeal and oil are the main ingredients in feeds, but they are a limiting source. The challenge is to replace these ingredients with novel ingredients that can promote sustainable aquaculture production. In the iFishIENCi project, ingredients such as insects, algae or microbial ingredients are being investigated. On the one hand, new ingredients can have an influence on fish health and fish growth, but they can also influence the nutritional composition of the fish meat. This can mean changes in sensory properties such as appearance, smell, taste and texture. Three fish species, rainbow trout, African catfish and tilapia were studied. Different novel feed ingredients adapted to the fish species were fed for specific periods of time. Subsequently, nutrient analyses and sensory tests were carried out. No significant changes were observed in the nutrient composition of the investigated fish species rainbow trout and African catfish. There were also no sensory abnormalities; hedonic evaluations as well as the description of sensory properties were not significantly different.

0 Introduction

Fish aquaculture is essential for providing healthy food to a growing world population but fulfill this task success depends upon the ability to develop more sustainable farming practices. More effective ways of monitoring fish-health and welfare and effective ways of feeding fish that reduce pressure upon the source of fish-feed ingredients are main goals of the iFishIENCi project. The use of alternative feed ingredients, such as plant ingredients, insect ingredients or microbial ingredients enables more sustainable production with limited dependency on fish meal. Research on the production of these ingredients, the ingredients' effects on fish health and the effects of the ingredients on product quality and sensory acceptance by the consumers will lead to a more sustainable production with limited dependency on fishmeal.

The consumer will only recognize the advantages of fish from aquaculture as a healthy food if production chains are transparent and sustainable implementations, which serve animal welfare, the environment and consumers' health, are successfully communicated. When buying fish products, the consumer is influenced by the brand, product information and experience. Regarding product acceptance and repurchase, priority is given to hedonic acceptance. As sensory characteristics have a high impact on consumers acceptance, two different approaches have been used to a) define the sensory acceptance and b) describe the sensory characteristics of different fish species produced in pilot productions.

In order to investigate the impact of fishmeal reduced diets on the nutritional value of these different fish species, different parameters have been analyzed. Different fish species have been studied in the partner countries. Sensory investigations were carried out for three fish species, corresponding to the respective fish farms of the partners involved.

1. Tilapia, Sensory trial in Laos, at the National Fisheries Development Center, Namxouang in February 2021 and at Aquatic Devlopment Co. in November2021. In the first trial with tilapia, the fish received a control diet and two diets enriched with 3,5% bioactive material, which consisted of either black soldier fly meal or Nannochloropsis meal. In the second trial, in additon to the three different diets in the first trial, a diet with 3,5% bioactive material which is already commercially available, was tested.
2. Trout, Sensory trial and nutritional value analysis at Aller Aqua Research GmbH in Büsum and at ttz Bremerhaven, Germany, September 2022. Rainbow trout received a control diet with 15% fishmeal, three other diets contained 5% fishmeal replacement with a Candida diet or Nannochloropsis.

3. Catfish, Sensory trial and nutritional value analysis in Győr, Hungary, January 2023. African catfish received a control diet and a diet with 5% fishmeal replacement by Nannochloropsis.

Fish parameters, such as daily feed intake, growth rate and feed conversion ratio, have been evaluated in the demonstration experiments of this workpackage.

1 Methods Sensory Evaluation

1.1 Hedonic consumer test (acceptance test):

Affective and hedonic testing methods are used to explore unconscious and emotional perceptions in consumers. They were developed because many studies showed that consumers are unable to make meaningful statements about the causes of their positive, neutral or negative assessments. Therefore, hedonic investigation methods do not ask about supposed motives for the assessment, it is queried to what extent a product is accepted in its characteristics. Hedonic-affective testing methods are used in new product development, as part of modification or optimization processes of existing products, but also for the continuous monitoring of the sensory quality as part of quality assurance. In this trial, the (hedonic) popularity and spontaneous preference of consumers towards the products was recorded. Tests were carried out in sensory laboratories (CLT, central location test) for Hungary and Germany or at an aquaculture farm (Laos). The sensory acceptance of fish products by the consumers was queried using the attributes appearance, smell, taste, consistency and overall impression.

1.2 Qualitative profiling using CATA (Check-all-that-apply):

CATA was used to determine specific sensory characteristics of the fish. Sensory descriptions of product properties are usually assessed using a trained descriptive panel that is able to discriminate sensorially and verbally and to reproduce their perceptions on a scale. The results give a relatively precise and quantitated picture of the sensory profile of a product. Classical descriptive methods (e.g. conventional profiling or Quantitative Descriptive Profiling, QDA®) for which products are described and intensity-evaluated, require a complex screening of panelists and training program prior to the actual evaluation of the products. In contrast, rapid profiling methods use untrained or semi-trained assessors to characterize samples' sensory characteristics. The CATA method is a rapid qualitative profiling method based on measures of the absence or presence of sensory characteristics. Thus, it represents an interesting alternative to complex descriptive test methods and is a suitable method to be used in agriculture and in small and medium-sized manufacturing companies where no trained panels are available. Compared to traditional descriptive analyses with trained panels CATA results give a meaningful but less accurate picture. Although, no intensities are measured, the qualitative profiles obtained provide a good overview of sensory parameters describing and discriminating between products.

For this method, consumers taste the samples and choose all those attributes from a predefined list that apply to or are perceived in the product – independent from their intensity. It is like a multiple-choice questionnaire using sensory terms. This method gives a rough description of the products and a relative comparison to other products. In scientific studies, CATA tests are carried out with large consumer groups (n->100). For the current study, a smaller number of consumers tested the products due to the limited sample volume available for this project.

1.3 RATA (Rate-all-that-apply):

The RATA method (Rate-All-That-Apply) is a variant of the CATA method. With RATA first all terms that apply to the respective sample are selected, then the intensity is rated on a 3-point scale. 1 corresponds to a weak intensity, 2 to a medium and 3 of strong attribute intensity. If a term is not checked, this applies to the data analysis as intensity = 0. If RATA is combined with hedonics, it is common to have consumers to first evaluate the products' acceptance, and subsequently assessing few selected attributes using the RATA method.

2 Tilapia Sensory Evaluation in Laos in February 2021

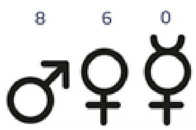
Sensory trials have been completed in Laos in February 2021. A combination of a hedonic consumer test with the Check-all-that-apply method has been applied.

2.1 Test design:

For this trial, the employees of the aquaculture farm acted as consumers. The Sociodemographic data is shown in table 1. The gender distribution was equally distributed, and consumers' age ranged between 20-50 years.

Table 1. Sociodemographic data of consumers.

Gender distribution



Age distribution

20-29 years	5
30-39 years	6
40-49 years	2
50 and older	1

2.1.1 Samples

The sample set consisted of three different tilapia fillets of Tilapia raised at the National Fisheries Development Center, Namxouang, Laos. The fish received different diets listed in table 2. Fishes received different feed with natural ingredients that might function as a bioactive stimulans, for e.g., enhancing the immune system. Therefore, as part of the work package, immune tests were carried out.

Table 2. Fish meal reduced diets.

Diet 1	**Control diet**
Diet 2	Insect diet (3,5% bioactive material: black soldier fly meal)
Diet 3	Algae diet (3,5% bioactive material: Nannochloropsis meal)

2.1.2 Pictures of samples

Samples served were of the same size and from the same part of the animal (see figure 1) to standardise the appearance of the samples. The fillets were steamed and served freshly prepared to the assessors. Samples were labelled with a three-digit-code. Every consumer assessed every sample, one after the other. The serving order was evenly randomized. Between the samples, a glass of water was served to neutralise the assessors' palates.

Figure 1. Preparation of samples tilapia.

2.1.3 Questionnaire:

Sensory acceptance was determined in the attribute appearance, odour, taste, mouthfeel, overall impression using a 9-point acceptance scale beginning from 1 ("dislike very much") to 9 ("like very much"). The samples' (qualitative) sensory profiles were measured using CATA. 14 consumers did participate in this test. The questionnaire is shown in Table 3.

Table 3. Questionnaire.

How much do you like the appearance of this fish fillets? 9-point-scale (from 1 ("dislike very much") to 9 ("like very much"))
Appearance: Check all the terms that you consider appropriate to describe this fish fillets **White/ivory/ green/ shiny/ dull/other**
How much do you like the odour of this fish fillets? 9-point-scale (from 1 ("dislike very much") to 9 ("like very much"))
Odour: Check all the terms that you consider appropriate to describe this fish fillets **Earthy, grassy, sour, nutty, sweet, chicken-like, maize, potato, mould, other**
How much do you like the taste of this fish fillets? 9-point-scale (from 1 ("dislike very much") to 9 ("like very much"))

Taste: Check all the terms that you consider appropriate to describe this fish fillets **Bitter, salty, sweet, sour, chicken-like, nutty, earthy, potato, maize, grassy, old, fish oil, other**
How much do you like the mouthfeel of this fish fillets? 9-point-scale (from 1 ("dislike very much") to 9 ("like very much"))
Mouthfeel: Check all the terms that you consider appropriate to describe this fish fillets **Firm, soft, easy to chew, sticky, juicy, other**
Would you like to buy this product for your family? Yes, maybe, I like other fish more
Sociodemographic data:
What is your gender? Female, male
How old are you? Below 20 years, 20-29 years, 30-39 years, 40-49 years, 50 years and older

In addition, and following the hedonic questions and the CATA, the buying intention, gender, and age were recorded.

2.2 Results

The results of this study should be seen as part of the development of the new feeds. Due to the small number of samples only 14 consumers evaluated the products Assessors were employees of the fish farm. The small number of assessments does not allow for statistically robust statements with regard to consumer acceptance and should not be generalised. The same applies for the descriptive method. Despite the small number of assessments, the data is worthwhile to be presented and may be seen as the basis for future research. The data shows that there are no differences between individual fish samples. Mean values range from 5.6 to 7.1 suggesting that the different feeding approaches have no influence on the sensory quality of the fish.

Graphic design: Mean values were calculated for the closed questions related to hedonic acceptance for each attribute and product (figure 2; table 4).

Attributes chosen to describe and rate the fish fillets (CATA) were summarised in table 5. Due to the low number of assessments no statistical analysis was conducted. Appearance: The mean values for *Insects* and *Algae* are higher than for *Control*. All products received similar attribute frequencies for "white". *Algae* was described as "ivory" and "green". *Insects* was most described as shiny and *Control* received the highest frequencies for dull. Regarding the products' odour profile, *Insects* and *Algae* were preferred over *Control*. The smell of *Control* was described as mouldy, potato-like and sweet. *Insects* was described as nutty and sweet and *Algae* being mouldy and sweet. All products received similar mean values for the attribute taste, *Control* and *Algae* were described as "sweet". *Control* was also characterized by a nutty and old taste. *Algae* was also described by an "old" taste. *Insects* were described as "old" and "sweet". Interestingly, all products received high mean values despite some unfavourable descriptions. The mean value for general impression for *Insects* and *Algae* is higher than *for Control*. The lower mean value for general impression for *Control* could be due to the lower values in appearance and taste. Overall, more consumers would purchase *Algae* and *Insects* (see figure 3). Both products received higher mean values for appearance and odour than for *Control*.

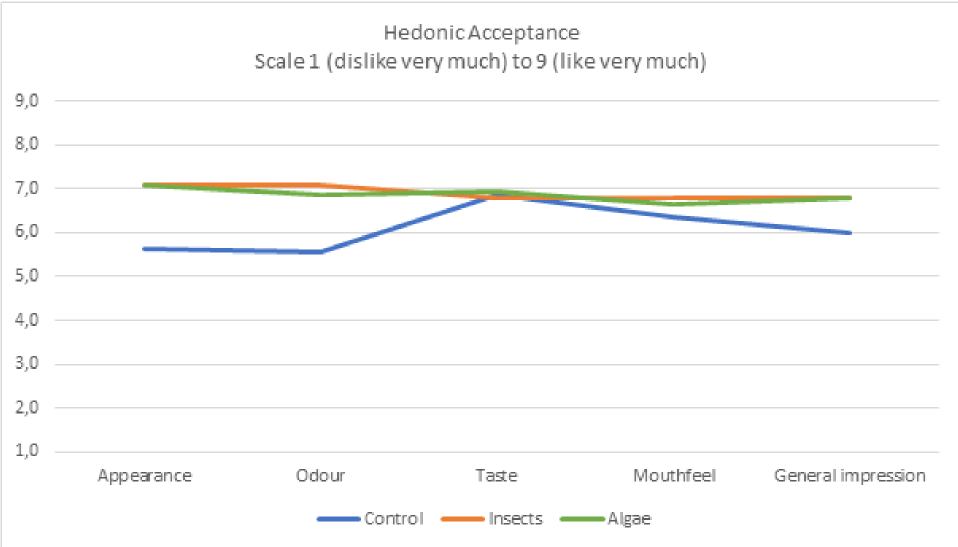


Figure 2. Mean values hedonic acceptance.

Table 4. Mean Values Hedonic Acceptance - Sensory acceptance: Scale from 1 (dislike very much) to 9 (like very much).

	Appearance	**Odour**	**Taste**	**Mouthfeel**	**General impression**
Control	5,6	5,6	6,9	6,4	6,0
Insects	7,1	7,1	6,8	6,8	6,8
Algae	7,1	6,9	6,9	6,6	6,8

Table 5. CATA, amount of answers given to the respective attributes - Attribute selection frequencies (assessments by n = 14 consumers).

Appearance		**Control**	**Insects**	**Algae**
white		4	3	4
ivory		1	2	3
green		3	3	4
shiny		3	5	1
dull		3	1	0
other	pale	1	0	0
other	bold	0	0	2

other	black	0	1	1
Smell		Control	Insects	Algae
earthy		2	1	1
grassy		0	0	1
sour		0	0	1
nutty		3	6	2
sweet		4	3	4
chicken-like		0	0	1
maize		0	2	0
potato		5	1	1
mould		5	2	4
other	dull	0	2	3
Taste		Control	Insects	Algae
salty		1	1	1
sweet		6	3	7
chicken-like		0	1	0
nutty		2	1	1
earthy		0	0	1
potato		1	2	0
maize		1	0	1
grassy		0	2	1
old		2	4	3
fish-oil		1	2	1
other	neutral	1	0	0
other	fish	1	1	1
other	dull	0	2	0
Mouthfeel		Control	Insects	Algae
firm		7	9	5
soft		3	1	4
easy to chew		5	4	4
sticky		0	0	1
juicy		0	1	2

other	flesh	0	1	0

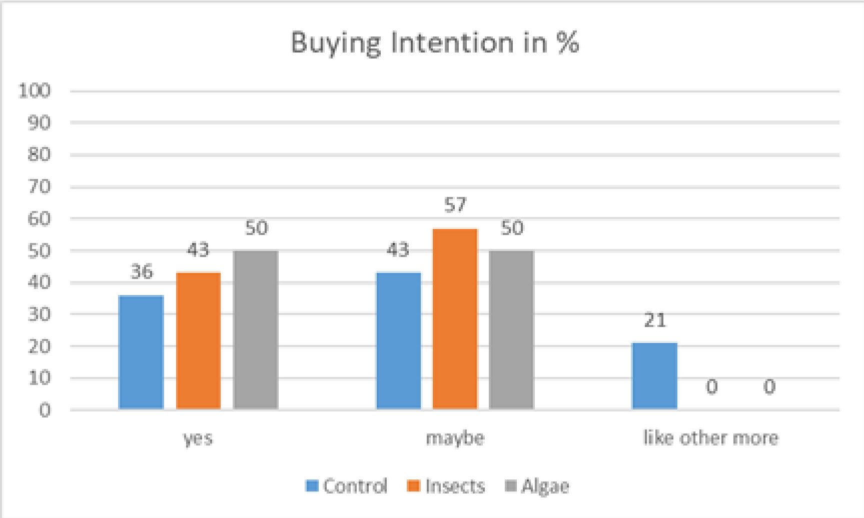


Figure 3. Buying intention.

2.3 Conclusion

Important information about the impact of two different fish feeds on the sensory profile and consumer acceptance of fish products could be obtained. Regarding the mean values for taste and general impression no major difference in the hedonic acceptance of the fish could be seen between *Control*, *Insects* or *Algae. The* sample *Insects* was described as having a “nutty” odour, *Control* and *Algae* tasted “sweet” the mouthfeel of all three products was perceived as being “firm”. This trial may be seen as a basis for future projects showing that the feeds enriched with bioactive stimulants in comparison to the control feed have no major impact on the sensory characteristics of the fish, and thus, no negative impact on consumer acceptance.

3 Tilapia Sensory Evaluation in Laos in November 2021

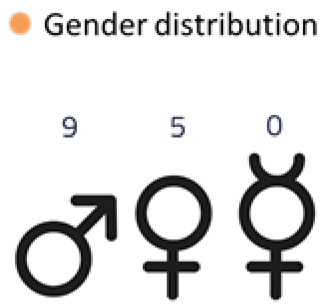
A similar organoleptic test with tilapia was conducted in November 2021.

3.1 Test design:

Sensory acceptance was determined using a 9-point acceptance scale beginning from 1 (dislike very much) to 9 (like very much). The description of sensory attributes was provided by the Check-All-That-Apply method (CATA). 14 consumers participated in this trial.

Sociodemographic data of participating consumers is shown in table 6. The employees of the aquaculture farm acted as test persons.

Table 6. Sociodemographic data.



Age distribution

20-29 years	3
30-39 years	4
40-49 years	4
50 and older	3

Date of test: November 2021, Laos

3.1.1 Samples

The samples were three different tilapia fillets. The fishes were raised at the National Fisheries Devlopment Co., Namhoum, Laos.

The fishes received different diets shown in table 7.

Table 7. Fish meal reduced diets.

Diet 1	**Control diet**
Diet 2	Insect diet (3,5% bioactive material added to the control diet: black soldier fly meal)
Diet 3	Algae diet (3,5% bioactive material added to the control diet: Nannochloropsis meal)
Diet 4	Bioactive products (3,5% bioactive additives commercially available added to the control diet)

Samples served to the consumers were of the same size and from the same part of the animal having the same general appearance. To each consumer one fillets was served. The fillets were steamed and freshly served to the consumers. Samples were labelled with a three-digit-code. Every consumer assessed each sample, one after the other. The serving order was evenly randomized. Between samples, a glass of water was served to neutralize consumers' palates.

3.1.2 Questionnaire

The same questionnaire was used as in March. It included asked consumers regarding their sensory acceptance in the attribute appearance, odour, taste, mouthfeel, overall impression in combination after qualitatively profiling the sensory profile of the products using the CATA method. In table 3, the design of the questionnaire is shown. In addition, the buying intention and sociodemographic data (gender, age) was recorded.

3.2 Results

The results are to be seen as part of the development of the new feeds. Due to the small number of samples in this trial and the local events, only 14 people evaluated the fishes. Test persons in this case were the employees at the fish farm. The small number of samples does not allow any statistically significant statement on the hedonic acceptance and the descriptive method.

Despite the small number of test subjects, we would like to present and analyze the results. The testers assessment shows that there are minor differences between the individual fish samples and we can conclude from this that the different feeds could have a minor influence on the sensory quality of the fish.

Graphic design: Mean values were calculated for the closed questions related to hedonic acceptance for each attribute and product (figure 4; table 7). Attributes chosen to describe and rate the fish fillets (CATA) were summarised in table 4. Due to the low number of accessors no statistical analysis was done.

Appearance: The mean values are the highest for *Control*. *Control* and *Bioactive* were described as "white", *Algae* and *Bioactive* got high scores for "ivory". *Insects* was most described as "white" and dull. Regarding the odour, *Control* and *Bioactive* were preferred over *Insects* and *Algae*. The smell of *Control* was described as "sweet" and "grassy". *Insects* was described as "chicken-like" and "sweet". *Algae* was also described as tasting like "maize". *Bioactive* was characterised with several attributes, none dominant. *Algae* received the best values in the attribute taste. *Insects* was clearly described as "chicken-like". *Control* was found to be "grassy" and "maize-like". *Bioactive* was describes as "chicken-like" and "nutty". *Algae* got the highest scores for "chicken-like". *Insects* was clearly described as "chicken-like". In the attribute mouthfeel, *Algae* got the highest values and was described as "easy to chew" and "soft". All products were described as "easy to chew". *Insects* and *Bioactive* were described as “firm”. *Control* got data in equal parts for “firm” and “soft”. The purchase decision is the highest for *Control,* 88% of the consumers stated that (figure 4).

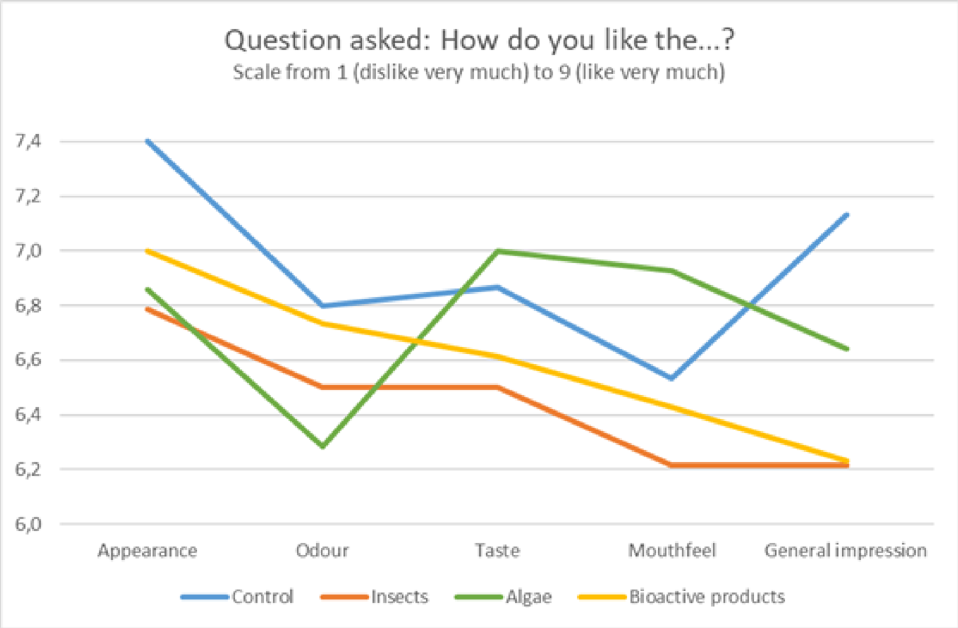


Figure 4. Mean Values Hedonic Acceptance, scale cut-out.

Table 8. Mean Values Hedonic Acceptance - Sensory acceptance: Scale from 1 (dislike very much) to 9 (like very much).

	Appearance	Odour	Taste	Mouthfeel	General impression
Control	7,4	6,8	6,9	6,5	7,1
Insects	6,8	6,5	6,5	6,2	6,2
Algae	6,9	6,3	7,0	6,9	6,6
Bioactive products	7,0	6,7	6,6	6,4	6,2
Significant differences	no	no	no	no	no

Table 9. CATA attribute frequencies, checks of individual attributes - Attribute selection frequencies (assessments by n = 14 consumers).

Appearance		Control	Insects	Algae	Bioactive
white		10	5	6	9
ivory		3	3	7	6
green		1	1	0	0
shiny		4	2	3	3
dull		1	4	1	1

other	none	0	0	0	0
Smell		Control	Insects	Algae	Bioactive
earthy		1	1	2	2
grassy		4	3	2	2
sour		0	0	1	2
nutty		0	1	1	1
sweet		5	2	2	2
chicken-like		1	4	1	2
maize		3	4	5	2
potato		2	0	2	3
mould		0	0	0	0
other	no odour	0	0	1	0
other	fishy	0	0	0	1
Taste		Control	Insects	Algae	Bioactive
bitter		0	1	1	1
salty		0	2	1	2
sweet		2	3	2	0
sour		0	0	1	1
chicken-like		2	6	4	5
nutty		1	2	0	4
earthy		1	1	1	0
potato		1	2	2	1
maize		4	2	2	2
grassy		6	3	3	3
old		0	0	0	3
fish-oil		1	0	0	0
other	fishy	0	0	0	1
Mouthfeel		Control	Insects	Algae	Bioactive
firm		4	6	2	7
soft		4	3	7	4
easy to chew		5	6	5	4
sticky		2	1	0	1

juicy		3	3	2	2
other	dry	0	0	0	1

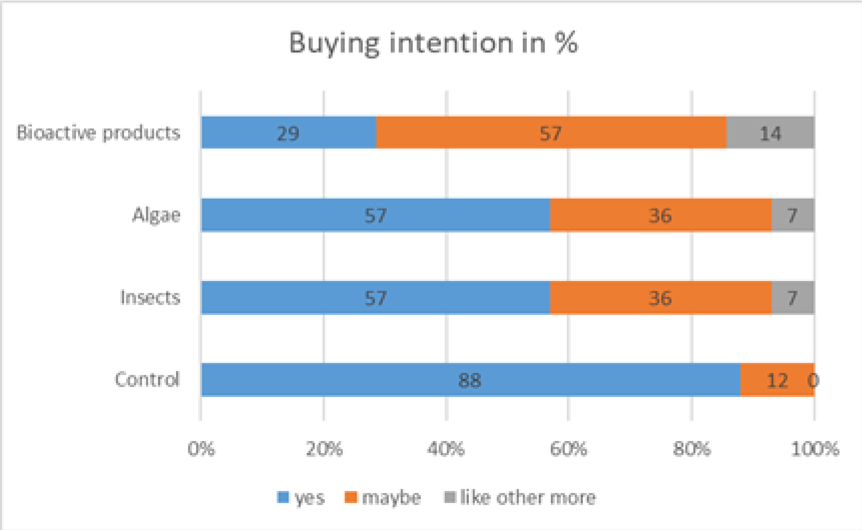


Figure 5. Buying intention.

3.3 Conclusion

Again, only 14 subjects were used in this test period, so no statistically robust data could be collected. Nevertheless, important information about the different diets could be obtained. Regarding the mean values for all sensory attributes and general impression no major differences in the hedonic acceptance of the fish could be seen; all scores (appearance, odour, taste, mouthfeel, general impression) were between 6,2 and 7,4. *Contro*l and *Algae* were evaluated slightly better than *Insects* and *Bioactive*. With the Check-All-That-Apply-Method the sensory properties were described slightly differently. Despite the low number of testers important information about the three different feeds could be achieved. To achieve more statistically robust data, the test needs to be completed by at least 100 assessors.

4 Rainbow trout Nutritional and Sensory Evaluation in Germany in September 2022

4.1 NUTRITIONAL VALUE ANALYSIS

Analysis of fish meal reduced diets to evaluate the nutritional potential of microbial ingredients produced from yeast (*Candida utilis*) or algae (Nannochloropsis) in combination with a partial astaxanthin substitution in test diets for rainbow trout. Nannochloropsis is a marine microalga which is rich in high-quality protein, essential amino acids, polyunsaturated fatty acids, sugars, minerals, vitamins and pigments. Because of its dominant fatty acid eicosapentaenoic acid it has potential as a fish oil replacer in fish feeds. The yeast *Candida utilis* is also rich in these macronutrients and rich in Astaxanthin. For this reason, both Nannochloropsis and Candida are optimal organisms to partially reduce the content of fishmeal.

4.1.1 Samples

The fishes were fed for eight weeks until apparent satiation at optimal temperature (14.8°C) until a final weight of 350-400g weight. At the end of the trial 10 left-side fillets per treatment were sampled and frozen at -20°C until analysis at TTZ (4 x 10 fillets left side corresponding to the three test diets and one control diet, Table 10).

Table 10. Fish meal reduced diets and partial Astaxanthin substitution in pilot scale trial RAS6_275.

Diet 1	**Control diet (with fish meal 15% and 40mg/kg Astaxanthin)**
Diet 2	Candida diet (5% substituted for FM; 40mg/kg Astaxanthin)
Diet 3	Test diet Nanno 1 high pigment (5% substituted for FM; 40 mg/kg Astaxanthin)
Diet 4	Test diet Nanno 2 low pigment (5% substituted for FM; 20 mg/kg Astaxanthin)

4.1.2 Results

The nutritional composition of the individual feeds was different, see Table 10. The daily feed intake (DFI) of the trout did not significantly differ among treatments, with a trend to be lower for Nanno diets. The specific growth rate (SGR) significantly declined for Nanno diets, as a result of reduced DFI and impaired feed conversion rate (FCR). The slaughter yield (SY) did not differ among the treatments, the fillets yield (FY) was higher for Candida diet compared to Nanno 2 diet, but not to control diet. The condition factor (CF), the hepatosomatic index (HSI) and the spleensomatic index (SSI) ranged at comparable level among all treatments (data not shown). Independent from initial inclusion level, the Astaxanthin degradation in the test feeds ranged between 83.58% (Candida diet) and 91.73% (Nanno

2 diet) at the end of the experimental trial. Final Astaxanthin content of fillets ranged between 2.3mg/kg (Nanno 2 diet) and 3.11mg/kg (Test diet Candida) without significant differences (Table 11). No significant differences in moisture, crude ash, crude protein and crude fat could be measured (Table 11).

Fillets pigmentation was measured using a DSM SalmoFan™colour card at a defined area of the dorsal fillets utilising a light box with 6500 Kelvin (6500 Kelvin corresponding to sunny daylight). Control diet, test diet Candida and test diet Nanno 1 high pigment did show a significant difference compared to test diet Nanno 2 low pigment. The different feeds had no impact on the nutritional value of the fish.

Table 11. Nutrient composition of test diets used for the pilot scale trial RAS6_275 (in % original matter (OM), analysis by LUFA ITL, Kiel, Germany).

Parameter (% OM)	Control diet	Test diet Candida	Test dietNanno1 high pigment	Test dietNanno2 low pigment
Moisture	3.3	3.1	2.7	2.9
Crude protein	46.7	47.3	47.6	46.6
Crude fat	22.6	21.4	23.1	23.5
NfE	18.7	19.4	17.9	18.3
Crude fibre	1.2	1.5	1.3	1.4
Crude ash	7.5	7.3	7.4	7.3
P	0.99	1.05	1.00	0.92
Ca	1.31	1.18	1.12	1.08
Gross energy (MJ/kg)	23.45	23.24	23.72	23.71

Table 12. Nutrient composition of rainbow trout fillets (pilot scale trial RAS6_275, analysis by LUFA ITL, Kiel, Germany).

Nutrient composition of fillets (average ±S.D.; n=10) Parameter	Control diet	Test diet Candida	Test diet Nanno1 high pigment	Test diet Nanno2 low pigment
Moisture (% OM)	71.19 ±0.86	71.10 ±0.63	71.54 ±0.48	71.80 ±1.09
Crude ash (% OM)	1.34 ±0.05	1.31 ±0.09	1.34 ±0.05	1.34 ±0.07
Crude protein (% OM)	20.74 ±0.47	20.43 ±0.57	20.28 ±0.38	20.61 ±0.45
Crude fat (% OM)	6.81 ±1.29	7.32 ±1.37	7.00 ±0.63	6.89 ±1.41
Astaxanthin (mg/kg)	3.00 ±0.92	3.11 ±0.97	3.15 ±1.61	2.30 ±0.92

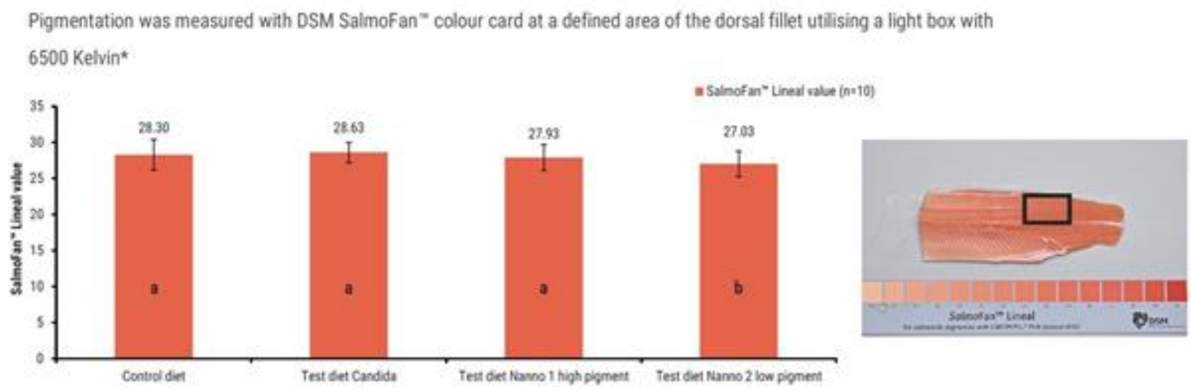


Figure 6. Fillet pigmentation measured using a DSM SalmoFan™colour card at a defined area of the dorsal fillets utilising a light box with 6500 Kelvin (6500 Kelvin corresponding to sunny daylight). Feeding Control diet, test diet Candida and test diet Nanno 1 high pigment demonstrated an effective pigmentation of the fillets, which was significantly higher compared to test fillets of fish fed the diet Nanno 2 low pigment.

4.2 CONSUMER ACCEPTANCE

Sensory trials have been completed in Bremerhaven in September 2022. A combination of a hedonic consumer test with the Rate-all-that-apply method has been applied.

For trout, a hedonic test method was combined with the Rate-All-That-Apply-Method.

4.2.1 Test design

Sensory acceptance was determined using a 9-point acceptance scale beginning from 1 (dislike very much) to 9 (like very much). The description of sensory attributes was provided by the RATA method. 21 consumers completed this test.

Sociodemographic data is shown in Table 11. Consumers' gender was evenly distributed, and the age ranged between 20 years and 35 years. Consumers had to consume trout products regularly to be invited to the test.

Date of test: September 2022, Sensory laboratory of ttz Bremerhaven (TTZ), Bremerhaven, Germany.

Table 13. Sociodemographic Data.

Gender distribution

♂	♀	⚥
48	53	0

Age distribution

20-25 years	29%
26-30 years	43%
31-35 years	29%

Consumption of fish

More than once a week	38%
Once a week	43%
Once in two weeks	9%
Once a month	5%
Less than once a month	5%

4.2.2 Samples

The sample set consisted of 1o lefts-side filets per treatments, four different treatments (diets) correspond to 40 left-side fillets of rainbow trout for a complete analysis at TTZ. The fishes were raised at Aller Aqua Research (AAR) and were derived from the trial_RAS6_275. The fishes received different diets, which are shown in Table 9.

4.2.3 Pictures of samples

In figure 7-10, the different samples are shown in frozen, thawed, and steamed states.

Figure 7. Control diet (with FM 15% and Asta 40mg/kg).

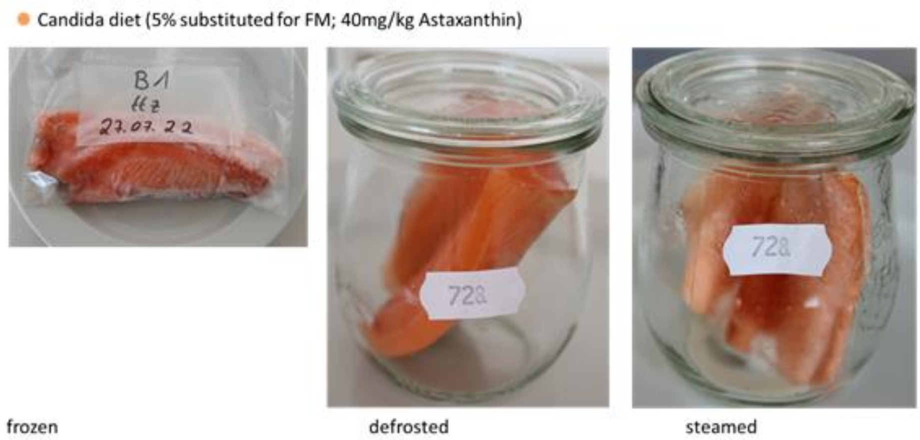


Figure 8. Candida diet (5% substituted for FM; 40mg/kg Astaxanthin).

Figure 9. Test diet Nanno 1 high pigment (5% substituted for FM; 40 mg/kg Astaxanthin).

Figure 10. Test diet Nanno 2 low pigment (5% substituted for FM; 20 mg/kg Astaxanthin).

The sensory laboratory received ten fish halves (left-side fillet) of every diet. Samples served to the testers were of the same size and from the same part of the animal and looked the same. To each assessor a sample consisting of 60-80 grams fillets was given. The fillets were steamed in WECK glasses in the oven for six minutes. The samples were served to the testers directly after steaming. Samples were labelled with a three-digit-code. Every consumer tested every sample, one after the other. The serving order was evenly distributed between consumers. Between the samples, a glass of water and some tasteless bread was served to neutralise their palates.

4.2.4 Questionnaire

Consumers were asked to state their sensory acceptance towards the samples with regard to appearance, odour, taste, mouthfeel, and the overall impression. In addition, the intensity of selected sensory characteristics was quantified using the RATA method. Figure 11 shows the design of the questionnaire to assess appearance. In addition, after the hedonic questions and the RATA questions, the buying intention was recorded.

How much do you like the appearance of this fish filet?
Check all the terms that you consider appropriate to describe this fish filet:

☐	☐	☐	☐	☐	☐	☐	☐	☐
Dislike very much								Like very much

	none	mild	moderate	severe
white	☐	☐	☐	☐
ivory	☐	☐	☐	☐
green	☐	☐	☐	☐
shiny	☐	☐	☐	☐
red	☐	☐	☐	☐
dull	☐	☐	☐	☐
Other:_______	☐	☐	☐	☐

Figure 11. Questionnaire cut-out for the attribute appearance.

4.2.5 Results

The results are to be seen as a supplement to the nutritional analysis. Due to the small number of samples, only 21 test persons could be invited to the test. The small number of samples does not allow any statistically significant statement on the hedonic acceptance and the descriptive method.

Despite the small number of test subjects, we would like to analyze the results. The consumer assessment shows that there are no differences between the individual fish samples and we can conclude from this that the different foods have no influence on the sensory quality of the fish.

Graphic design: Mean values were calculated for the closed questions related to hedonic acceptance for each attribute and product. Attributes chosen to describe and rate the fish fillets (RATA) were summarised in a table. The statistical analysis was conducted using XLSTAT: ANOVA (Tukey/Fisher), Principal Component Analysis (PCA).

The hedonic acceptance, mean values in a scale cut-out, is shown in figure 12 and mean values in table 3. For all sensory attributes and general impression no significant differences in the hedonic acceptance of the different fish samples could be seen.

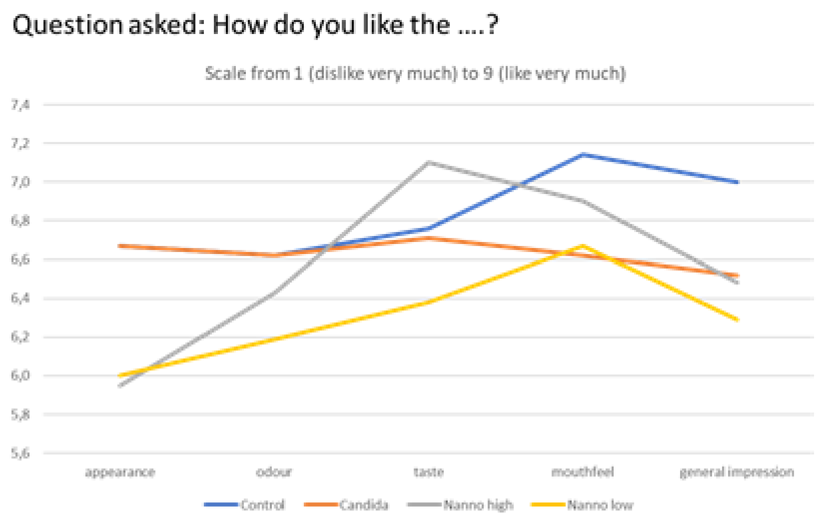


Figure 12. Mean values hedonic acceptance.

Table 14. Mean Values Hedonic Acceptance (Mean Values - Scale from 1 (dislike very much) to 9 (like very much)).

Sample	Control	Candida	Nanno high	Nanno low	ANOVA
Code	404	728	51	433	NS (no significance)
Code FIZZ	1521300 1218052	1521300 2218052	1521300 3218052	1521300 4218052	S (significance)
Appearance	6,7	6,7	6,0	6,0	NS
Odour	6,6	6,6	6,4	6,2	NS

Taste	6,8	6,7	7,1	6,4	NS
Mouthfeel	7,1	6,6	6,9	6,7	NS
General Impression	7,0	6,5	6,5	6,3	NS

The different fish samples were not described and rated significantly differently (table 12 and 13). The samples were described in appearance as "red", with highest rates for Candida. The appearance of all samples was described as "shiny" rather than "dull". Regarding the samples' odour, no significant differences are shown in the hedonic response. Significant differences could be detected for the attribute "earthy" between *Control* and *Nanno low* (1,6) to *Candida* and *Nanno high* (1,2/1,0). None of the attributes was rated as medium or high. The attribute "potato" was rated from 1,0-1,2 (low intensity), all other attributes were rated below 1,0 (non-low). No significant differences were shown in the ratings of the taste attributes. The taste was rated as low to medium "earthy", low in "potato", "fish oil" and "nutty". The attributes "sweet, old, sour, bitter, chicken, corn" and "salty" were rated below low (0,1-0,7). No significant differences were shown in the hedonic response and in the ratings of the mouthfeel attributes. The mouthfeel was rated as medium "juicy" and "easy to chew." The attributes "firm" and "soft" were rated low to medium (1,4-1,8). The buying intention is the highest for Control (figure 13). The relatively large rejection can be explained by the fact that the fish fillets were not prepared in any way, the consumers evaluated the steamed fish.

Table 15. Table 13: Mean Values RATA (Mean Values RATA). 0=none; 1=low; 2=medium; 3=strong.

	Control	Candida	Nano high	Nano low	NS (non-significant)/S (significant)
AP_white	1,2	1,0	1,3	1,3	NS
AP_ivory	1,4	1,0	1,4	1,6	NS
AP_green	0,5	0,5	0,7	0,5	NS
AP_red	1,7	2,0	1,6	1,3	NS
AP_shiny	1,6	1,7	2,0	1,5	NS
AP_dull	0,6	0,7	0,7	0,8	NS
OD_earthy	1,6	1,2	1,0	1,6	NS
OD_sweet	0,7	0,4	0,4	0,6	NS
OD_moldy	0,6	0,8	1,0	0,7	NS
OD_fatty	0,9	0,9	0,9	0,7	NS
OD_chicken	0,4	0,3	0,3	0,5	NS

OD_sour	0,2	0,3	0,3	0,2	NS
OD_corn	0,4	0,2	0,9	0,2	NS
OD_nutty	0,8	0,8	0,6	0,8	NS
OD_potato	1,0	1,0	1,2	1,1	NS
FL_sweet	0,5	0,3	0,7	0,5	NS
FL_earthy	1,3	1,2	1,3	1,4	NS
FL_old	0,5	0,6	0,5	0,6	NS
FL_sour	0,1	0,3	0,1	0,3	NS
FL_potato	0,9	0,7	1,0	1,0	NS
FL_fish oil	1,4	1,2	1,3	1,2	NS
FL_bitter	0,2	0,1	0,0	0,4	NS
FL_chicken	0,6	0,5	0,5	0,7	NS
FL_corn	0,6	0,4	0,3	0,3	NS
FL_salty	2,5	2,7	3,4	2,7	NS
FL_nutty	3,4	3,9	4,3	4,8	NS
FL_fatty	7,3	6,1	5,7	5,4	NS
MF_firm	1,8	1,8	1,5	1,8	NS
MF_juicy	2,4	2,1	2,2	2,0	NS
MF_soft	1,8	1,4	1,4	1,4	NS
MF_easy chew	2,3	2,2	2,2	2,1	NS
MF_sticky	0,9	0,6	0,8	0,8	NS

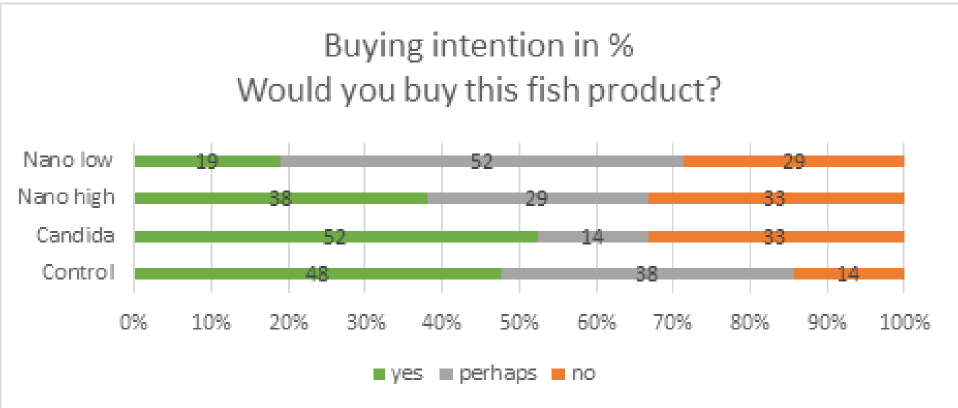


Figure 13. Buying intention.

4.2.6 Conclusion

Regarding the mean values for all sensory attributes and general impression no major differences in the hedonic acceptance of the fish could be seen. *Contro*l was evaluated slightly better than the other three samples. With the rate-all-that-apply-method the sensory properties were described and rated only slightly differently, no significant differences could be seen except in *odour earthy.* Despite the low number of testers important information about the four different feeds could be achieved. The different feeds had no impact on the hedonic evaluation of the products and no significant differences could be shown in the rating of the specific attributes in appearance, odour, taste and mouthfeel. The nutritional value analysis showed no significant differences between the different fish products. Both, the analytical and the sensory evaluation show no major differences of the new feeds to the standard feed.

5 African catfish Nutritional and Sensory evaluation in January 2023

5.1 NUTRITIONAL VALUE ANALYSIS

Investigation of the impact of one new feed on the nutritional value of African catfish.

5.1.1 Samples

The samples were two different African catfish fillets (one new feed and control). The fishes were raised at the GE site and come from the pilot scale trial of African catfish breeding. The fishes were 8 months old. One group of the control genotype and three parallel selected groups were used in the trial. The average weight of the fish was 550 ± 80g at the start and the average final weight was 1181±125g. The fish were fed for six weeks in eight separate groups with two different diets, which are shown in table 14. At the end of the trial 50 left-side fillets per treatment were sampled and frozen at -20°C sent to a food analytical lab for analysis Table 14.: Algae-containing diet.

Diet 1	**Control diet (with fish meal 6%, Soybean meal (24%) and Extruded soybean meal (8%).)**
Diet 2	Algae diet (5% Nannochloropsis meal of substituted for Soyabean meal (22%) and Extruded soyabean meal (5%)

5.1.2 Results

The nutritional composition of the individual feeds was different, see Table 15. There was no significant difference in the daily concussion. All groups fed with algae-containing feed had higher growth rates (*Figure 1.).* The average body weight was 5.3% higher than the control. In the case of the control feed, the growth of the selected groups was 19.3% higher, while the gain was 21.2% in the groups fed with the algae-containing feed. The nutrient composition of the African catfish meat was similar in the control and algae diet fed groups, only a few fatty acids (Palmitoleic acid, Behenic acid, Erucic acid), the total ash, vitamin A and the Beta -Carotene showed a significant increase, while the level of Lauric acid was significantly lower in the meat of the algae fed groups (Table 16).

Table 16. Nutrient composition of algae and control diets used for the African catfish pilot scale trial.

Nutrient composition of feed Parameter (% OM)	Control diet	Test diet Algae
Moisture	9.815	8.565
Crude protein	41.709	41,899
Crude fat	12.448	12.455
NfE	12.565	12.565

Crude fibre	3.166	2.817
Crude ash	2.857	2.993
P	0.620	0.652
Ca	0.520	0.517

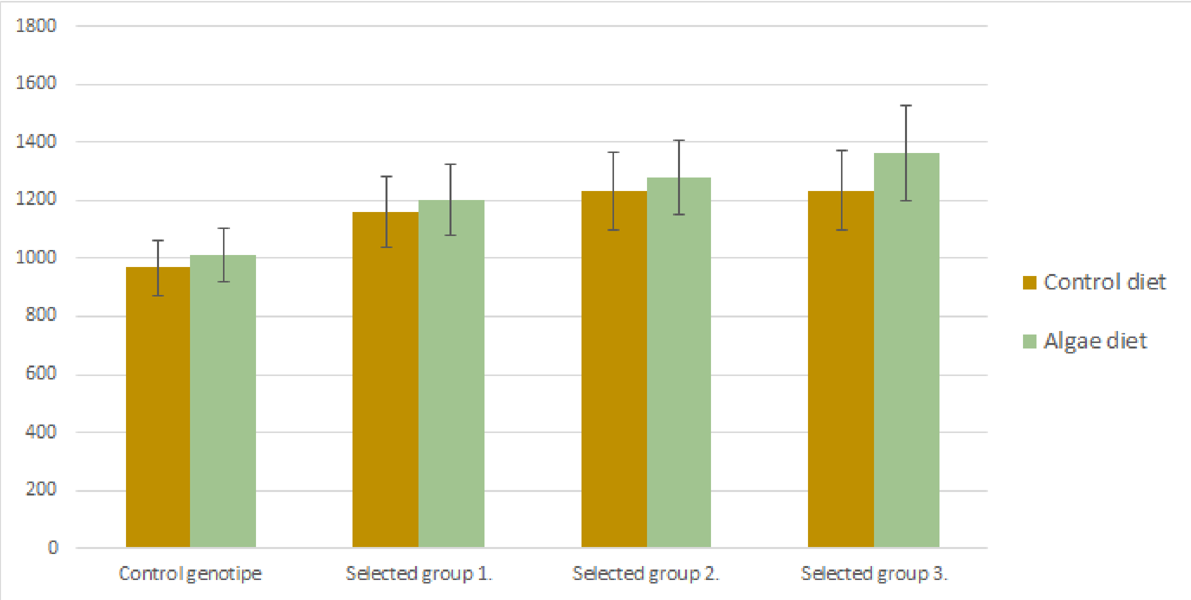


Figure 14. The average body weight of control and algae-based diet fed African catfish groups.

Table 17. Result summary of African catfish fillets composition measurements.

Nutritional Value Analysis African Catfish						
	Control Average		Algae Average			
Sample	Average B	SD	Average A	SD	differece (%)	T-test
Energy content ª (kJ/100g)	495,20	27,16	511,40	24,17	3,27	0,348287
Energy content ª (kcal/100g)	118,20	6,65	121,80	6,10	3,05	0,398313
Total fat content ª (m/m %)	4,95	0,80	5,38	0,65	8,81	0,370525
Saturated fatty acids (g/100g)	1,76	0,25	1,99	0,22	13,20	0,155203
Monounsaturated fatty acids (g/100g)	2,15	0,40	2,29	0,29	6,32	0,551823
Polyunsaturated fatty acids (g/100g)	1,04	0,17	1,11	0,15	6,76	0,513467
Butyric acid (C 4:0) ª (m/m %)	0,00	0,00	0,00	0,00		
Caproic acid (C 6:0) ª (m/m %)	0,00	0,00	0,00	0,00		
Caprylic acid (C 8:0) ª (m/m %)	0,02	0,03	0,00	0,00	-100,00	0,141113
Capric acid (C 10:0) ª (m/m %)	0,02	0,03	0,00	0,00	-100,00	0,141113
Undecionic acid (C 11:0) ª (m/m %)	0,00	0,00	0,00	0,00		
Lauric acid (C 12:0) ª (m/m %)	0,28	0,13	0,11	0,05	-61,27	0,021841
Tridecic acid (C 13:0) ª (m/m %)	0,00	0,00	0,00	0,00		
Myristic acid (C 14:0) ª (m/m %)	1,27	0,11	1,27	0,10	0,32	0,952735
Myristoleic acid (C 14:1) ª (m/m %)	0,01	0,02	0,01	0,02	0,00	1
Pentadecenoic acid (C 15:1) ª (m/m %)	0,00	0,00	0,00	0,00		
Pentadecic acid (C 15:0) ª (m/m %)	0,17	0,01	0,18	0,01	3,49	0,453499
Palmitic acid (C 16:0) ª (m/m %)	22,65	0,86	23,09	0,66	1,92	0,392628
Palmitoleic acid (C 16:1) ª (m/m %)	3,07	0,24	3,57	0,21	16,31	0,007603
Heptadecenoic acid (C 17:1) ª (m/m %)	0,00	0,00	0,00	0,00		
Margaric acid (C 17:0) ª (m/m %)	0,20	0,02	0,22	0,01	7,84	0,084414
Stearic acid (C 18:0) ª (m/m %)	7,27	0,33	7,79	0,38	7,10	0,050086
Oleic acid (C 18:1) ª (m/m %)	38,09	1,83	36,82	1,09	-3,32	0,221047
Linoleic acid (C 18:2) ª (m/m %)	17,72	0,62	17,57	0,64	-0,87	0,709442
Linolenic acid (C 18:3n-3) ª (m/m %)	0,94	0,12	0,82	0,06	-12,34	0,0917
Gamma-linolenic acid (C 18:3n-6) ª	2,25	0,20	2,12	0,14	-6,12	0,234722
Arachinic acid (C 20:0) ª (m/m %)	0,26	0,02	0,25	0,02	-4,58	0,273139
Gadoleic acid (C 20:1) ª (m/m %)	2,15	0,11	2,00	0,16	-6,99	0,125791
Behenic acid (C 22:0) ª (m/m %)	0,34	0,04	0,65	0,24	93,49	0,020365
Erucic acid (C 22:1) ª (m/m %)	0,06	0,01	0,10	0,04	85,71	0,028146
Tetracosanoic acid (C 24:0) ª (m/m %)	3,20	0,31	3,43	0,38	6,99	0,338251
Saturated fatty acids (Calculated value) ª (m/m %)	35,72	1,53	37,00	0,78	3,58	0,133073
Total carbohydrate content (m/m %)	0,18	0,08	0,20	0,07	11,11	0,6938
Protein content (Nx6,25) ª (m/m %)	18,20	0,32	18,18	0,27	-0,12	0,910056
Moisture content ª (m/m %)	76,18	0,68	75,58	0,45	-0,79	0,140117
Total ash content ª (m/m %)	1,07	0,02	1,11	0,04	4,32	0,045976
Vitamin ª (all-trans-retinol) ª (mg/100g)	0,01	0,00	0,02	0,00	58,18	0,026485
α-carotene ª (mg/100g)	0,00	0,00	0,00	0,00		
β-carotene ª (mg/100g)	0,00	0,00	0,01	0,01		0,008079
0 means that the value is under the detection limit						

The colour of 15 fillets from both the control and algae-treated groups was measured using a Chroma Meter CR-400 (Konica Minolta) with a 5 cm wide head and the CIE L*A*B* colour space system (Table 17). A statistically significant difference was observed in B*, with a ΔE* value of 2.19 falling within the perceptible category (Figure 15).

Figure 15. colour measurement of algae treated and control African catfish filets.

Table 18. Result summary of African catfish fillets colour measurements.

	L*	A*	B*
Control diet (average)	48,96	16,39	17,34
SD	2,16	2,44	2,06
Algae diet (averade)	48,78	15,81	18,94
SD	1,36	1,53	2,27
Difference (%)	0,363047	3,537877	-9,26204
T -test	0,633521	0,170385	0,000579

5.2 CONSUMER ACCEPTANCE

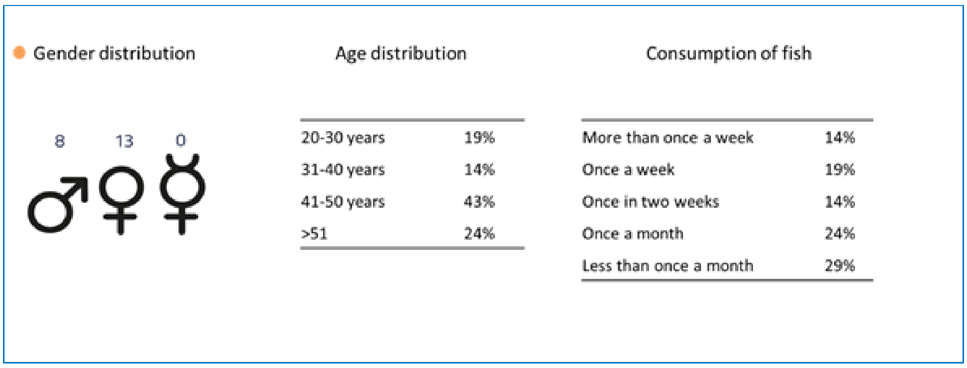
Sensory trials have been completed in Gyor in January 2023. A combination of a hedonic consumer test with the Rate-all-that-apply method has been applied. For catfish, a hedonic test method was combined with the Rate-All-That-Apply-Method.

5.2.1 Test design

Sensory acceptance was determined using a 9-point acceptance scale beginning from 1 (dislike very much) to 9 (like very much). The description of sensory attributes was provided by the RATA method. 21 consumers completed this test.

Sociodemographic data is shown in Table 18. Consumers' gender was evenly distributed and the age ranged between 20 years and 65 years.

Table 19. Sociodemographic Data.



Gender distribution

♂	♀	⚥
8	13	0

Age distribution

20-30 years	19%
31-40 years	14%
41-50 years	43%
>51	24%

Consumption of fish

More than once a week	14%
Once a week	19%
Once in two weeks	14%
Once a month	24%
Less than once a month	29%

5.2.2 Samples

The sample set consisted of two different African catfish fillets. The fishes were raised at Győr and were derived from the African catfish breeding trial. The fishes received different diets, which are shown in Table 19.

Table 20. Test diets.

Diet 1	**Control diet**
Diet 2	Nannochloropsis diet (5% substituted for FM)

5.2.3 Pictures of samples

In figure 16, the samples are shown unprepared (raw) and steamed.

Figure 16. Fresh fillets in KERRES Steam Oven before steaming / steamed fillets.

The sensory laboratory received ten fish halves of every diet. Samples served to the testers were of the same size and from the same part of the animal and looked the same. To each assessor a sample consisting of 90-110g grams fillets was given. The fillets were steamed in a *KERRES* Steam Oven. The samples were served to the testers directly after steaming. Samples were labelled with a three-digit-code. Every consumer tested every sample, one after the other. The serving order was evenly distributed between consumers. Between the samples, a glass of water and some tasteless bread was served to neutralise their palates.

5.2.4 Questionnaire

Consumers were asked to state their sensory acceptance towards the samples with regard to appearance, odour, taste, mouthfeel, and the overall impression. In addition, the intensity of selected sensory characteristics was quantified using the RATA method. In addition, after the hedonic questions and the RATA questions, the buying intention was recorded. The same questionnaire was used as in the organoleptic analysis of trout.

5.2.5 Results

The results are to be seen as a supplement to the nutritional analysis. Due to the small number of samples, only 21 test persons could be invited to the test. The small number of samples does not allow any statistically significant statement on the hedonic acceptance and the descriptive method.

Despite the small number of test subjects, we would like to analyze the results. The consumer assessment shows that there are no differences between the individual fish samples, and we can conclude from this that the different foods have no influence on the sensory quality of the fish.

Graphic design: Mean values were calculated for the closed questions related to hedonic acceptance for each attribute and product. Attributes chosen to describe and rate the fish fillets (RATA) were summarised in a table. The statistical analysis was conducted via R: Mann-Whitney U test (Wilcoxon rank sum test).

The hedonic acceptance, mean values in a scale cut-out, is shown in figure 17 and mean values in table 20. For all sensory attributes and general impression no significant differences with Wilcoxon rank sum test ($p>0.05$) in the hedonic acceptance of the two fish samples could be seen.

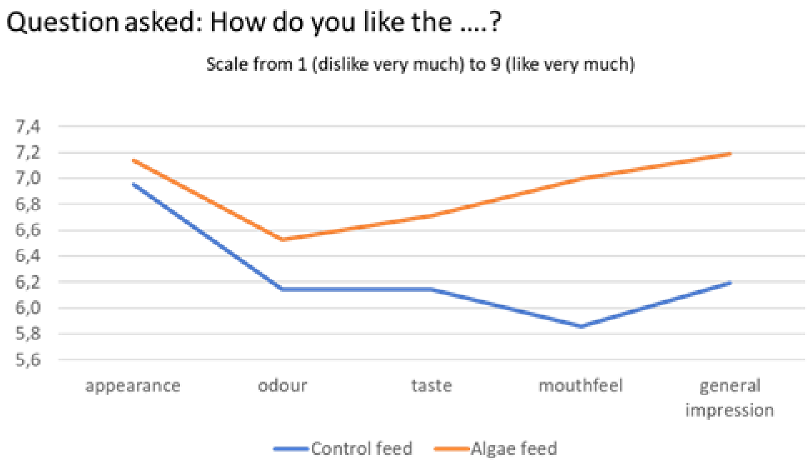


Figure 17. Mean values hedonic acceptance.

Table 21. Mean values hedonic acceptance.

Sample	Control feed	Algae feed	Wilcoxon (NS (no significance)/S (significance)
Appearance	7,0	7,1	NS
Odour	6,1	6,5	NS
Taste	6,1	6,7	NS
Mouthfeel	5,9	7,0	NS
General Impression	6,2	7,2	NS

Table 22. Mean Values RATA (Mean Values RATA). 0=none; 1=low; 2=medium; 3=strong.

	Control	Algae	NS (non-significant)/S (significant)
AP_white	0,6	0,7	NS
AP_ivory	1,7	2,1	NS
AP_Salmon colour	0,0	0,3	NS
AP_green	0,2	0,0	NS
AP_shiny	0,5	0,8	NS
AP_dull	0,8	1,2	NS
AP_spotted	0,3	0,2	NS
OD_earthy	0,2	0,0	NS
OD_sweet	0,6	0,7	NS
OD_mouldy	0,0	0,0	NS
OD_grassy	0,1	0,0	NS

OD_chicken	1,1	1,1	NS
OD_sour	0,0	0,0	NS
OD_corn	0,3	0,3	NS
OD_nutty	0,1	0,3	NS
OD_potato	0,3	0,2	NS
FL_sweet	0,1	0,0	NS
FL_earthy	1,2	1,1	NS
FL_old	0,4	0,4	NS
FL_sour	0,0	0,0	NS
FL_potato	0,2	0,4	NS
FL_fish oil	0,1	0,0	NS
FL_bitter	0,4	0,4	NS
FL_chicken	0,1	0,0	NS
FL_corn	0,1	0,0	NS
FL_salty	0,1	0,0	NS
FL_nutty	0,2	0,3	NS
FL_fatty	0,2	0,6	NS
MF_firm	1,0	0,7	NS
MF_juicy	1,5	1,4	NS
MF_soft	1,8	2,0	NS
MF_easy chew	2,3	2,5	NS
MF_sticky	0,4	0,1	NS

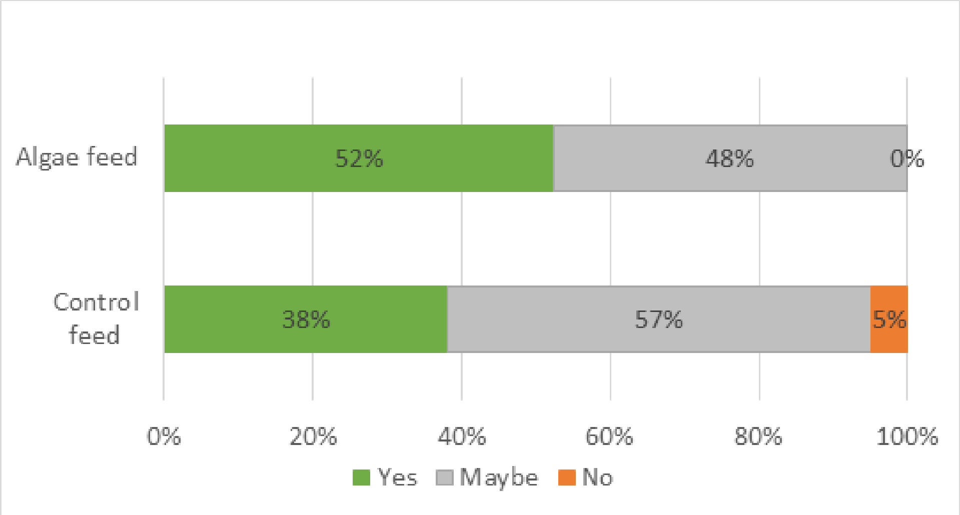


Figure 18. Buying intention.

5.2.6 Conclusion

The rating of the of the two samples did not show any significant differences (Table 21). Algae feed was evaluated slightly better than the control one. Algae feed group appearance was more „salmon color" and less green or white color than the control group. Algae feed group odour was more neutral than the control group. Corn, and nutty odours were more prominent in the algae group. The taste remained neutral in the algae group, but corn and nutty taste appeared next to the chicken taste. The mouthfeel did not change too much. The stickiness decreased a bit and the texture was less firm in the algae feed group. Buying intention is higher with the algae feed (figure 18).

The new algae feed had no impact on the sensory acceptance of the fish fillets by the assessors.

6 Conclusion

In this study, the influence of new feeds, which either contain less fishmeal through the addition of algae or yeasts, or which were given a higher feed value through the addition of bioactive substances, was investigated.

In Laos, bioactive compounds as additives to the fish feed were examined. In Germany, Rainbow trout received feeds with three different fish meal substitutes (source algae and yeast) and in Hungary, African catfish were fed with one fish meal substitute (source algae)

The number of different feeds tested was reduced to two/three feeds for tilapia, to three new feeds for rainbow trout and one new feed for African catfish. Detailed information on the functionality, formulas and production of the new feeds is given in D1.4.. Biological responses, feeding efficiency and environmental impacts to feeds are discussed here.

Sensory methods were chosen that assess hedonic acceptability as well as descriptive tests that are part of the so-called rapid profiling and can efficiently highlight product characteristics and product differences.

The studies presented were conducted with a relatively small number of consumers. This is due to the fact that the feed trials are very time-consuming and only a limited number of fish could be made available for the sensory tests. For this reason, the tests were only carried out in the participating partner countries. The selection of the fish tested was based on the species that correspond to the country's typical cuisine and the consumption habits of the population. A statistically robust data situation would have been achieved with 100 consumers.

From a purely sensory point of view, for all three fish species, tilapia, rainbow trout and African catfish, no difference in enjoyment value, i.e. sensory perception and acceptance, could be perceived between the individual fish samples by the participating consumers. The hedonic acceptance, i.e. the question of whether the appearance, smell, taste or mouthfeel of a sample is pleasing, could also be answered unambiguously positively. Also in the product description, i.e. in the properties that characterise a product, no difference could be found by the consumers. This applies to the pure description of the properties via adjectives (in the case of tilapia) as well as to the intensities of these descriptions (in the case of rainbow trout and African catfish).

The nutritional analyses carried out on rainbow trout also showed no differences between the different fish samples. The new feeds thus show no effect on the nutritional composition of the fish fillets. An analysis of the fatty acid pattern was not carried out, as the replacement of the fish meal in this study was only 5%. Here the crude fat value was measured.

Consumer acceptance of the tested fish products supports the plan to commercialise the project (WP5). Newly developed fish feeds do not show any sensory differences in the end product and thus comply with the standard. Changes in recipes are therefore no obstacle to launching the various fish products on the market. In addition, the research carried out helps to get in touch with the end consumer (WP6) and to and to promote the acceptance of sustainable aquaculture products.