Dietary supplementation with buttermilk fat and krill oil concentrates phospholipids influence hippocampus synaptic signaling and mitochondrial function

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INTRODUCTION

Mitochondrial dysfunctions are pathological changes observed in various neurodegenerative diseases. Moreover, energetic state levels in brain tissue are influenced by mitochondrial biogenesis, which can be dramatically damaged during aging. In neurons, mitochondria perform various functions such as adenosine triphosphate (ATP) formation and reactive oxygen species (ROS) generation.

Mild cognitive impairment (MCI) is an intermediate state between normal cognitive aging and dementia, which does not have pharmacological alternatives for its prevention. Lipids such as phospholipids and omega-3 fatty acids are important in the sustainment of the nervous system. Nutritional strategies (e.g., through nutraceuticals) may be effective for the prevention and sustainment of the nervous system.

Here, two bioactive polar lipid concentrates (BPLCs) were studied: buttermilk fat concentrate (BMFC), rich in phospholipids including phosphatidylserine (PS) and sphingomyelin (SM), and krill oil concentrate (KOC), rich in phosphatidylcholine (PC) and long-chain fatty acids eicosapentaenoic acid and docosahexaenoic acid.

RESULTS

BPLCs ameliorate cellular energy states

BPLCs groups showed a statistically significant rise in ATP levels

Suggests improved energetic state in rat hippocampus cells

BPLCs increase mitochondrial biogenesis in BMFC+KOC

Increased expression of genes involved in the mitochondrial respiratory chain (MRC)

BMFC + KOC supplemented groups showed increased expression of proteins from all complexes

Improvement of cell energetic state appears to be, at least in part, mediated by an increase in mitochondrial biogenesis

BPLCs increase synaptic signaling in BMFC+KOC

Increased expression of Str1A gene levels were highly augmented in BMFC+KOC animals

Dag4, Dag2 & Dag3 with decreased expression in BMFC+KOC group

Vamp-2 was increased in all BPLC-supplemented animals

Suggests improved synapsis signaling

OBJECTIVE

To investigate mitochondrial biogenesis and synaptic signaling in the hippocampus of 18 month-old Wistar rats after a 3-month supplementation with BPLCs.

METHODS

18-month♂ Wistar rats, n=46

Randomized into 4 study groups

- 50 g standard diet (SD) + 70 mg refined olive oil n=11
- 50 g SD + 70 mg of BMFC n=12
- 50 g SD + 70 mg of KOC n=10
- 50 g SD + 70 mg of BMFC + 70 mg of KOC n=12

 METHODS

- Mitochondrial energy metabolism predisposed 384-well plate.
- Synaptotagmin gene expression
- Western blot assays
- ATP levels

Statistical analysis

The ANOVA method was used for gene expression analysis and fold-change values reported as 2−ΔΔCt. GAPDH was used for protein expression normalization or in the case of phospholipidic proteins their corresponding total form.

Data from independent samples from all experiments was compared by one-way ANOVA using Student’s t test for protein comparisons, p < 0.05 was considered significant. Results are presented as means ± SEM. Statistical analyses performed with GraphPad Prism 7.02 software (GraphPad Software, Inc., La Jolla, CA, USA).

CONCLUSIONS

- Dietary supplementation with both BPLCs favors an improvement in the energetic state of hippocampus cells, facilitating both mitochondrial and protein synthesis, which are necessary for synaptic plasticity.
- Increase in the expression of presynaptic genes and proteins points towards enhanced synapsis signaling.
- Dietary supplementation with BMFC + KOC could protect local protein synthesis and energy balance within dendrites, favoring neuronal health and delaying cognitive decline associated to age-related diseases.
- In summary, both BPLCs, especially in combination, ameliorate the energetic machinery and might be useful as part of a nutritional strategy to prevent MCI.

Acknowledgement

This work was financially supported by the Spanish Ministry of Science and Innovation from project AGL 2014-56464.