

PLANT-BASED MEAT ANALOGUES (SEITAN/TOFU) CAUSE IMPAIRED DIGESTION, OXIDATIVE STRESS & INFLAMMATION IN WISTAR RATS

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I. INTRODUCTION

Certain plant-based foods, commonly known as vegan products, are typically produced from isolated proteins from soy beans (e.g. tofu) and cereals (e.g. wheat gluten/seitan) [1]. In an undeniable scenario of a global campaign against meat consumption, supporters of vegan foods encourage the consumption of these products claiming health benefits. Yet, a recent report from the Food & Agriculture Organization (FAO) [2] emphasises the relevant role of animal-source foods on human nutrition and health. Since the impact of vegan foods on health has been poorly investigated, we performed an *in vivo* study to assess the effect of dietary tofu and seitan (wheat gluten) on protein digestibility and gut health. The results were compared with those obtained for red meat (beef sirloin).

II. MATERIALS AND METHODS

Twenty-one Wistar rats were used in the present study (approved by an Animal Experimentation Ethical panel from the University of Extremadura; process nº EXP-20200904). Three high-protein diets (30%) differing in protein source (beef vs. plants) were supplied for 10 weeks to rats (n=7 in each group). Beef, seitan and tofu groups (B, S and T, respectively), received experimental chows formulated with cooked beef sirloin, gluten wheat (seitan) and tofu, respectively. All diets were isocaloric and isoproteinic and no effects of diet on feed/water consumption was observed during the assay. At the end of the experimental period, the rats were euthanized by exsanguination via cardiac puncture under 5% isoflurane and the entire gastrointestinal tract was aseptically sampled. The intraluminal material was gently removed and properly stored. Tissues were gently clean with PBS and stored at -80°C until analyses were performed. Pieces of each compartment were stored in 10% formalin for microscopic analysis. Total true protein digestibility was calculated according to McDonough *et al.* [3] Tissue oxidative stress was assessed through quantification of lipid and protein carbonyls and protein aggregates. Inflammation was analysed via microscopic measurement of size (diameter) of Peyer patches in small intestine and colon. SPSS Statistics version 27.0 was used for data analysis.

III. RESULTS AND DISCUSSION

The study of the total true digestibility (Fig. 1A) of the three proteins assessed *in vivo*, reveals that beef proteins were more effectively digested than proteins from plant-based products (98% vs 93-92%). The animal protein was mainly digested in the stomach (>70%) while 50% of tofu protein and 76% of seitan protein moved to the small intestine undigested (Fig. 1B). In duodenum, seitan proteins were intensively digested while nearly 40% of dietary tofu proteins arrived undigested to the colonic stage. In cecum and colon, a share of dietary proteins was eventually fermented with tofu being the dietary protein suffering a more intense degradation at this stage. These results may not only have consequences in terms of nutritional value, but the fermentation of undigested proteins also leads to dysbiosis and production of different metabolites, with some of them having proadipogenic/inflammatory/pro-oxidative potential (unpublished data). The different digestibility of animal/plant proteins may be related to the structure and amino acid composition as well as the extent of oxidation. It is worth emphasizing that both vegan products are recognized UPF and the extent of

oxidation and protein aggregation in these foods is higher than in beef (data not shown) which could hamper *in vivo* digestion. The analysis of oxidative stress in the intestine of rats revealed that most of the damage was observed in the colon and plant proteins from UPF, particularly seitan, led to the highest extents of carbonyl stress.

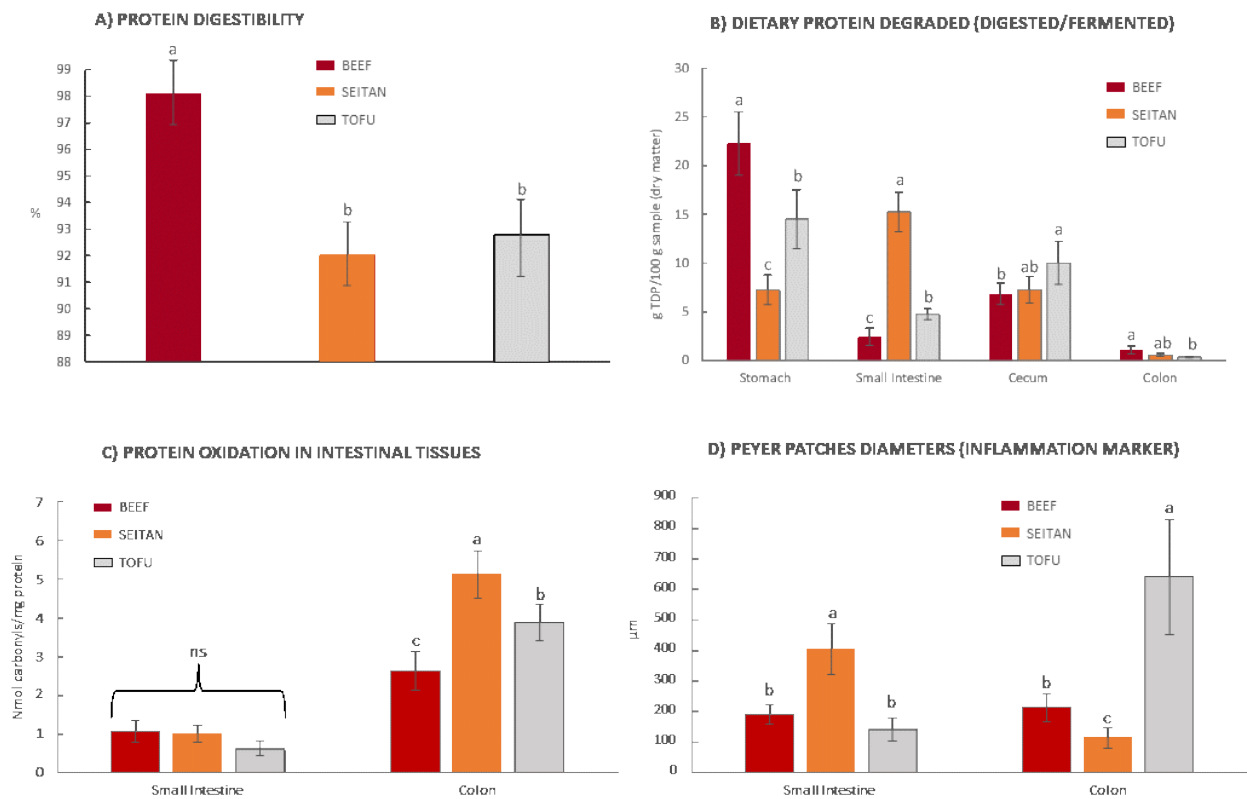


Figure 1. A) Total protein digestibility; B) Dietary protein degraded at different digestion stages; C) Protein oxidation in small intestine and colon and D) Diameter of Peyer Patches as indicator of inflammation. Letters on top of bars denoted $p < 0.05$ between dietary proteins/experimental groups.

The severe inflammation caused by wheat gluten in small intestine (Fig. 1D) is compatible with the recognized allergenicity of this protein and the onset of coeliac disease at this particular location. Inversely, the colon of rats fed with tofu had the largest Peyer patches indicating local inflammation at this location, where intense protein fermentation of from this vegan product occurred.

IV. CONCLUSION

The results from the present study show than the health claim of “vegan foods” as generally healthy is scientifically misleading and commercially deceitful. These results could contribute to explaining the recent report by WHO in which these vegan UPF are linked chronic diseases [2].

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