

Bioavailability of docosahexaenoic acid [22:6(n-3)] from regio- and enantio-pure triacylglycerols

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Introduction

Long-chain n-3 polyunsaturated fatty acids (PUFAs) play crucial roles in various physiological processes. Docosahexaenoic acid [DHA, 22:6(n-3)] is particularly essential for proper development and function of the brain and retina throughout life. The molecular structures of dietary lipid molecules delivering the n-3 PUFA likely influence the digestion and absorption of these valuable fatty acids (Yoshinaga et al., 2015). Currently, there is very limited knowledge on the regio- and stereospecific position of n-3 PUFAs in dietary lipids affects their bioavailability and metabolism.

Objectives

The objective is to improve the current understanding of the significance of positional distribution in TAG molecules for the bioavailability and metabolic fate of DHA. To reach this objective, we performed an animal feeding trial was performed and studied the FA composition in plasma, liver, brain, and visceral fat of rats after intervention feeding with regio- and enantiopure triacylglycerols (TAG) containing DHA in *sn*-1, 2, or 3 position and palmitic acid (16:0) in the remaining positions (Figure 1).

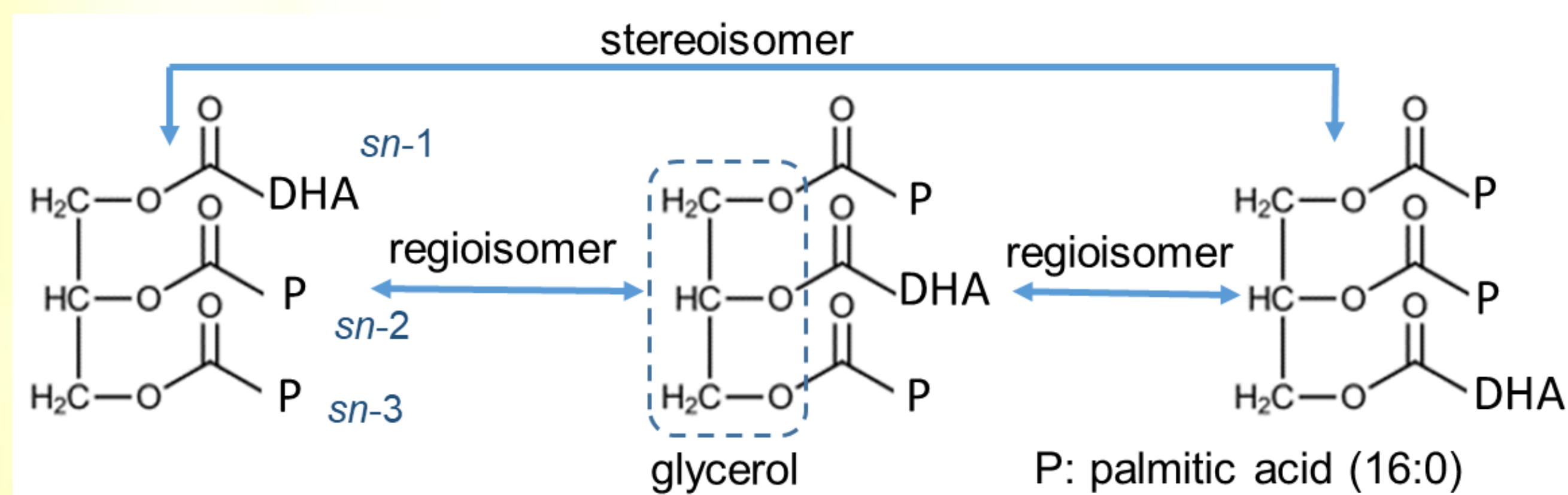


Figure 1. DHA-containing TAG regio- and stereoisomers used in this study

Study Design

Seventy-two male Sprague-Dawley rats (age 21 ± 2 days) were kept for 7 days in isolation at a constant temperature and humidity and on an adaptive feeding of the standard AIN-93G diet which contained soybean oil as a source of (n-3) FA. Thereafter, the rats were randomly divided into six experimental groups, 12 animals in each group receiving normal feed, n-3 deficient feed, or n-3 deficient feed supplemented with tripalmitate or DHA-containing TAGs (Table 1). In DHA groups (3-6), each rat received the structured TAG at a daily dosage of 500 mg /kg body weight, and the intervention feeding lasted for four weeks. At the end of feeding, the rats were executed after 12 hours of fasting, plasma and organs were collected and stored at -80 °C. The lipids were extracted using the modified Folch method (Folch et al., 1957), and the fatty acids were analysed as FAMES by gas chromatography (Linderborg et al., 2019). For plasma and liver, the lipids were fractionated into neutral lipid fraction rich in TAGs and polar lipid fraction rich in phospholipids (PL), thereafter, fatty acids were analysed from these fractions.

Table 1. Experiment groups and feeding treatments

Group number	Group name	Treatment feed
1	Normal feed group	AIN-93G ¹
2	n-3 FA deficiency group	AIN-93G contained peanut oil ²
3	Tripalmitin group	Tripalmitin + AIN-93G contained peanut oil
4	<i>sn</i> -1 DHA group	<i>sn</i> -1- DHA+ AIN-93G contained peanut oil
5	<i>sn</i> -2 DHA group	<i>sn</i> -2- DHA+ AIN-93G contained peanut oil
6	<i>sn</i> -3 DHA group	<i>sn</i> -3- DHA+ AIN-93G contained peanut oil

References

- Folch, J. et al. (1957). A simple method for the isolation and purification of total lipides from animal tissues. The Journal of Biological Chemistry. [https://doi.org/10.1016/s0021-9258\(18\)64849-5](https://doi.org/10.1016/s0021-9258(18)64849-5)
- Linderborg, K. M., et al. (2019). Bioavailability of docosahexaenoic acid 22:6(n-3) from enantiopure triacylglycerols and their regioisomeric counterpart in rats. Food Chemistry, 283(December 2018), 381–389.
- Yoshinaga, K., et al. (2015). Differential effects of triacylglycerol positional isomers containing n-3 series highly unsaturated fatty acids on lipid metabolism in C57BL/6J mice. Journal of Nutritional Biochemistry, 26(1), 57–63.

Results

The DHA groups showed significantly higher DHA content than the normal feed group in all the tissues and organs, except for the brain lipid. Intervention feeding with DHA located in the *sn*-1 position of TAGs resulted in a significantly higher content of DHA in the plasma TAG compared with feeding with *sn*-3 DHA, whereas in visceral fat, the DHA content was highest in the *sn*-3 group among all the three DHA-fed groups. There was a tendency towards a difference between the *sn*-1 DHA and *sn*-3 DHA groups regarding the DHA content in other organs, such as plasma PL and liver, although the difference did not reach statistical significance.

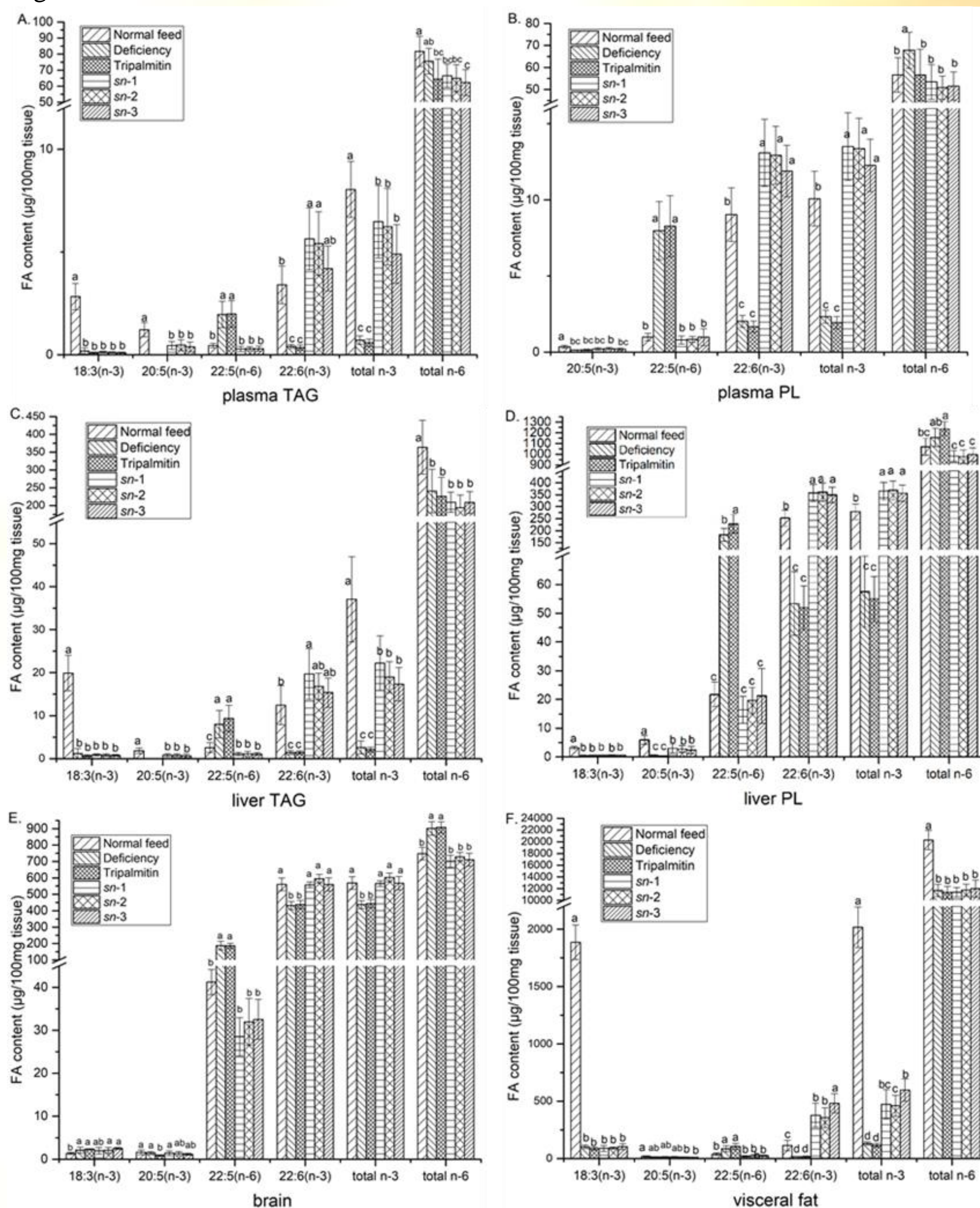


Figure 2: Content of n-3 and n-6 PUFAs in different tissues and organs. Bars labelled with different letters differ statistically ($p < 0.05$) among the groups.

Conclusion

The results of this study indicate possible differential tissue accumulation and metabolism of DHA from *sn*-1 and *sn*-3 positions of dietary triacylglycerols. Future studies with a longer intervention time could provide more evidence to confirm the findings of this study. This study also demonstrated that four-week n-3 deficient feeding reduced n-3 PUFA levels and increased the content of n-6 PUFAs in tissues and organs of rats in comparison with n-3 adequate feeding.

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