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Review article

**The “apports nutritionnels conseillés (ANC)”
for the French population**

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Abstract — The apports nutritionnels conseillés (ANC) for the French population are the reference which are used in France to assess the nutritional status of the population. These references have been elaborated by a transparent and collective expert process, conferring on them an official reference. The originality of the French method was to add to the classical analysis of each nutrient an analysis concerning both a global approach to specific groups (children, pregnant women, elderly people, sportsmen) and the links between nutrients and foods. Many original works, which have been specifically performed for this revision, highlight the absolute need for rigorous evaluation of food consumption patterns and for valuable food composition tables.

nutrition / reference dietary intake / requirement / French population / nutritional status

1. INTRODUCTION

The ANC or “apports nutritionnels conseillés” for the French population are reference values which are used in France to assess the nutritional quality of actual dietary intakes of populations or groups, for its adequacy to physiological requirements, or to conceive diets or foods to satisfy these requirements.

From a historical point of view, the elaboration of such references has been delayed

in France: the first edition was published in 1981 [8], the second one in 1992 [9] and the last edition in 2001 [12]. The latter edition results from work carried out over four years by 89 specialists and was reviewed by more than one hundred experts. By contrast, the United States have recently published the 11th edition of their national references [11]. However, this delay does not represent an exception in Europe: publications on this topic have only been found in Italy [17], Germany (in association with

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Austria and Switzerland [7]), the United Kingdom [3], the European Union ([4], for the French edition) and the Scandinavian countries (1996).

Reasons for such a delay are certainly diverse, some of which could be more specific to French culture: perhaps it was thought for a long time that in the country of "fine cuisine", nutritional problems could not occur; research in nutrition, despite noticeable pioneering studies, has only recently begun to reach an international level; moreover, interest in public health is not well developed in our country. Nutrition has only recently become a public health concern, when France proposed this issue as a main area of concern during its presidency of the European Union in the second part of year 2000. This new approach in public health led to the publication of a long report by the Haut Comité de la Santé Publique (High Committee for Public Health [10]).

Several factors put forward the argument for periodic reexaminations of dietary reference values: the rapid increase in the knowledge of nutrition and in the links between nutrition and health; the current modifications in food consumption patterns; the acceleration of food innovation in the food industry, which is seeking to promote its products on the basis of their nutritional quality (food fortification, functional foods, nutraceuticals...).

2. CONCEPT EVOLUTION

In France as well as in foreign countries, the aim of dietary reference values has clearly evolved from the consideration of the prevention of inadequacy (health protection) to the issue of health promotion. Following the sharp decline, and even the disappearance, of clinical forms of nutritional deficiencies, the aim is now to develop reference values which could prevent, or at least, decrease the risk of, degenerative

disorders which are drastically increasing in developed countries, such as cancer, cardiovascular diseases, diabetes and osteoporosis.

This conceptual change raises new problems, since many more works have to be taken into account, especially the numerous reports of intervention studies which are performed around the world. The main problem lies in the extrapolation to the French population of results obtained in countries where the basal rates of some diseases are very different and where usual dietary patterns are quite different.

Such difficulties justify the development of a French reflexion on the issue of dietary reference values, insofar as the national context, in terms of regulatory corpus or nutrition philosophy, could occupy an important place. Despite an actual convergence in the values proposed by different countries, there are still discrepancies, which could induce non negligible consequences: through these values, and the need to reach them to encourage (or not) food fortification, dietary supplements or new health products, the relation of a population towards its food perception could be progressively modified. Finally, it must also be taken into account that scientific data form the basis of the international regulations at the World Trade Organisation. Promotion of specific positions must receive strong scientific support.

3. OBJECTIVES AND METHODS OF THE REVISION OF ANC

At the beginning of this work by the end of 1996, several objectives were assigned to this revision and corresponding methodologies were developed:

- to provide a French edition readily available for anyone interested in the nutrition field;
- to properly present the basis of the reference values in order to make explicit the strength of the scientific support for the

values. Besides the classical analysis of international scientific literature, original works from data obtained on the French population were specifically developed for this revision;

- to ensure a better coherence between analytical approaches to nutrients and global approaches for population groups. Working groups for these two approaches were culturally different: people trained in the basic sciences for the first type of approach and physicians for the second. The balance between the various arguments was not automatically the same, especially for the issues where the margin of interpretation was quite large (in the case of calcium, vitamin D, or E, in elderly people for example). Reaching an agreement between the two cultures on a single value was considered as the best compromise achievable with the current state of knowledge;

- to validate methodologies and results via collective expert appraisal. Namely, three steps of discussion and validation were followed: at the level of working groups (also using expert people outside the groups); at the level of the pilot committee in charge of coherence of the global work; at the level of national committees, competent in the nutrition and food area, such as the French High Council for Public Hygiene (CSHPF, *Conseil supérieur d'hygiène publique de France*) or the Committee on food for special dietary purposes (CEDAP, *Commission d'évaluation des produits destinés à une alimentation particulière*);

- to evaluate the possibility of reaching ANC at the population level with usual foods. Several methodologies have been developed specifically for this purpose.

4. BUILDING ANC

A general conceptual framework has been elaborated and used by all the authors involved in this revision. Usual definitions used are:

- ANC (*apports nutritionnels conseillés* for the French population) as the intake necessary to cover the physiological requirements of almost every individual in the population (97.5%), given as the value of the average nutritional requirement, to which are added two standard deviations of 15% each, characterising and assuming normal statistical distribution; therefore, ANC remain reference values for a population and are only indicative for individuals; in any case, they do not imply that every individual must reach these values or that they are sufficient for every individual in any situation; moreover, ANC are designed only for healthy people;

- average nutritional requirement, calculated as the mean of requirements of a (varying) number of individuals. It is obtained from the net requirement taking into account the average bioavailability of the nutrient in a “usual” diet;

- net requirement, as the amount of a given nutrient required to satisfy various needs (maintenance, metabolic and physiological functioning of the organism), if necessary including requirements according to specific situations (growth, pregnancy, lactation);

- optimal requirement: this notion goes beyond physiology and considers quality of life in the long term (“successful aging”), including risk reduction for degenerative diseases involving nutritional factors. It is proposed that ANC represent optimal values at a population level in the present state of knowledge, not precluding complementation or supplementation requirements for some individuals in a specific context;

- safety limits, using the definition and values proposed by the French High Council for Public Hygiene [5] and corresponding to the maximum amount of a given nutrient which could be consumed every day throughout life without any identified health concern. This does not imply that such an amount is useful or without risk, but that no risk has been detected and published so far,

often because no specifically and rigorously designed study has been devoted to this issue.

The methods used for the determination of ANC vary in their principles and results (factorial method, balance method, depletion-repletion method, clinical and epidemiological methods) [15]. The greatest certainty is reached when different methods result in similar values. In other cases, the respective weight given to different methods may vary in different expert committees, according to the health issue examined or the scientific, nutritional and cultural context of different committees, which explains persistent discrepancies between values from various countries.

The factorial method separately determines different requirements of the organism (net requirements for maintenance, growth, pregnancy, lactation), including unavoidable losses and restoration or conservation of nutrient stocks, and applies to the result the absorption coefficient of the nutrient determined in the usual diet. Results are sometimes difficult to interpret: for example, during pregnancy, the factorial method applied to energy requirement leads to a value much higher than currently observed energy intakes during normal pregnancy, which cannot be explained by well known limitations of dietary records. The possibilities for adaptation in usual life or during certain physiological situations (such as pregnancy) are often difficult to take into account and appear to be more efficient in situations of insufficiency than in situations of excess.

Epidemiological approaches allow to better study variability within a population (from genes or behaviour) and "long-term" effects (even if they are always too short as compared to the actual duration of human life). The best studies allow to compare dietary intakes with biological markers. Two works of this type have been specifically carried out for this revision, using dietary and biological data from the SU.VI.MAX study concerning vitamin C and folic acid.

It was possible to link, for 6000 individuals, dietary intakes of vitamin C and serum concentrations of vitamin C [2]. The curve displays a clear kink when plasma saturation is reached, which is obtained with a mean dietary intake of 85 mg·d⁻¹ in both genders. The addition of two standard deviations led to proposing an ANC of 110 mg (as compared to 100 mg now proposed in some other countries using other approaches). It has been demonstrated that no subject in the study requires more than 250 mg·d⁻¹ (which is also achievable by diet alone) to reach the zone of plasma saturation, thus leading to the proposal of this value as a frontier between nutritional and pharmacological areas.

For folic acid (vitamin B9), the marker which was used was plasma homocysteine, which is considered as an independent risk factor for cardiovascular disease: cardiovascular risk increases for values above 15 µmol·L⁻¹ and is minimal for values below 10 µmol·L⁻¹. The median value for folic acid intakes allowing to remain below the threshold of 10 µmol·L⁻¹ in SU.VI.MAX subjects was 330 µg·d⁻¹ for men and 270 µg·d⁻¹ for women. Using the definitions, the value obtained was proposed for ANC in men; for women, the value was increased to 300 µg·d⁻¹ to take into account higher requirements during a possible pregnancy.

The biggest difficulty (and thus most of the discussions) originated from the interpretation of numerous intervention studies, the only studies which can demonstrate a causal link between nutrient intake levels and health (or, more often, diseases). However, most of these studies have been performed in selected populations at risk, with high doses which are not nutritionally relevant, and without testing dose range effects. Besides, they are performed in populations which are very different in terms of basal risk and dietary habits, which makes extrapolation to the French population difficult. Moreover, some studies performed with toxicologically safe doses of nutrients (ATBC

[1], CARET [14]) led to results opposite to those expected: they do not rule out the relevance of high nutritional intakes of these nutrients included in foods, but highlight that classical toxicology with active nutrients cannot eliminate the possibility of adverse events in the complex system of human nutrition and lifestyle.

5. ENERGY AND MACRONUTRIENTS

5.1. Energy

Energy intake escapes the definition of ANC: the addition of two SD would lead to high values which will clearly be deleterious for the majority of the population. The basal metabolic rate constitutes the principal component of energy expenditure (usually 60–70% in moderately active people), and energy expenditure from physical activity constitutes the second, highly variable, component. Expenditure from dietary thermogenesis represents the smallest, more constant part (around 10%). Methods of indirect calorimetry and, more recently, of doubly labelled water, have allowed great progress in the knowledge of energy requirements, thus making it possible to propose an estimation of individual requirements: the basal metabolic rate (BMR) can be predicted using equations including simple anthropometric measurements (age, gender, height and weight), the validity of which has been verified in the French population [19]; the energy cost of 113 activities (38 for adolescents) was determined for adults. Knowing the daily duration of each type of activity, it is possible to calculate the average weekly physical level (*niveau d'activité physique moyen*, NAP) and derive the corresponding energy expenditure. The addition of both calculations, BMR and energy linked to NAP, gives a good estimation of energy requirement.

Whereas for adults, the proposed values are of the same order of magnitude as in the

previous edition, for children, they are significantly lower. In the two population categories, it is important to promote physical activity, which must not be reduced to sports, but must include daily routine exercise (walking rather than driving, climbing stairs...).

5.2. Proteins

Increasing the use of isotopic tracers, particularly recently with stable isotopes, has enlarged knowledge of protein metabolism and regulation, especially by nutritional factors. These methods have contributed to enrich classical methods, i.e. the factorial and nitrogen balance methods. Even though all the controversies are not yet resolved, all the available knowledge, regularly examined by international expert panels, has led to the proposal of $0.8 \text{ g}\cdot\text{kg}^{-1}\cdot\text{d}^{-1}$ as a value allowing to satisfy requirements for all essential amino acids among the majority of the population. Therefore, a percentage of 8–12% energy from good quality proteins appears to be sufficient. This value is lower than in the previous edition (which took into account usual intakes in France) and is much lower than current intakes.

5.3. Lipids

Determination of ANC for lipids relies on several criteria:

- the need to ensure optimal intake of essential fatty acids, linoleic acid (C18:2 n-6) and linolenic acid (C18:3 n-3), which leads to examine the role of these fatty acids in the physiopathology of diseases, especially cancer and cardiovascular diseases. The very large number of published data now calls into question the safety of intakes of linoleic acid that are too high, as compared to current low intakes of linolenic acid. The physiological roles of these two acids and of their derivatives (such as eicosanoids), as well as the interactions between the two series at the

metabolic level, and epidemiological studies, which are in good agreement with experimental data, raise health concerns for the imbalance between n-6 and n-3. This has led to the proposal of an average supply of $2 \text{ g}\cdot\text{d}^{-1}$ for linolenic acid for the adult, using a ratio n-6/n-3 of 5, lower than the actual ratio;

- the need to limit total lipid intake to 30–35% of total daily energy, following international recommendations. Indeed, lipids are the principal determinant of food energy density such that lipid excess may easily induce energy imbalance and the risk of obesity; moreover lipids have little action on satiety. Adaptation of fat oxidation to fat intakes is limited and slow as compared to carbohydrate oxidation and their storage requires little energy. Finally, an intake above 30% results in a proportionate increase in postprandial lipaemia, which is thought to be an important factor in the development of atherosclerosis;

- the need to limit the intake of saturated fatty acids for their well documented deleterious effects on health;

- the relevance of conserving lipids long enough for the pleasantness of foods may be resolved by large use of oleic acid, which is now considered to be neutral for metabolism and health.

The impact on public health of the large increase in consumption of linoleic acid rich oils in the past decades has certainly been good, since it led to a better balance between animal and plant fats and was accompanied by an increase in vitamin E intake. Moreover, it was coincidental with the sharp increase in life expectancy in the French population. However, present scientific data seem to be sufficient to propose a more precise equilibrium between the two series of fatty acids.

Data are less abundant and more recent for long chain polyunsaturated fatty acids; thus only docosahexaenoic acid (DHA, C22:6 n-3) displays an ANC (especially for premature newborns).

5.4. Carbohydrates

The case of carbohydrates is difficult insofar as no carbohydrate is strictly essential for our organism. ANC for carbohydrate are mathematically derived from ANC for other macronutrients. A rigorous examination of scientific literature for the impact of carbohydrates on various aspects of physiology and health (satiety, weight control, sleep, atherosclerosis, diabetes, dental caries...) allows to conclude that there is no argument to question the classically proposed value of a carbohydrate intake above 50% total daily energy.

Data does not appear to be sufficient to propose a limit for simple sugar consumption, but attention is drawn to the insertion of simple sugars into the whole diet: they inhibit fat oxidation; foods rich in simple sugars are often poor in dietary fibres; their use between meals, and particularly on drinking occasions are probably more important for their consequences than simple sugars per se, with these occasions frequently providing “void calories”.

A sufficient intake of dietary fibre is justified by the many studies dealing with the function and health of the digestive tract (constipation, diverticulitis, colon cancer...) or fibre effects on the whole organism, especially in the cardiovascular area. A consumption of $25\text{--}30 \text{ g}\cdot\text{d}^{-1}$ is proposed for adults; for children, the American recommendation of “age + 5” $\text{g}\cdot\text{d}^{-1}$ has been thought to be adequate. Possible interactions of a high consumption of dietary fibres with mineral bioavailabilities are not an issue, since crude fibres in fibre-rich foods are associated with a high mineral content, which is not the case for purified fibres.

6. MICRONUTRIENTS

6.1. Minerals

The nutritional requirements for minerals have been evaluated, when sufficient data

were available, by the factorial method: this was the case for calcium, phosphorus, magnesium, iron, zinc and copper. For calcium and phosphorus, the differences in the estimations of the Food and Nutrition Board of the United States [11] have been particularly well documented. Moreover, more than calcium intake alone, the importance of the balance with vitamin D and phosphorus is underlined.

For the other minerals, adequate intakes have been derived from the consideration of the thresholds for deficiency diseases, store maintenance, and sometimes, of usual intakes without apparent deleterious effects on health. There is much room for improvement of the scientific basis of ANC for some minerals (copper, manganese, chromium...), for example from the future discovery of more sensitive biomarkers. Finally, for some other minerals (boron, nickel, vanadium...), knowledge is now very limited; only indicative values can be proposed, without practical consequences inasmuch as these minerals are present in high quantities in our diets such that problems of essentiality are not a dietary issue.

A special case is represented by sodium: the need to sharply decrease its intake has been controversial for a long time and is still somewhat controversial [18]. Fervent national or international debate does not contribute to the serenity of scientific analysis, but has the advantage of raising it. There is no argument towards greatly exceeding ANC for any nutrient, and salt might be considered as a surprising exception. If physiological requirements are agreed to be around $2 \text{ g}\cdot\text{d}^{-1}$ by a large majority of scientists, there is no reason to accept that usual intakes are on average 4–5 times this value, reaching more than ten times for extreme consumers. Reflection is currently undertaken, as has been done in some other industrialised countries, to put in place means of reducing average intake and narrowing intake distribution.

6.2. Vitamins

There are sharp contrasts in the area of vitamins:

- on the one hand, there are vitamins for which recent studies are lacking, in such a way that ANC have only been slightly reduced in order to adapt to actual energy intakes;

- on the other hand, there are some vitamins for which there is a plethora of papers and sometimes many intervention studies (vitamins A, E, D);

- between the two extremes, some vitamins for which significant progress has been recorded (B3, B6, B9, B12).

Antioxidant vitamins (especially vitamin E) and beta-carotene were actively discussed. For vitamin E, the working group agreed to maintain the previous value ($12 \text{ mg}\cdot\text{d}^{-1}$) but stressed that it is necessary that the population mean reaches this value rather than increasing ANC.

For vitamin D, division by a factor 2 of the ANC, which decreases from 10 to $5 \text{ }\mu\text{g}\cdot\text{d}^{-1}$, is only apparent: the latter value corresponds to dietary requirement, with a “normal” sunlight exposure, whereas the former corresponds to total requirement. Obviously, care must be taken for complementation when sunlight exposure is lacking (skin pigmentation, clothes, winter season, particular behaviours...).

7. POPULATION GROUPS

7.1. Newborns, children and adolescents

Whereas there is a relative certainty as regards adult values, few specific studies are devoted to infant requirements. For newborns, reference to amounts provided by maternal milk appears to be sound. Therefore, we thought it was possible to interpolate between the two values for adults and newborns. Interpolation for vitamins was tested using different parameters representative of the French infant population;

among these parameters, only two allow a good interpolation; thus according to the vitamin studied, we use either the square of the height (dependent on the lean mass) or the energy input. This led to the possibility of expressing values for narrower age classes than done previously.

7.2. Pregnant and lactating women

There are still many gaps in the knowledge of energy and macronutrient requirements during pregnancy. Therefore, dietetic counselling for general populations are also valuable: dietary errors must be detected and corrected to avoid excessive or insufficient weight gain, without fixation of strong standards or manipulation of weight gain within usual gains. For micronutrients, the focus has been drawn on iron and folic acid:

– for iron, two different positions have been proposed, because no consensus was reached. The first position considers that there is a drastic increase in iron requirements and that ANC must be set at 25–30 mg·d⁻¹. According to this position, the increase in iron absorption during pregnancy is only the result of iron store depletion before and at the beginning of pregnancy. Therefore, iron supplementation must be systematic. According to the other position, the increase in iron absorption is a physiological adaptation to a normal physiological state, so that pregnancy can be successful with a usual iron intake. Iron supplementation must be restricted to documented cases of iron deprivation and low stores;

– by contrast, there is a consensus on the need for a good folic acid status before conception and on the increase in requirements during pregnancy. In this respect, consideration of typologies of food consumption patterns in the French population are disturbing: there is a group of young women whose consumption of fast-food products is high, for whom folic acid intakes average only 200 µg·d⁻¹.

Pregnancy probably constitutes a favourable period of good receptivity to dietary counselling, information and education.

7.3. Elderly people

The most difficult issue lies in the definition of elderly people, with practical consequences for older studies which could be taken into account: the increase in life expectancy without disease led to consider that studies in the 1960–1970 period, performed on individuals aged 60–65 y, could be used, since the physiological state of such individuals was similar to the physiological state of people up to 75 y today. Very elderly people have been defined as people above 85 y: very few scientific studies are available for this group.

The second problem lies in the heterogeneity of elderly people: healthy elderly people, who are still autonomous and active; frail healthy people, for whom intercurrent diseases could disrupt equilibrium and who require that careful attention be paid to dietary intakes; ill elderly people, with a loss of autonomy, generally in specialised institutions, for whom dietary supplements and complements are necessary at least to maintain, if not improve, their present status. A better account of other factors, such as appetite, sense of smell, dentition..., could help to overcome some nutritional problems in the elderly.

For macronutrients, frequently, comparisons with only young people allow to address actual needs. For proteins, at least 1 g·kg⁻¹·d⁻¹ of good quality proteins appears to be necessary to maintain nitrogen balance. There are possibly specific needs for some essential amino acids, such as cysteine in common conditions like chronic inflammation. As for adults, the fatty acid balance must be modified. It is important to maintain a high intake of dietary fibres.

For micronutrients, there are more intervention studies in frail elderly people, for

their relevance in some functions (immunity or cognition were particularly studied) or in some diseases (cataract, cardiovascular disease...). Taking into account the frequent decrease in absorption capacities, ANC higher than for adults have been proposed for calcium, zinc, selenium, vitamin B6, B9, D and E [6].

7.4. Sportsmen and people undertaking intense physical activity

Due to the economic background of professional sports, many studies have been devoted to the effects of macro or micronutrient intakes on performance. A good knowledge of muscle energy paths has practical consequences for nutrition in sportsmen.

Protein requirements are increased according to the type of sport; they can range from $1.5\text{--}2\text{ g}\cdot\text{kg}^{-1}\cdot\text{d}^{-1}$ for endurance sports to $2\text{--}3\text{ g}\cdot\text{kg}^{-1}\cdot\text{d}^{-1}$ for strength sports, preferably for limited durations. Such intakes could require the use of good quality protein supplements, but there is no scientific data to support other forms of amino acid supply. For lipids, there is no data to make different recommendations from those to the general population. For carbohydrates, which constitute the main muscle fuel, very accurate schedules have been elaborated. The glycaemic index, which is not pertinent for the general population, is very important in sports, to optimise muscle glycogen load before exercise and its synthesis after exercise. As a general rule, the closer the time to exercise, and during exercise itself, the higher the glycaemic index must be; by contrast, the longer the time since exercise, the lower the glycaemic index must be.

Micronutrient requirements increase in proportion to energy expenditure. Except for correction of a basal low micronutrient status, there is no scientific support for supplementations having specific effects on performance, though there are still gaps in knowledge for antioxidant requirements.

Meeting requirements can be achieved by a well-balanced diet alone. Moreover, many dietary supplements for athletes are sold with abusive unsupported claims. Optimisation of sportsmen diets, early on in their career, could be one of the means of delaying or limiting doping (the eradication of which goes beyond the scope of nutrition).

With the exception of very regular and intense exercise, practicing sports for leisure does not justify specific ANC.

8. FROM NUTRIENTS TO FOODS

Humans eat foods and not nutrients; thus it is important to assess whether dietary habits, in accordance with recommendations of dieticians, could satisfy requirements in the current food context. Besides a chapter devoted to the examination of the health status of the French population and to the evolution of dietary habits over the past decades, original works have been performed, using data from a nationwide representative dietary survey (ASPCC survey):

- study of diet diversity. According to the diversity index set forth by USDA, a diet is diversified if foods from 5 groups are consumed every day (meat-fish-eggs, milk and milk products, fruit, vegetables, cereals and cereal products);

- simulation studies: using representative data on dietary habits, it was possible to calculate the amounts – at the population level – of nutrients as recommended made by dieticians on type and frequency of principal food categories;

- linear programming studies consist in automatically developing diets from a food database, with respect to prefixed constraints such as diversity, portion size, respect of ANC and cost;

- study of consumer typologies based on 44 food category consumption patterns.

All these studies are convergent and demonstrate that meeting requirements is

possible using usual foods, by applying simple recommendations of nutritionists. The satisfactory nutritional status of the French population [16], however, must not mask the obvious existence of groups at risk of insufficient intakes and insufficiency diseases. Typology analysis is an interesting tool to better characterise these groups and define tools for correction.

9. CONCLUSION

It is difficult to condense into a few pages 4 years of work resulting in a 600-page book with 1 800 references; and a more comprehensive abstract will be published [13]. It is clear that there is still much room for improvement in knowledge and ANC will continue to be revised periodically. Many questions remained unanswered and, especially, future results of intervention studies could lead to ANC modifications. However, many more efforts should be devoted to research on global diets, including fractionation between meals, dietary rhythms..., since the focus on only a few – though essential – nutrients could divert attention from the balance of the whole diet or lifestyle. This could be detrimental for public health and lead to the disappearance of the French cultural specificity, that is the pleasure of eating good food in pleasant conditions...

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