DLG EXPERT REPORT 3/2021

Spirulina as Food

Consumer-oriented product development to promote sustainable nutrition

www.DLG.org

DLG
EXPERT REPORT
3/2021

Spirulina as Food

Authors:

Richard Wiesen
Brianne A. Altmann
Antje Risius
Georg August University in Göttingen, Germany

Stephanie Grahl
Institute for Sensory Research and Innovation Consultancy (isi GmbH)
Rosdorf, Germany

Published by:

DLG e.V.
Competence Center Food
Eschborner Landstr. 122 · 60489 Frankfurt am Main · Germany

2nd edition, as of 3/2024

Spirulina in human nutrition

Adequate nutrition with protein-rich foods is a global challenge that is becoming greater as the world's population continues to grow. The distribution of food is already inadequate and around 11% of the world's population suffers from malnutrition (FAO, 2017). Furthermore, animal farming, together with the application of farm manure, was already responsible for approximately 35% of greenhouse gas emissions in German agriculture in 2017 (German Federal Office for the Environment, 2019). As a result, there is a great need for alternative sources of protein that can be produced easily, quickly and in large quantities without causing a major impact on the world's ecosystems and climate.

Algae can be a source of a wide range of essential nutrients that promote human health – in particular the microalgae spirulina (A. platensis). It is already being used successfully in the Global South to combat malnutrition (Siva Kiran et al., 2016). For the Western European food market, spirulina is particularly interesting as an alternative to established animal protein sources, but little research has been carried out to date. The microalgae is rich in protein (approx. 60%), unsaturated fatty acids and contains other nutritionally valuable substances such as gamma-linolenic acid and beta-carotenoids (Harun Diraman et al., 2010). Spirulina is mainly cultivated in tanks or large pools, which makes it independent of local soil conditions and highly productive. Some new farms have been established in Europe in recent years, but the majority are currently still found in Asia (Akal Food, 2020; SPIRULIX, 2020; Vigani et al., 2015).

A series of studies conducted by the University of Göttingen in Germany investigated the extent to which spirulina is suitable for the production of foodstuffs. The first study used descriptive sensory analysis to investigate the manageability of spirulina in wet extrusion (see Grahl, Palanisamy et al., 2018). This is an established process for producing fibrous and firm products from soy protein, for example, which are similar in texture to meat (e.g. soy schnitzel, steaks or nuggets). As spirulina has hardly been researched in this process to date, descriptive analysis by a trained sensory panel and instrumental texture analysis were used to investigate the extent to which production has an influence on the sensory properties of the texturate and whether spirulina offers an alternative with regard to its use as a meat substitute. Finally, possibilities for controlling the desired texture of future spirulina-based foods were derived. It became apparent that the spirulina-soya mixture is in principle suitable for extrusion and that a fibrous, meat-like texture can also be achieved. The resulting products with a higher spirulina content showed a more distinct algae flavour, which should be taken into account for further product development (Grahl, Palanisamy et al., 2018).

In a second study, various product concepts were created using consumer-orientated product development (see Grahl, Strack et al., 2018). In general, constant feedback and control processes with consumers, beta testers and expert interviews are used to increase the probability of success of a new product on the market and consequently consumer acceptance. Various product ideas relating to algae extrudates were initially discussed in interviews with food experts. Finally, before the products were actually manufactured, an online survey was conducted to find out which products consumers thought were the most promising. Stuffed pasta as a staple food, spirulina sushi based on the principle of "flavour pairing" and a vegan alternative to dried meat ("jerky") were presented to consumers in photos. This involved analysing

Figure 1: Images of the product ideas as they were shown to respondents online (from left to right: pasta, sushi, jerky).

which combination of product and marketing strategy would generate the highest level of acceptance. This step enabled an early evaluation of the ideas by the end users even before resources were channelled into the actual product development (Costa & Jongen, 2006).

Consumers favoured spirulina-filled pasta over the other two categories, which is due to the fact that pasta is generally very familiar (Grahl, Strack et al., 2018). Conversely, all three products with spirulina would be conceivable, provided they are equally well-known among consumers. With regard to marketing opportunities based on the benefits of sustainability, health and innovation, it has been shown that healthy products in particular meet with a high level of acceptance (Grahl, Strack et al., 2018).

The microalgae spirulina therefore has the potential to be offered as a food in various forms in terms of product manufacture and consumer expectations in order to promote a sustainable, meat-reduced diet and increase the consumption of protein-rich algae.

Survey of willingness to pay for spirulina products

Products based on alternative protein sources such as spirulina can only be implemented across the board if they are both accepted and purchased by consumers and offer economic incentives for food producers. In the same way, consumer groups must be identified that would be the most promising (greatest willingness to pay) for a successful market launch of spirulina products.

In a third study, respondents were therefore asked directly how much they would be willing to pay (in €) for filled pasta, sushi or jerky with spirulina. A double enquiry procedure was used for this purpose. After the first 'uninformed' enquiry, consumers were informed about the price of a comparable product without spirulina (i.e. standard spinach-filled pasta, maki sushi with salmon filling and conventional beef jerky) and then asked again about their willingness to pay for the respective spirulina products. This was intended to achieve two goals: On the one hand, the open enquiry about willingness to pay often encounters the problem that consumers are not in a position to assess the price level of the product (Tress, 2015). Here, information about the comparative product provides assistance for test subjects and leads to increased reflection. On the other hand, the change in willingness to pay in the second survey allows conclusions to be drawn about the cross-price elasticity of spirulina products in order to quantify the added value of spirulina products in direct comparison with the established product variants (Lusk & Hudson, 2004).

The survey was conducted online with 176 respondents in Germany. The respondents had an above-average level of education, an above-average income and the average age was only just below the national average (Federal Statistical Office, 2020). The sample was mainly distributed across areas of northern Germany (Lower Saxony, Hamburg, Bremen, Schleswig-Holstein, Mecklenburg-Western Pomerania; n = 95) and southern Germany (Bavaria and Baden-Württemberg; n = 72). Due to this special aspect, the willingness of the sample to pay was analysed again separately for "Northern Germany" and "Southern Germany".

Product performance

For all three products, the first price enquiry was significantly higher than the second after the information on the price of the comparison products was provided (Fig. 2). The most significant aspect is the high average willingness to pay for spirulina pasta, which is around 40% higher than the price of the comparison product. However, for the other two products, sushi and jerky, the willingness to pay is significantly lower than for the price of the comparison product. In absolute terms, the willingness to pay is highest for sushi, followed by pasta and finally jerky. This shows that although the respondents are unable to quantify exact prices through their assessment, they are very well able to assign products to a price category and differentiate between them even without a price comparison.

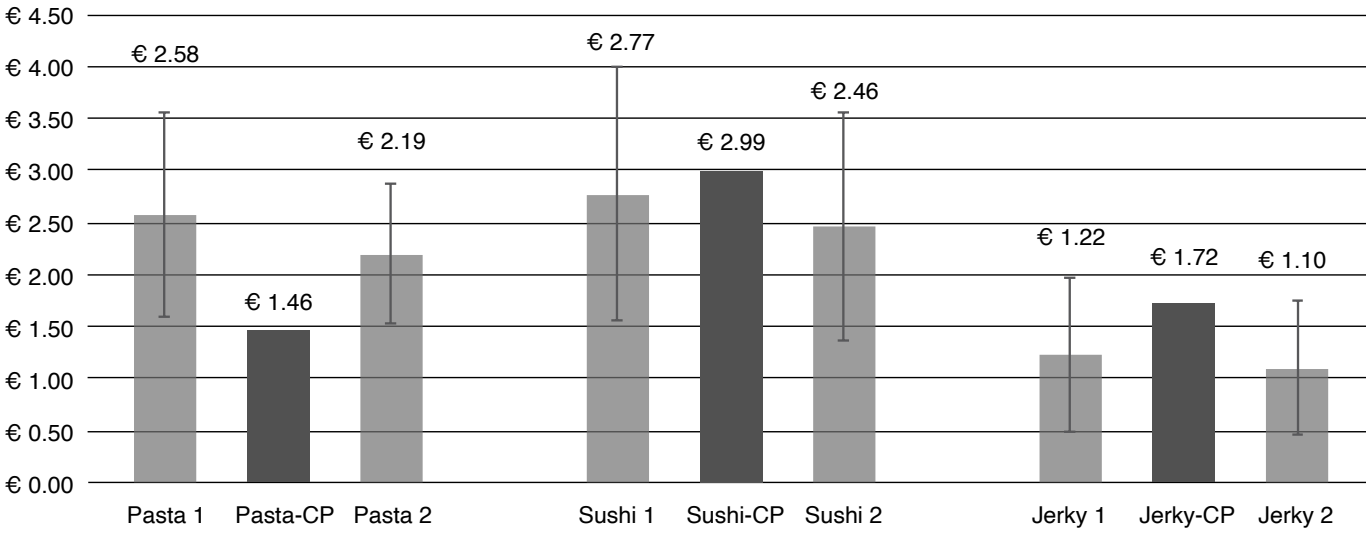

Figure 2: Average willingness to pay; n = 176; "1" shows the first enquiry; "2" shows the second enquiry for information on the price of the comparison product (CP)

Overall, it is clear that spirulina is accepted, but is characterised by a "negative willingness to pay" for most products. This means that only spirulina pasta would be suitable as a competitive concept on a large scale. Spirulina pasta could therefore be placed next to the comparable product and would be considered by interested buyers despite the higher price. Spirulina sushi and jerky, on the other hand, require a special communication effort to convey the added value or equivalence to consumers.

However, it is worth looking at the distribution of consumers' willingness to pay for the specific products, as this allows any niche markets with a group of consumers with an above-average willingness to pay to be identified (Lusk & Hudson, 2004). If these exist, it is possible to market the product profitably by means of targeted marketing for the "more willing to pay" group, even if the general average willingness to pay is below that of the comparable product. Spirulina sushi stands out here in particular, which 31% of respondents would not buy (corresponding to a price of € 0.00), but which buyers (willingness to pay > € 0.00) rated as approx. 28% more willing to pay on average than the price of the comparison product.

In addition to their willingness to pay, the respondents were also asked how much they thought they would like the taste of the respective concept product. This was assessed on a scale from "Very bad" (1) to "Very good" (5). If the taste expectation was high, there was a significant positive correlation with the willingness to pay within the product categories. It is interesting to note here that the expected product flavour for pasta also correlated significantly with the willingness to pay for sushi and, conversely, the expected product flavour for sushi correlated significantly with the first price query for pasta. However, the expected overall liking for the spirulina jerky had no correlation with the other two price preferences. This shows that consumers like spirulina jerky for different reasons than the other two spirulina product concepts. As a result, there is little overlap between the two consumer groups, who are either interested in sushi and pasta or jerky. This kind of information is important in the marketing of meat alternatives, as not all products serve the same needs and motives of consumers. It is therefore to be expected that the products will not cannibalise each other.

Segment-specific positioning

The most relevant influencing factors from which consumers' willingness to pay can be derived are age, origin and nutritional style. The level of education also allows conclusions to be drawn to a certain extent. Surprisingly, there is no correlation between prior knowledge of spirulina and willingness to pay. Previous experience with spirulina is therefore not a criterion for consumer acceptance of the innovative products, which can ease the burden on marketing.

Table 1: Correlations between consumer characteristics and willingness to pay

	Age	Meat consumption	Income	Level of education[2]		Prior knowledge of spirulina
				University entrance qualification	Secondary school leaving certificate	
Pasta	-	(-)	0	0	0	0
Sushi	-	--	0	+	-	0
Jerky	--	(+)	0	0	0	0

(-) weakly negatively correlated; – negatively correlated; -- strongly negatively correlated; (+) weakly positively correlated; + positively correlated; 0 no correlation; [2] no statements on other groups possible due to group size

Older consumers are generally less willing to spend money on spirulina foods. The influence of nutritional style can be explained by the fact that consumers may not see pasta and sushi products as meat substitutes, but at best as meat alternatives. This should be taken into account in product marketing and only the jerky should be advertised as a meat substitute product. The respondents' level of education influences their willingness to pay for spirulina sushi. For both surveys, respondents with a university entrance qualification indicated a higher willingness to pay.

Interestingly, there were regional differences within the sample for the willingness to pay for spirulina pasta. Here, respondents from southern Germany showed a significantly higher willingness to pay in both surveys. This difference could not be explained by any other variable (e.g. level of education, income) within the sample. It would be plausible that food is simply more appreciated in southern Germany than in northern Germany. It would therefore be advisable to market spirulina products in southern Germany first in order to achieve higher prices.

Recommendations for the future of the products

Spirulina pasta is the most familiar product and appeals to the broadest customer base overall. It not only achieves a higher average willingness to pay, but also the highest willingness to pay relative to the comparable product. In the growing market for vegan and vegetarian food alternatives, there seems to be a need for staple foods and spirulina pasta offers tangible added value for consumers.

Spirulina sushi was rated highly by consumers who like sushi as a product category and, as a vegetarian alternative in this niche, appeals specifically to consumers who regularly eat sushi. Spirulina jerky, on the other hand, achieved the lowest willingness to pay not only in absolute terms, but also relative to the comparison product. This could also be due to the fact that jerky is still rather unknown in Germany and has less of a tradition than in North America, for example. This means that the findings on the product categories presented cannot be generalised, but are strongly influenced by the food culture of the region examined. This must be taken into account when developing products for specific target markets.

The price of the comparison product can be identified as having the greatest effect on the willingness to pay. However, this occurs in both directions, so that a higher sales price could be achieved with appropriate product placement of the alternative spirulina products alongside conventional products. The specific recommendation for action here is to offer the products in supermarkets and organic markets on shelves next to premium brands. Spirulina pasta could outperform the cheaper products with an integrated placement in the refrigerated section. The spirulina sushi should appeal to a customer group that is particularly open to sushi. In addition, competition with cheaper products must be avoided. Spirulina jerky is perceived as a meat substitute, but is not competitive with standard beef jerky. It is therefore currently not a potentially successful spirulina product. The main target group of spirulina product marketing should consist of young and preferably well-educated consumers. The regions with the highest probability of a successful market launch of the products would therefore be, for example, university towns or large cities with a high level of education in the geographical south of Germany.

Bibliography

- Akal Food. (26 September 2020). About us – Akal Food is the species-appropriate spirulina from Germany. https://akalfood.de/info/uber-uns.html
- Bundesamt für Umwelt (German Federal Office for the Environment). (2019). Beitrag der Landwirtschaft zu den Treibhausgas-Emissionen. https://www.umweltbundesamt.de/daten/land-forstwirtschaft/beitrag-der-landwirtschaft-zu-den-treibhausgas#emissionen-aus-der-landwirtschaft-im-jahr-2017
- Costa, A. & Jongen, W. (2006). New insights into consumer-led food product development. Trends in Food Science & Technology, 17(8), 457–465. https://doi.org/10.1016/j.tifs.2006.02.003
- FAO. (2017). Building resilience for peace and food security. The state of food insecurity in the world: Vol. 2017. FAO.
- Grahl, S., Palanisamy, M., Strack, M., Meier-Dinkel, L., Toepfl, S. & Mörlein, D. (2018). Towards more sustainable meat alternatives: How technical parameters affect the sensory properties of extrusion products derived from soy and algae. Journal of Cleaner Production, 198, 962–971. https://doi.org/10.1016/j.jclepro.2018.07.041
- Grahl, S., Strack, M., Weinrich, R. & Mörlein, D. (2018). Consumer-Oriented Product Development: The Conceptualization of Novel Food Products Based on Spirulina (Arthrospira platensis) and Resulting Consumer Expectations. Journal of Food Quality, 2018, 1–11. https://doi.org/10.1155/2018/1919482
- Diraman, H., Koru, E. & Dibeklioglu, H. (2010). Fatty Acids in Spirulina, 2010.
- Lusk, J. L. & Hudson, D. (2004). Willingness-to-Pay Estimates and Their Relevance to Agribusiness Decision Making. Review of Agricultural Economics, 26(2), 152–169. https://doi.org/10.1111/j.1467-9353.2004.00168.x
- Siva Kiran, R. R., Madhu, G. M. & Satyanarayana, S. V. (2016). Spirulina in combating Protein Energy Malnutrition (PEM) and Protein Energy Wasting (PEW) – A review. https://doi.org/10.13140/RG.2.1.3149.0325
- SPIRULIX. (26 September 2020). SPIRULIX: Spirulina-Superfood aus Österreich. https://www.spirulix.at/
- Statistisches Bundesamt (German Federal Statistical Office). (14 July 2020). Haushalte und Haushaltsmitglieder für Deutschland, das frühere Bundesgebiet und die Neuen Länder einschließlich Berlin. https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Bevoelkerung/Haushalte-Familien/Tabellen/1-1-privathaushalte-haushaltsmitglieder.html
- Tress, A. (2015). Ein Vergleich der Ansätze zur Messung der individuellen Preisbereitschaft [E-Book]. Diplomica Verlag GmbH.
- Vigani, M., Parisi, C., Rodríguez-Cerezo, E., Barbosa, M. J., Sijtsma, L., Ploeg, M. & Enzing, C. (2015). Food and feed products from micro-algae: Market opportunities and challenges for the EU. Trends in Food Science & Technology, 42(1), 81–92. https://doi.org/10.1016/j.tifs.2014.12.004

DLG Expert report.
Knowledge for practice.

Food Technology

- DLG Expert report 2/2022
  Extrusion
- DLG Expert report 5/2019
  Predictive Maintenances
- DLG Expert report 14/2018
  Reduction Strategies for Fat, Sugar and Salt (Part 5)
- DLG Expert report 13/2018
  Reduction Strategies for Fat, Sugar and Salt (Part 4)
- DLG Expert report 5/2018
  Use of Pulsed Electric Fields (PEF) in the Food Industry

Sensory Evaluation

- DLG Expert report 4/2020
  Sensory evaluation: Contact-free, digital and online
- DLG Expert report 2/2020
  Practice guide for sensory panel training (Part 3)
- DLG Expert report 15/2018
  Sensory Evaluation 4.0
- DLG Expert report 12/2018
  Practice guide for sensory panel training (Part 2)
- DLG Expert report 11/2018
  Food Fraud

Food Chain

- DLG Expert report 2/2023
  Vertical Farming: Possible differences between raw materials from indoor and outdoor cultivation
- DLG Expert report 2/2021
  Data analytics
- DLG Expert report 1/2020
  Online trade with food and beverages – Success factors for greater quality and safety
- DLG Expert report 6/2019
  Blockchain in the Food Supply Chain
- DLG Expert report 6/2018
  Application of high pressure for structure modification of food and food ingredients

Download at www.DLG.org/en/expertreport

DLG e.V.
Competence Center Food
Eschborner Landstr. 122 · 60489 Frankfurt am Main · Germany
Tel. +49 69 24788-311 · Fax +49 69 24788-8311
FachzentrumLM@DLG.org · www.DLG.org