

0.05). PP and LD had no laxative effect. Nevertheless, these two fibres modified stool composition by increasing water content: $78.4 \pm 2.1\%$ (PP) and $76.8 \pm 1.9\%$ (LD) vs $68.5 \pm 2.6\%$ (Cel), $P < 0.05$. Neither EC nor PP changed OFTT, whereas LD increased it (96.6 ± 19.8 h vs 64.9 ± 15.3 h, $P = 0.016$), which could be due to its high viscosity.

In conclusion, the fibres isolated from dietary seaweeds exert digestive effects which depend on their physico-chemical and fermentative properties. Among the tested fibres, EC appears as an efficient laxative well accepted by the subjects.

Colo-ileal reflexes modulate terminal ileum motility in pig. G Cuche, CH Malbert (*Inra, station de recherches porcines, 35590 Saint Gilles, France*).

The terminal ileum exhibits typical motor patterns, Discrete Clustered Contractions (DCC) and Prolonged Propagated Contractions (PPC), induced by ileal infusion of caeco-colonic compounds [Kruis et al (1985), *Am J Physiol* 249, G264-270; Kamath et al (1987), *Am J Physiol* 253, G427-433]. The aim of this study was to evaluate: *i*) the possible reflux of colonic contents in the terminal ileum; *ii*) the relationship between these reflexes and ileal motor events.

In four conscious pigs, the motility of the terminal ileum was evaluated using three strain gauges sutured 15, 10 and 5 cm proximal to the ileocecal sphincter (ICS). The ileal pH, used as an indicator of coloileal reflexes [Roger et al (1990), *J Gastrointest Motil* 2, 224-229], was continuously measured 5 and 10 cm proximal to the ICS.

During interdigestive and postprandial periods, frequent pH dips were recorded. 82% of these dips were detected successively by the two pH probes. Their frequency (8 ± 0.5 vs 6 ± 0.4 h⁻¹; interdigestive vs postprandial, $P < 0.05$), duration ($262 \pm$

12.7 vs 356 ± 27.0 sec, $P < 0.05$), but not amplitude (0.6 ± 0.02 vs 0.6 ± 0.03 pH, NS) were modified by feeding. The frequency of DCC increased during pH dips (0.6 ± 0.18 vs 1.6 ± 0.15 contraction.min⁻¹, $P < 0.05$). The onsets of 46% of the dips were preceded by more frequent retrograde contractions. On the contrary, while pH went back to basal level, contractions were mainly aborally propagated. About half of PPC occurred 6 ± 0.9 sec before the end of the pH decrease. The amplitude (0.4 ± 0.06 pH) and duration (118 ± 26.0 sec) of pH dips associated with PPC were reduced compared to those not temporally related to pH dips ($P < 0.05$).

In conclusion, the last 10 cm of the ileum are periodically invaded by caecocolonic fluids. These acidic reflexes are temporally related to ileal motility.

Systemic and mucosal immune responses after oral administration of bovine lactoferrin in mice. H Debbabi, M Dubarry, M Rautureau, D Tomé (*Unité Inra de nutrition humaine et de physiologie intestinale, INA-PG, 16, rue Claude Bernard, 75005 Paris, France*).

Lactoferrin (Lf) is an ironbinding glycoprotein presents in milk, in different external secretions, and in specific secondary granules of neutrophils. Bovine Lf has been shown to have bacteriostatic and immune functions. As Lf acts also as an oral antigen, we have studied the systemic and mucosal immune responses after oral administration of bovine Lf in mice.

Three groups of mice were force-fed during 4 weeks with either: 1 mg/day (Lf1), 20 mg/day (Lf20) of bovine Lf or water (T) as control. The humoral immune response was determined in mucosal secretions and in sera. IgA and IgG productions and IL 2 and IL-5 secretions by B lymphocytes and T helper lymphocytes respectively were mea-

sured after specific (Lf) or polyclonal stimulation of Peyer's patches cells and splenocytes.

The uptake of Lf induces both a stimulation of total IgA, IL-2 and IL-5 productions and a stimulation of IL-2 and IL-5 secretions by Peyer's patches cells and splenocytes respectively. Increasing level of anti-Lf IgA and to a lesser extent IgG antibodies production was observed in intestinal secretions during the 4 weeks of feeding. In sera, the mice have developed an IgG specific response. These effects on the immune system are corroborated by the dose-dependent proliferation response of the same cells.

In conclusion, the ingestion of bovine Lf with low digestibility in the mice induces a mucosal immune response which probably acts in preventing its systemic absorption.

Energy expenditure during heavy sustained exercise. P Ritz¹, N Fellmann², P Rousset¹, J Ribeyre², A Chamoux², B Beaufrère¹, J Coudert² (¹Laboratoire de nutrition humaine; ²Laboratoire de biologie et de physiologie du sport; ^{1,2}CRNH-Auvergne, Clermont-Ferrand, France).

Adequate energy (EI) and water intakes are key conditions for physical performance. Whereas EI measurements are often biased, the doubly labelled water (DLW) method is the only method for the measurement of total energy expenditure (TEE) and water fluxes that does not interfere with physical exercise. Energy expended during exercise can be estimated from heart rate (HR) recordings, the relationship HR-VO₂ having been calibrated during the assessment of VO_{2max}. The aim of this study was to measure energy and water needs during a 7-day endurance raid.

Nine subjects (42.1 ± 7.8 year, mean ± SD) engaged in a triathlon of 595 km and 13 100 m cumulative gain in altitude. On

day 1 they drank a DLW dose (150 mg/kg ²H and ¹⁸O). Saliva/urine samples were collected before, 4, 5, and 6 h after the dose (for total body water estimates, TBW) then daily till day 7 (for measurement of isotope rate constants). TBW was measured again on day 8. HR monitoring was performed during each exercise session with portable HR monitors, and transformed into VO₂ to calculate energy expended during exercise, and relative exercise intensity (% of VO_{2max}).

Time spent on exercise varied between 622 ± 43 min (day 1) and 521 ± 16 min (day 7). Relative intensity of exercise decreased between day 1 (57.6 ± 5.0% of VO_{2max}) and day 7 (47.4 ± 5.1%, *P* < 0.001). TBW increased by 4.1 ± 2.0 L (day 1 to day 7, *P* < 0.001) although body weight was kept constant (68.4 ± 6.5 kg day 1, 68.1 ± 6.8 kg day 7). Water outflow rate (skin, respiratory and urine losses) was 6.44 ± 0.89 L/day. Mean energy expended daily during exercise was 16.9 ± 1.4 MJ/day. TEE was 32.1 ± 4.6 MJ/day, ie, 561 ± 44 kJ/kg lean body mass.

In conclusion, heavy sustained exercise is accompanied by a TEE almost three times as high as sedentary subjects. Water retention observed in the present study suggests a massive energy deficit.

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Comparison of methods for determining energy expenditure of elderly people in free-living conditions. B Morio, P Ritz, E Verdier, C Montaurier, Y Boirie, B Beaufrère, M Vermorel (*Inra, laboratoire de nutrition humaine, centre de recherche en nutrition humaine, 58, rue Montalembert, BP 321, 63009 Clermont Ferrand cedex 1, France*).

The aim of the study was to compare three methods available to determine daily energy