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Consensus recommendations on the effects and benefits of fibre in clinical practice

Rémy Meier[a], Miquel A. Gassull[b,*]

[a]*Kantonsspital, Liestal, Switzerland*
[b]*Hospital Germans Trias i Pujol, Badalona, Spain*

The consensus meeting generally agreed that:

- Dietary fibre is generally accepted as an important part of a healthy diet. There is convincing evidence to support the general consensus that fibre-rich diets—those rich in fruit, vegetables and whole grains—are generally beneficial to health. These benefits may not necessarily be due to fibre per se, but may reflect the fact that such diets tend to be rich in vitamins, minerals, antioxidants and other phytochemicals and are low in energy-dense nutrients. A fibre-rich diet may also reflect an otherwise healthy lifestyle. This view represents the basis for the advice contained in national dietary guidelines—that people should obtain an adequate intake of dietary fibre. Although there are problems with the methodology in measuring the contents of fibre in different foodstuffs, the recommended figures for fibre intake are more than 20 g non-starch polysaccharides (NSP) or more than 25 g of dietary fibre (FAO and WHO).
- Since the definition of fibre according to its physiological properties and as functional fibre no longer stands, fibre should be chemically defined.
- Dietary fibre has beneficial effects upon intestinal function, and should be included in the diet of all patients at least to the same extent as recommended for the general healthy population, if there are no contraindications.
- For epidemiological and clinical studies, uniform definitions of fibre have to be used. In epidemiological studies fibre intake has to be assessed by adequate and uniform methods. For clinical studies it has always to be considered that fibre has specific effects on metabolic and on gastrointestinal function. For specific diseases, the optimal fibre has to be chosen on the basis of their chemical, physical and physiological properties.

Many specific health claims have been made regarding fibre. The following sections provide a consensus view based on current available evidence of the benefits that may be obtained from an adequate intake of fibre in normal food or specific supplementations in relation to:

I. Inflammatory bowel disease (Crohn's disease, ulcerative colitis and pouchitis)
II. Constipation, diarrhoea and irritable bowel syndrome
III. Prevention of colorectal cancer
IV. Metabolic effects
V. The use of fibre in enteral nutrition

*Corresponding author.
E-mail addresses: remy.meier@ksli.ch (R. Meier), mgassull@ns.hugtip.scs.es (M.A. Gassull).

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Inflammatory bowel disease

Rationale for using fibre in inflammatory bowel diseases (IBD)

The oligo-polysaccharide components of fibre are fermented, in different degrees, by colonic anaerobic bacteria. This process induces, at least, two relevant effects in the luminal environment of the colon: a decrease in pH and the production of short-chain fatty acids (SCFA): acetate, propionate and butyrate.

Butyrate is the preferred energy substrate for the colonocytes. Oxidation of butyrate produces acetyl-Co-A, which is involved in numerous metabolic pathways in the cell, among them synthesis of cholesterol and phospholipids, important elements of cell membranes, as well as mucus synthesis. Deficient butyrate oxidation has been described in ulcerative colitis (UC) in vivo, which has been attributed to the presence of an excessive number of sulphate reducing bacteria in the colon in this condition. This may jeopardise the important acetyl-Co-A-dependent metabolic pathways inducing changes in cell membrane structure and in mucus which might favour the triggering and perpetuation of the inflammatory process. Moreover, butyrate has been shown experimentally to exert immunomodulatory effects via the inhibition of the activation of transcription factor NF-κB.

Decreasing luminal pH in the colon may induce changes in microflora, and has been shown experimentally that adding some highly fermentable oligosaccharides to a fermentation system with human luminal colonic contents and faeces increases the number of colonies of Lactobacilli and Bifidobacteria and decreases those of Clostridia and Bacteroides. There are no convincing published studies of other polysaccharides (except inulin) having prebiotic properties.

Evidence

Only few clinical data are available on the potential therapeutic effect of fibre in active ulcerative colitis and maintenance treatment. In most the fermentation-derived metabolite butyrate has been used as the administered major component. Butyrate has been administered intra-rectally in active distal colitis (and also in radiation proctitis) in short series of patients with promising results. Orally administered fibre-polysaccharides have only been administered in two studies: as treatment of active inflammation of the ileo-anal pouch (pouchitis) and as remission maintenance treatment in UC.

Inulin is the only polysaccharide tested in active inflammatory bowel conditions. It showed a significant decrease of intracolonic pH, significant increase of the concentration of butyrate and a significant decrease of the number of colonies of both total Bacteroides and *Bacteroides fragilis* as compared to placebo. This was shown over 3 weeks in a cross-over design in a group of patients with pouchitis, most of them after colectomy for severe UC. The results showed a significant improvement in disease, endoscopic and histological activity indices when inulin was given (**Level of evidence II**).

Plantago ovata has been shown in a multicentre, randomised, 5-ASA controlled study to be as effective as 5-ASA (usual treatment), and both treatments together in maintaining UC in remission during 1 year (**Level of evidence II**).

So far, on the basis of the actual knowledge, there is no evidence that fibre has any positive effect in Crohn's disease. This may be due to the fact that most of the known potential therapeutic effects are related to the fermentation process, which mainly takes place in the colon and very rarely in the small intestine. However, to our knowledge, no extensive data regarding the fermentation process in colonic Crohn's are available.

What kind of fibre should be used?

Only trials using inulin in pouchitis and *P. ovata* as maintenance treatments in ulcerative colitis have been published, both showing significant clinical benefits. It is difficult to extrapolate this concept to that of fermentable fibres, because the metabolites produced may vary according to the substrate given and it is not always butyrate. This may be influenced by excessive presence of S and N compounds because of excessive sulphate reducing bacteria or excessive ingestion, respectively. There are also no data related to the effect of this unbalanced bacteria in the intestinal lumen on the effectiveness of the fermentation process and the production of butyrate. The fermentation rate along the colon is also of importance. UC is often a distal colon disease and a highly fermentable fibre can be fermented in the cecum but cannot reach the inflammed areas (this may also apply to inulin).

Recommendation for using fibre in UC

Although many experimental data suggest a role of a deficient fibre polysaccharides-metabolite oxidation and production in the large bowel in the

pathogenesis of colon inflammation, there is not enough evidence to support it.

The preliminary Japanese data on fermented barley, the inulin role in pouchitis and even the role of *P. ovata* in the maintenance treatment of UC, although the strongest in the literature, need further confirmation (**Recommendation B**).

Contraindications for using fibre in IBD

The major contraindication for the use of fibre in IBD is the presence of strictures and fistulae, due to the possibility of mechanic complications. Avoiding of coarse and poorly fermented fibre is mandatory in this situation. Easy fermentable fibre could be considered safer; however, the production of large quantities of gas proximally to a stricture may induce at least very uncomfortable symptoms to the patient. There is no data to give evidence-based recommendations in this subject.

In active UC poorly fermentable fibre could even increase diarrhoea, although data supporting this assumption are lacking.

Areas for future research

With the data published so far, research on fibre and IBD should focus on the following:

- Optimising the fermentation process in order to obtain the desirable rate of butyrate production and maintenance of low pH along all segments of the colon.
- Minimising the action of substrates limiting the synthesis of butyrate, S and N by decreasing the activity of sulphate-reducing bacteria and diminishing the sources of N-compounds.
- Evaluating the beneficial synergistic effects of fibre-poly/oligosaccharides and probiotic bacteria (synbiotic effect) on colonic inflammation.
- Exploring the synbiotic effect in inflammation of the small intestine.

Constipation, diarrhoea and irritable bowel syndrome

Rationale for using fibre in intestinal diseases

It is well established that dietary fibre reaches the large intestine and exerts specific effects: some type of fibre have more bulking effects and others are more fermented. The fermentation process increases SCFAs, H_2, CO_2 and biomass. The rate of fermentation depends on the physico–chemical properties of the fibre. The physiological consequences of fermentation are diverse and several have important implications for human diseases. The specific effects of fibre in the large bowel were the rational for using fibres in large bowel disorders.

Evidence

Resistant starch shows some of the attributes of non-starch polysaccharides in that it provides substrates for fermentation with the production of SCFA and other consequences. Resistant starch increases stool weight on average by 1.5 g/g resistant starch fed and is less effective than raw bran (7.2 g/g fibre fed), fruit and vegetables (6.0 g/g fibre fed) (**Level of evidence I**).

On the other hand, fermentable fibre increase SCFA and these can increase colonic sodium and water absorption. Soy polysaccharides showed some beneficial effects in children with acute and antibiotic induced diarrhoea. Furthermore, oral rehydration solution with partially hydrolysed guar gum (PHGG) and also starch reaching the colon showed beneficial effects in children with acute and chronic diarrhoea or in patients with cholera (**Level of evidence I**).

What kind of fibre should be used?

Several dietary fibres increase stool weight. Raw bran, fruit and vegetables are more effective than cooked bran, psyllium, oats, gums and mucilages. Soy polysaccharides and pectin have only a weak effect. It has to be considered, that within each group of fibre, there is a great variability in changing stool weight.

The variability is due in part to the inherent difference in individual responses and to varying experimental designs, and the fact that in some studies uncontrolled diets were used. A major problem is lack of consistency in methodology for measurement of dietary fibre. Around 20 different methods were used in those studies.

Recommendation for using fibre in intestinal diseases

Constipation

Constipation is a symptom/syndrome rather than a disease. Different patient groups exist and may have different needs, but there is not enough evidence in RCT for recommendations. The populations include slow transit constipation, outlet obstruction, and

treatment related constipation (e.g. opiates in cancer patients). At present, the evidence is insufficient to suggest guidelines for treatment of constipation in the different groups of patients.

Overall, there is convincing data to show that fibre results in a modest increase in bowel movement frequency (on average plus 1.4–1.5 bowel movements per week) (**Recommendation A**).

Fibres improve symptoms such as pain and stool consistency, but there are no long-term data available. In regard to which fibre sources are most effective, there are insufficient data available to make evidence-based recommendations. Increase in stool weight and altered transit times may not fully reflect symptom relief and patient satisfaction. Patient's tolerance of fibres (particularly in regard to the amount/volume of fibre) is important.

Dietary fibre (raw bran, fruit and vegetables) is of potential benefit in many circumstances, and is often used in self-care. There are numerous data, but most are from uncontrolled studies and thus not applicable to evidence based guidelines. Lifestyle factors, patient's preferences and tolerance of fibre are important facts to consider.

Diarrhoea

There are problems in regard to definition and quantification of diarrhoea—the opinions differ from patients to nurses, doctors and relatives. A common physiological definition would be based on daily stool weight exceeding 200 g. Clinical definitions would reflect a change in consistency and frequency. Diarrhoea is commonly regarded as more than three loose stools per day. There are not enough data to say which types of fibre might be of benefit in different types of diarrhoea.

Owing to the lack of data, no specific recommendations about the benefit of fibre in diarrhoea can be given in general. The only data available regarding a beneficial effect of fibre on diarrhoea are those showing a significant effect of PHGG and resistant starch in an oral rehydration solution in children with acute and chronic diarrhoea and in patients with cholera (**Recommendation A**).

Irritable bowel syndrome (IBS)

Fibre is generally recommended in IBS, but there is little evidence to support its use. Patients with predominant constipation may benefit, although data supporting its use are mostly on bowel frequency and not on bloating or pain relief. There is a lack of long-term data.

Overall, therefore, the benefits of fibre in patients with irritable bowel syndrome are unproven despite many trials. Some of these patients may benefit from fibre; however side-effects (e.g. bloating) may override its benefits. Some fibre sources (e.g. PHGG) may be better tolerated than others, but there are insufficient data on which to make recommendations.

Contraindications of using fibre

There are no real contraindication to use dietary fibre and functional fibre in constipation and irritable bowel syndrome. To overcome bloating and flatulence as a fermentation consequence, it has been suggested that the co-administration of probiotics can be helpful, but there are no data available so far to recommend this.

Areas for future research

- There appears to be paucity of research into treatment of constipation. Future trials are required comparing different dietary fibre and additional fibre (e.g. PHGG) alone or in combination with probiotics to assess clinical effectiveness and cost-effectiveness.
- The efficacy of PHGG and resistant starch should be investigated in acute and chronic diarrhoea in combination with probiotics.
- For all kind of irritable bowel syndrome the combination of different pre- and probiotics seems to be a reasonable approach for future research. These trials should be placebo-controlled and lasting at least 12 weeks with a control period of 4 weeks after treatment stop.

Prevention of colorectal cancer

Rationale to consider an anti-carcinogenic effect of fibre

The physical effects of fibre on stool mass and transit time were considered for many years as the preventive mechanism of colorectal cancer. The actual knowledge suggests that this claimed effect could be achieved through the metabolites produced by the action of bacteria on the complex carbohydrates reaching the colon. The best-studied anti-neoplastic effect of these metabolites is that of butyrate. This compound interacts with mutated APC, modulates p53 (both suppressor genes), inhibits the activity of the transcription factors (such as NF-κB) controlling cell division and decreases the apoptotic rate, probably by modulating the activity of caspases. Hence, butyrate gives the immature cells a survival advantage.

Evidence

A metanalysis pooling the data of the results of the best 13 case–control studies provided substantive evidence that the intake of fibre-rich foods was inversely correlated to the risk of cancer of both colon and rectum. It was estimated that the risk of colorectal cancer in the US population could be reduced by 31% with increasing and average of 13 g/day in fibre intake from food sources (**Level of evidence I**).

The relationship of fibre intake to colon cancer is the subject of ongoing investigation and currently unresolved. In fact, various cohort studies showed conflicting results, but the large European Prospective Investigation into Cancer and Nutrition (EPIC study) has clearly shown that dietary fibre in food inversely correlated to the incidence of large bowel cancer: the protective effect was higher for the left side of the colon and lower for the rectum (**Level of evidence I**).

Polyp recurrence intervention trials using fibre over 3–4 years failed to show any significant effect. However, the type and source of fibre in the diet was not fully evaluated in these studies. In addition, and of utmost importance, these intervention studies were performed in high-risk populations who had already developed adenomas, i.e. precursors of cancer.

What kind of fibre should be used?

In view of the poor experimental evidences, no specific recommendations can be given in order to prevent colorectal cancer. In this sense it is worthwhile to consider the findings of the EPIC study, which has shown that the total intake of fibre-rich foods inversely correlated to the incidence of large bowel cancer. No source of fibre was significantly more protective than another. Fruits and soluble fibre showed a modest effect on distal colonic adenoma formation, but this effect could not be demonstrated with cereals, vegetables and non-soluble fibre.

Recommendations for using fibre for the prevention of colorectal cancer

The review of controlled clinical trials reveals that the role of dietary fibre as an anti-carcinogenic agent is, at best equivocal. This is due to the fact that many studies show important methodological problems (mainly difficulties with the food frequency questionnaires, quantitative and qualitative heterogeneity in the dietary intakes, and lack of prospective data).

When considering recommendations it has to be taken into account whether the intervention is in a high-risk individual. An individual that has already developed large adenomas in the colon has a high risk of developing cancer because genetic mutations may have already taken place and the effect of major changes in the diet on adenoma development may need longer than 5–19 years to show-up. However, major recommendations in the diet early in life might be beneficial in the future. In fact the intake of high fibre diet is recommended from childhood onwards in the general population. It is advised to consume preferentially fibre-rich foods like vegetables, fruits and whole grains. These may also include other protective substances. In addition it has to be considered that fibre is not an isolated substrate within the diet and the diet is also related to lifestyle.

Contraindications of using fibre in the prevention of colorectal cancer

There are no contraindications for a fibre rich diet for primary or secondary prevention of adenoma and colorectal cancer. There is no evidence against the use of high fibre diet in childhood.

Areas for future research for the use of fibre in colorectal cancer prevention

- The adenoma-carcinoma sequence provides a unique human model for studying the potential anti-proliferative effects of fibre. These studies should have, at least, an observational period between 5 and 10 years, because of the prolonged interval between early adenoma formation and carcinoma (about 10 years).
- There is an important need to incorporate early pre-neoplastic markers in the fibre-cancer-intervention studies.
- Future studies should incorporate the evaluation of the potential synergistic anti-carcinogenic effect of fibre, other nutrients and some drugs.

Metabolic effects

Rationale for using fibre for metabolic control

The ingestion of certain types of fibre (i.e. viscous fibre) can have a mild cholesterol-lowering effect, which is attributable to the increased viscosity of intestinal contents slowing ileal bile acid uptake and enhancing fecal bile acid loss, thus promoting hepatic cholesterol catabolism. The increased

viscosity of chyme also reduces the rate of intestinal glucose uptake and subsequent insulin response.

Soluble (viscous) fibre (guar gum, pectin, psyllium) has a cholesterol-lowering effect in both healthy and hyperlipidaemic subjects. According to one limited meta-analysis, for each 1 g of soluble fibre added to the diet, total cholesterol is lowered by 0.045 mmol/l and LDL-cholesterol is lowered by 0.057 mmol/l. Others have shown greater effects. There is no significant effect on HDL-cholesterol or triglycerides. For other sources of soluble fibre (e.g. fructo-oligosaccharides) there is a lack of consistent evidence for effects on blood lipids. Insoluble fibre (wheat bran, cellulose) has no effect on blood cholesterol.

In short-term randomised feeding trials, guar gum, pectin, and the laxative fibre psyllium reduce blood glucose levels by 29–44%. Slowing starch digestion or modifying other factors such as lipid and protein content of the meal and thus slowing gastric emptying reduces the postprandial glycaemic and insulin responses. However, there is only limited evidence of long-term improvement of metabolic control of diabetes with high fibre intakes.

Evidence of a protective against coronary heart disease and diabetes

Meta-analyses of prospective observational studies suggest a protective effect of dietary fibre and/or whole grain cereals against coronary heart disease (**level of evidence III**). On the other hand, refined cereals lack a protective effect.

Pooled data from prospective studies suggests that dietary fibre and/or whole grain cereals may have a protective effect against type 2 diabetes (**level of evidence III**). Fruit and vegetables, nuts, legumes, and plant-based diets in general have a similar beneficial effect in cohort studies.

There is a need for randomised clinical trials to confirm the protective effects of high-fibre diets.

What kind of fibre should be used?

The distinction between soluble and insoluble fibre may not be helpful. Physical characteristics, including viscosity may be more worthwhile together with the digestion characteristics of the whole food. However, as mentioned above, to assess purity, it is recommended to address dietary carbohydrates by their chemical structure.

Recommendations to the general public should be based on a prudent, vegetable-rich diet. At present this best sums up our knowledge of the topic.

Recommendation for using fibre in cardiovascular protection

Regular intake of viscous fibre or psyllium shows beneficial effects on blood cholesterol, LDL-cholesterol and reduces postprandial glucose levels and insulin response. (**Recommendation A**)

Viscous fibres have demonstrated benefits in lipid metabolism and glycaemic control; nevertheless, there are no data from randomised controlled trials with hard end points to indicate a clear benefit in terms of prevention of CHD and diabetes.

Regular fibre intake has shown beneficial effects on CHD, but fibre is only one factor of many dietary components, which affect the risk. (**Recommendation A**)

Contraindications for adding fibre to the diet

There are no contraindications for using fibre to further the beneficial effects of healthy diets. In diabetic patients, long-term studies using soluble fibre may be associated with a number of problems of acceptability, dose, and side effects.

Areas for future research

- Short-term studies in acute critically ill patients using different soluble (viscous) fibre in enteral nutrition to control hyperglycaemia looking on morbidity and mortality should be done (see also chapter V).
- Long-term studies in enterally fed, insulin dependent patients using different types of fibre to control blood glucose levels, insulin and lipids on long-term complications (e.g. micro- and macrovascular diseases) would be important.
- Clearly defined fibre should be used in long-term studies using hard endpoints (e.g. prevention of acute coronary heart disease or re-infarction rates).

The use of fibre in enteral nutrition

Rationale for using fibre in enteral nutrition

Feeding the gut to maintain gut physiology, improving gastrointestinal tolerance (e.g. prevention of diarrhoea) and glycaemic control in glucose intolerant patients should be the major endpoints.

In acute disease, the use of fermentable fibre would appear to be the best way to achieve this. Chronic patients requiring long-term enteral nutrition may also need bulking fibre to maintain normal bowel function (e.g. preventing constipation).

Thus, some kind of fibre should be provided to most (if not all) patients receiving enteral nutrition, but the fibre need to pass the enteral tubes without blocking.

Evidence

The available clinical studies using fibre in enteral nutrition have yielded divergent results.

There is evidence that:

- PHGG is effective in reducing enteral nutrition associated diarrhoea in patients after surgery and in critically ill-patients (**Level of evidence I**).
- Soy polysaccharides, or soy polysaccharide combined with oat fibre are effective to increase daily stool weight and frequency in individuals on enteral feedings, but the effect of fibre was studied in small group of patients during short periods (**Level of evidence III**).
- Supplementation of soy polysaccharides (20–30 g/l in enteral solution) showed a significant increase in stool weight during one year of enteral feeding in 11 patients (**Level of evidence III**).

What kind of fibre should be used?

For enteral nutrition in acute illness (intensive care, perioperatively) fermentable fibre (e.g. PHGG) can be recommended. Hydrolysis appears to be a *conditio sine qua non* for incorporating fibre into enteral formulas. This process alters the fibre in the way that some of its properties are lost (particularly viscosity and bulking effects) but they are still fermented (e.g. PHGG).

For patients with chronic illness requiring long-term enteral nutrition, both non-fermentable fibre (bulking fibre, e.g. soy polysaccharide) and fermentable fibre (e.g. PHGG) may be appropriate.

Recommendation for using fibre in enteral nutrition

To prevent enteral nutrition induced diarrhoea in post surgical- and in critical ill-patients supplementing enteral nutrition with PHGG is effective (**Recommendation A**).

Fermentable and viscous fibres (e.g. oat β-glucan) are effective for glycaemic control, but the available studies make it difficult to ascertain to what extent fibre supplementation contributes to the beneficial effects of the diabetes formulas (**No recommendation**).

Short-term studies showed that soy polysaccharides or soy polysaccharides combined with oat fibre, increased daily stool weight and frequency. There is only one pilot study showing a beneficial effect of adding soy polysaccharides to control bowel habits in patients on long-term enteral feeding (**Recommendation C**).

Contraindications for adding fibre to enteral nutrition

Contraindications for adding fibre to enteral nutrition include intestinal or colonic strictures (e.g. IBD), fistulae (liquid fibre could be used, but there is no data on this topic) and gastroparesis (except when post pyloric access could be reached). However, the level of evidence for this recommendation is poor.

Areas for future research

- Future research should seek to confirm that including fibre in enteral nutrition is beneficial for gut function. Work should also be directed at identifying the best type of fibre for different conditions, for instance in the ICU (trauma, burns, sepsis and surgery) for specific diseases (gastrointestinal disease, cancer, diabetes) and for long-term use.
- Additional work should also explore the synergistic effects of fibre/pre- and probiotics. It is suggested that the effect of individual fibre preparation should be tested in each condition. This would allow better definition of the optimal fibre mixture to be used in future enteral formulas.
- There is need for larger trials with clinical relevant primary end-points; both in short-term enteral nutrition in acute patients and in long-term conditions.

Consensus conference panel

Chairmen

Rémy Meier
University Hospital, Liestal (*Switzerland*)
Miquel Angel Gassull
Hospital Germans Trias I Pujol, Badalona (Spain)

Lecturers

Ingvar Bosaeus
Sahlgrenska University Hospital, Gothenburg (*Sweden*)
Eduard Cabré
Hospital Germans Trias I Pujol, Badalona (*Spain*)
John Cummings
Ninewells Hospital and Medical School, Dundee (*UK*)
Glenn Gibson
The University of Reading (*UK*)
Heinz-Herbert Homann
University Hospital Bergmannsheil, Ruhr-University (Bochum)
David Jenkins
St. Michael's Hospital, Toronto, Ontario (*Canada*)
John Rombeau
Hospital of the University of Pennsylvania, Philadelphia (*USA*)
Wolfgang Scheppach
University of Wuerzburg, Wuerzburg (*Germany*)

Workshop groups and Participants

I **Inflammatory bowel disease**
Chairmen: John Cummings, Ninewells Hospital and Medical School, Dundee (UK), Glenn Gibson, The University of Reading (UK)
Lisbeth Mathus-Vliegen, Academisch Medisch Centrum, Amsterdam (Netherlands)
Alberto Miján de la Torre, Hospital General Yagüe, Burgos (Spain)
Ana Ma̧ Pita, Ciutat Sanitària de Bellvitge, Hospitalet de Llobregat, Barcelona (Spain)

II **Constipation, diarrhoea and irritable bowel syndrome**
Chairman: Ingvar Bosaeus, Sahlgrenska University Hospital, Gothenburg (Sweden)
Philippe Ducrotte, CHU Charles Nicolle, Rouen (France)
Andrea Pezzana, Ospidale Giovanni, Torino (Italy)
Joanne L. Slavin, University of Minnesota, St. Paul (USA)

III **Prevention of colorectal cancer**
Chairmen: Wolfgang Scheppach, University of Wuerzburg, Wuerzburg (Germany), John Rombeau, Hospital of the University of Pennsylvania, Philadelphia (USA)
Carlo Pedrolli, Ospedale S. Chiara, Trento (Italy)
Barbara Schneeman, University of California, Davis (US)
Paul AM van Leeuwen, Free University Hospital, Amsterdam (The Netherlands)

IV **Metabolic effects**
Chairman: Emilio Ros, Hospital Clínic I Provincial, Barcelona (Spain)
Henrik Andersson, Sahlgrenska University Hospital, Goteborg (Sweden)
Peter Ballmer, Kantonsspital, Winterthur (Switzerland)
Maria Ermelinda Camilo, Faculdade de Medicina de Lisboa, Lisboa (Portugal)
Jordi Salas, Universitat Rovira i Virgili, Reus, Tarragona (Spain)

V **The use of fibre in enteral nutrition**
Chairman: Eduard Cabré, Hospital Germans Trias I Pujol, Badalona (Spain)
Stig Bengmark, University College London (UK)
Cécile Chambrier, Hôpital Edouard Herriot, Lyon (France)
Luiza Kent-Smith, Facüldade de Ciencias da Nutricao, Porto (Portugal)
Reto Stocker, University Hospital Zurich (Switzerland)

Scientific Coordination
Mireia Morera, MD, Medical Affairs, Novartis Medical Nutrition, Barcelona (Spain)

This Consensus was reached after discussion within the groups and the general group of chairmen, lecturers and participants.