**30**

**ACUTE EFFECTS OF DARK CHOCOLATE CONSUMPTION ON STRESS PARAMETERS IN COLLEGE GOING STUDENTS, MUMBAI: A RANDOMIZED CONTROLLED TRIAL**

Shikha Naresh Bhatia

Dr Rupali Sengupta

**ABSTRACT**

Introduction: Flavonoids are a group of polyphenolic compounds that widely occur in fruits, tea, wine, cocoas and chocolates. Chocolate is known for its mild psychoactive properties, principally methylxanthine and its constituents, caffeine and theobromine. These stimulants, combined with the sensory pleasures associated with chocolate’s bittersweet taste, creamy texture, and sensuous aroma, are known to produce short-term elevations in mood.

Aims & Objective: To study the effect of Flavanoids present in dark chocolate on various stress parameters amid college going students. Methods & Materials: Study included 150 subjects both males and females between the age group of 18-21 years, divided into 3 groups with different proportion of cocoa powder in their chocolates. The intervention period was 15 days with 40 g dark chocolates daily. Group A was given 75% cocoa concentrated chocolate, Group B 45% cocoa concentrate and Group C was considered to be the Control Group. Anthropometric data was collected for all subjects. Diet history was undertaken for records and a balanced diet along with lifestyle modifications was suggested. Pre and post-stress questionnaires were given to study the effect of dark chocolate. Setting: The study was carried out in various colleges of Mumbai city.

Results & Discussion: It can be observed that mean energy (kcal) intake (1328.15±14.00) was highest in group B (1346.31±23.861) and the lowest in group A (1311.91±21.54). Similar trend was observed with carbohydrate and protein consumption between the three groups. No significant difference among the groups was found when weight and BMI were analyzed. Thus, adequate dark chocolate consumption daily did not lead to any weight gain in the intervention group. When stress parameters were checked, emotional stress showed a significant difference (p< 0.05) (0.017) when group B was compared with group A and also when group B was compared with group C (0.00). A declining trend was observed in both males and females. Personal stress showed a significant difference (p<0.05) (0.030) when group A was compared with group C. Reduction in stress level was seen in group A and C with a mean of (-5.35±2.023). Similar trend like that of Emotional stress was observed in the Personal stress. When change in behavioral stress from pre to post was evaluated, significant difference (p<0.05) (0.018) was observed when group A was compared with group B, similarly a significant difference (p< 0.05) (0.030) was also observed when group A was compared with placebo. No significant difference was observed between the groups in sleep stress levels.

Conclusion: Dark chocolates consumption even in small quantity has a positive effect on the stress levels of college going students.

**Keywords:** *Dark chocolate, stress.*

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**1. Introduction**

Up till a few years ago, dark chocolate was considered as one of the unhealthy sweets to be consumed, especially in the young population. However, recently, a lot of studies have shown a beneficial effect on health with chocolate consumption and especially dark chocolate. 1 It is still generally accepted that chocolate is fattening. Nevertheless, there are differences between milk and dark chocolate in both ingredients and sensory properties and these differences might influence eating behaviour.2 Dark chocolate being one of the three major sources of flavanols, contains higher quantities of flavanols than the highly processed chocolate.4 Chocolate is considered vital because of its mild psychoactive properties, principally methylxanthine and its constituents, caffeine and theobromine. These stimulants, combined with the sensory pleasures associated with chocolate’s bittersweet taste, creamy texture, and sensuous aroma, are known to produce short-term elevations in mood.5 In spite of containing a number of polyphenolic compounds, it is particularly rich in flavonoids—specifically, flavanols, also called flavan-3-ols. Flavanols form complexes with salivary proteins and are responsible for the bitterness of cocoa.6-7 The average total flavanols content of commercially available dark chocolate was more than five times that of milk chocolate. 8 The main flavanols found in cocoa are epicatechin and catechin, and procyanidins. Procyanidins provide the majority of antioxidant activity in cocoa products.25 In addition to polyphenols, cocoa contains methylxanthine compounds—predominantly theobromine—about 2% to 3% by weight. Theobromine has antioxidant activity similar to caffeine7 and relatively little stimulating effect on the central nervous system. 8 The antioxidant activity of cocoa and chocolate was shown to be correlated with its catechin and procyanidin contents. Arts et al reported that dark chocolate contains catechins (a group of flavan-3-ol flavonoid compounds) at an average concentration of 0.535 mg/g, 4 times that of tea (139 mg/L).4 A 2003 study by NRG (Nestle Research Group) in the Journal of Agricultural and Food Chemistry in Switzerland was designed to study whether eating dark chocolate every day for two weeks could affect the way the body metabolizes stress hormones. 30 healthy young people were recruited 11 men and 19 women. They tested their anxiety levels and determined that 13 of them tested as “high anxiety” and 17 tested as “low anxiety” on standardized anxiety tests. They gave the volunteers 40 grams of dark chocolate (about an ounce and a half), containing 74% cocoa, every day for two weeks and tested their blood and urine at the beginning and end of the trial. In the high anxiety group, eating chocolate reduced the levels of their stress hormones, and the changes were “biologically significant”.9 Research findings on stress from engineering college students in Villupuram district, Tamil Nadu suggested the top five sources of stress were; change in sleeping habits, vacations/breaks, and change in eating habits, increased work load, and new responsibilities. The findings from this study might be used to examine sources of stress and its cause among college students.23 Eating a moderate amount of dark chocolate every day could help in reducing the hormones in the body that make one feel stressed. Biochemical basis for chocolate which revealed that the chemical compounds contained in dark chocolate may improve the disposition of people who experienced higher levels of stress. Dark chocolates used were made of 75% cocoa solids and were rich in chemical compounds that affect the metabolism, the chemical reactions that happen in body cells. “Anxiety and stress correlated on people’s wellbeing, causing a variety of physical and emotional conditions, and sometimes leading to more serious health concerns”.9 Stress is a term that refers to the sum of physical, mental and emotional strains or tensions on a person. Persistent stress that was not resolved through coping or adaptation, deemed distress may lead to anxiety or withdrawal (depression) behaviour. It is a significant health hazard which can rob the body of needed nutrients, damage the cardiovascular system, raise blood pressure, increase the risk of cancer and diabetes, and dampen immune defences. It can also drain emotional reserves; contribute to depression, anxiety, fatigue, and irritability; and punctuate our social interactions with hostility and anger.10 Prolonged stress has been one impediment to academic performance, followed by lack of sleep.12 A Cross sectional study using quantitative methodology was conducted among undergraduate medical students of Govt. Medical College, Surat by Kantharia in 2012. The target population was undergraduate students currently enrolled in Govt. Medical College, Surat during the study period. Taking into consideration the prevalence of anxiety and depression from various studies conducted previously at approximately 40%, the sample size was calculated using the statistical formula 4pq/L2. By lottery method, equal numbers of students were chosen from each year as the number of enrolment in first year was the same since last five years in undergraduates. The data for present study was obtained through a special designed self – reporting questionnaire related to psychological stress with each stress factor having grading from 1 to 5 according to severity. The questionnaire consisted of 25 item list which was administered to a sample of 160 students for study. The options given were ‘strongly disagree’, ‘disagree’, ‘neutral’, ‘agree’ and ‘strongly agree’. The response strongly disagree had assigned a value of zero and strongly agree the highest score five. Score less than or equal to 3 was considered as no stressor and score greater than 3 was considered as a stressor for individual factor. Out of total 160 students, 96.8% of students were found to suffer from stress. Among them 55.6% had mild to moderate stressor experience and 41.2% had severe stressor experience. Presence of severe stress was highest among the final year students (28.79%) and lowest among the second year phase I students (12.12%) as compared to the students of other years. Both academic and emotional factors are responsible for this stress. Proper guidance and counselling by faculties may help to improve the present scenario.11 Stressful life events and inadequate social support contribute to mental disorders among people aged 15 to 24 more than among other age groups. Researchers suggest that individuals moving from adolescence into adulthood face increased stressors of all kinds.13 The high incidence of suicide among college students is assumed to indicate high personal and societal stress in the lives of young people, as is the increasing rate of anxiety disorders.14 Keeping in view, the different level of stress at various organizations, the present study was an attempt taken to reduce the stress level in the college students of Mumbai and analyzing the various factors responsible for same. Methods Participants Young, healthy participants aged 18–21 years (Males & Females) residing in Mumbai, were recruited through different colleges. Potential participants expressing interest in the study were screened for the following inclusion criteria: not currently suffering medically diagnosed cardiovascular or cognitive impairment, bleeding disorders, or gastrointestinal disorders; no clinically significant pulmonary, cardiovascular, psychiatric, or neurological conditions in the past 12 months; not taking any illicit drugs, cognitive enhancing medication, or herbal supplements; not pregnant or lactating; not colour blind; not taking antidepressants, antipsychotics, or anticoagulants; hold a good working knowledge of English language. Design The current trial investigated the effects of cocoa supplementation on different parameters of stress using a randomized, placebo-controlled, double-blind, parallel design over a two-week period. Participants were allocated to receive one of three daily treatments: (1) Group A- 75% cocoa (2) Group B- 45% cocoa (3) Group C- Control group Participants were required to take two chocolates daily for 2 weeks. The chocolates were presented in visually identical packing, differing only in the labels, which depicted the participant ID number as well as a code relating to the relevant group allocation. The placebo chocolate was identical to the test chocolates, and blinding success of participants was evaluated at the conclusion of the study using a questionnaire. Participants were assigned to receive either test or placebo chocolates based on their stress scores. Participants having moderate to high stress levels were randomly categorized in one of the two experimental groups. Randomization was performed independently in the trial, and the test products were labelled according to the randomization schedule. The blinding code was only revealed after analysis of the study outcomes. Sample Size: 150 subjects were recruited using convenient sampling technique. The subjects were divided into three groups; group A included 50 subjects who were given 40 g of dark chocolate with 75% cocoa solids, group B also with 50 subjects who were again given 40g of dark chocolate with 45 % cocoa solids and group C was taken as the control group. Out of the 150 subjects 27 subjects did not participate in the study due to various personal reasons. 15 subjects out of 27 did not submit their questionnaires and hence were excluded from the study whereas 7 subjects started taking medication and therefore excluded. The remaining subjects failed to complete the 2 weeks intervention period and hence were not included. Therefore, out of 150, 123 students were included and segregated into group A and group B as the experimental group and control group C, each comprising of same sample size i.e. 41 subjects. The 123 subjects were then evaluated to assess whether dark chocolate consumption for 2 weeks had any effect on their stress levels and were monitored accordingly. The stress levels were measured by the Perceived Stress Scale (PSS) by Dr. Sheldon Cohen. Data collected was analysed using SPSS package and following observations were made.24 Dosage of Dark Chocolate: As per literature survey, standard dose was taken as 40 g of dark chocolate in some of the studies whereas in some other studies it was taken up to 70 g of dark chocolate. Keeping that in view, the following dosage was finalized. (1) Group A- 75% cocoa – 40g dark chocolate (2) Group B- 45% cocoa – 40g dark chocolate (3) Group C- Control group -- 40g milk chocolate Method of Preparation: Pure dark chocolate slabs were bought from the market containing 40% cocoa solid and remoulded into 40 g chocolate blocks which were given to participants in Group-B. For Group-A additional Cocoa was added to make it 75% cocoa solid concentrate during remoulding. Group C were given Milk chocolate of similar weight. Statistical Analysis All data analyses were conducted with use of the SPSS version. Data were expressed as means ± SEs, and any effects of diet were tested by using analysis of variance. P values determined with the use of paired t tests. Results & Discussion: Of the 150 subjects recruited in the study 123 subjects completed the study. Of these data, 41 subjects in both the test groups and 41 in the control group were used for the final analysis. The cases were ranging from 18 to 21 years with average age 20.71years and 19.40 years in Group A and Group B respectively which was comparable to 19.95 years among control group, and the difference was not statistically significant. As the subjects were taken randomly, group A had the maximum number of females (94.3%) and only (5.7%) males. Group B had nearly the same number in both males (48.6%) and females (51.4%). Similar was seen in group C where males (46.2%) nearly equalled the females (53.8%), and the difference was significant. N Mean Std. Deviation Age Group-A 35 20.71 .519 Group-B 35 19.40 1.063 Group-C 13 19.38 1.121 BMI Group-A 35 22.41 3.95 Group-B 35 22.08 2.72 Group-C 13 22.30 1.985 Table1. Age and BMI - within three groups From total subject population - Hindus were highest in number followed by Muslims and Catholics with 90.4%, 7.2% and 2.4% respectively. All three groups had maximum number of Hindus. Figure 1: Religion and gender - within three groups Fig 1 shows significant difference in the ratio of both the gender. As the subjects were selected randomly, group A had the maximum number of females (94.3%) as compared to group B and C. In other two groups the proportion of males to females was more or less similar. Group B showed similar trends between both genders. Almoosawi S et al conducted a study in 2012 on the benefits of dark chocolate on females with BMI ≥ 25 kg m(-2) and also females with BMI < 25 kg m(-2) who consumed 20 g of dark chocolates containing 500 mg polyphenols. Females with BMI ≥ 25 kg m (-2) responded less favourably to placebo than lean females.15 25.0 58.0 75.0 6.0 2.0 0.0 20.0 40.0 60.0 80.0 Male Female Hindu Muslim Catholic Sex Religion Mean Figure 2: Anthropometric Data The subjects were classified as per Asian cut-offs for BMI. Mean BMI for group A was (22.41±0.66), group B (22.08±0.45) and group C (22.30±0.55). The trend for BMI classification was similar for all the three groups where maximum subjects were under the normal BMI category, few were overweight, underweight and obese. The mean difference for BMI was not significant (p> 0.05). A relationship exists between stress and eating pattern where individuals were much more likely to eat less than usual than to eat more than usual in response to stressful daily problems. The likelihood of eating more did not change as severity of stress increased, but the likelihood of eating less increased substantially. 16 Figure 3: Macro nutrients calculations of the various groups The consumption of total energy intake throughout the intervention period was (1328.15±14.004) where highest energy was consumed in group B (1346.31±23.861) and the lowest in group A (1311.91±21.547). Fig 3 showed a similar trend where Group B consumed the highest calories of carbohydrate and fat and Group A consumed least. Whereas mean fat intake was found to be lowest in the group B (28.40±0.74) and highest in (29.31±1.10). 22.4 22.1 22.3 22.1 22.1 21.8 21.4 21.6 21.8 22.0 22.2 22.4 22.6 Group A Group B Control kg/m2 BMI (Mean) Pre Post 207 53.3 29.3 217 56.1 28.4 213 54.8 28.7 0 50 100 150 200 250 Carbohydates Proteins Fats g/day Mean Macronutrient Composition Group A Group B Group C Energy Carbohydrates Protein Fat kcals g g g Group A 1312.0 207.0 53.3 29.3 Group B 1346.0 217.0 56.1 28.4 Group C 1328.0 213.0 54.8 28.7 Table2: Macro nutrients calculations of the various groups Sulkowski and Stone et al. found comparable data in 2011stating a correlation between binge eating and stress. Emotional stress was positively associated with binge eating. Conversely, rational and detached coping was negatively related to stress and binge eating. There was a correlation between binge eating and emotion coping stress in female population contradictory to the current study. 16-17 Physical Sleep Behavioural Emotional Personal Group A Pre 7.45 3.1 7.12 16.16 5.65 Post 4.78 1.97 4.07 4.12 3.19 Group B Pre 10.42 2.49 5.34 10.36 4.84 Post 6.57 2.03 4.32 4.24 3.09 Group C Pre 5.39 2.35 6.49 11.8 5.62 Post 2.74 1.91 4.42 11.45 3.06 Table3: Changes in Stress parameters pre and post intervention As shown in Figure 4; Physical stress was found to be highest in experimental group B (10.42) and lowest in control group C (5.39). Group A which consisted maximum girls as compared to the other two groups B and C, it was observed that the Behavioural, emotional and personal stress was found highest in group A. Similar to pre stress levels, physical and sleep stress were found to be highest in group B. Post intervention stress levels were found to be lower in all the groups. When changes in stress levels from pre to post were compared, a positive trend in stress reduction was observed in all the 3 groups. Kochhar et al in 2010 designed a study at the Nestle Research Center in Switzerland to see whether eating dark chocolate every day for two weeks could affect the way the body metabolizes stress hormones. The volunteers were given 40 grams of dark chocolate (about an ounce and a half), containing 74% cocoa, and every day for two weeks. In the high anxiety group, eating chocolate reduced the levels of their stress hormones, and the changes were “biologically significant”. Kochhar’s study supports the current study where the subjects benefited with the consumption of dark chocolate and had lower anxiety levels after the administration of same.18 The current study positively supported the study done by Hayssen et al in 2007. In this chocolates were tested because of its mild psychoactive properties, principally methylxanthine and its constituents, caffeine and theobromine. These stimulants, combined with the sensory pleasures associated with chocolate’s bittersweet taste, creamy texture, and sensuous aroma, are known to produce short-term elevations in mood.3 Figure 4: Change in Stress Parameters from Pre to Post A survey report 10.4 % of students in the past week did not get enough sleep to feel rested on even a single day.19 Sleep conserves body energy and restores you physically and mentally. Colds, flu, and many other ailments are more common when your immune system is depressed by lack of sleep.20 It contributes to healthy metabolism, which helps to maintain a healthy body weight. Restricting sleep can cause attention lapses, slow or poor memory, reduced cognitive ability, and a tendency for thinking to get “stuck in a rut.”21 Certain brain regions, including the cerebral cortex achieve some form of essential rest only during sleep. It is more likely to feel stressed out, worried, or sad when sleep deprived.22 Conclusion Thus the data revealed that dark chocolate which contains good amounts of antioxidants, flavanols and tannins which are highly beneficial in manipulating the stress hormones showed positive effects in lowering stress levels of the college students. As there were three categories, out of which group A were given 75% of cocoa solids showed a decrease in stress levels particularly in males whereas group B which consisted of 45% of cocoa solids lowered stress mainly in females. The control group C had marginal decline in stress levels. Limitation Our study was based on self-reported information provided by students. Therefore, there is some probability for reporting bias. Small sample size in each group was also one of the limitations. 5.1 1.5 0.7 27.9 12.1 8.6 7.4 5.9 37.9 11.4 7.1 1.2 7.2 17.3 6.8 0.0 5.0 10.0 15.0 20.0 25.0 30.0 35.0 40.0 Physical Sleep Behavioural Emotional Personal Stress Parameters Amongst Groups Group A Group B Control

**Reference**

1. Allen RR, Carson L, Kwik-Uribe C, Evans EM, Erdman Jr JW. Daily consumption of a dark chocolate containing flavanols and added sterol esters affects cardiovascular risk factors in a normotensive population with elevated cholesterol. J Nutr 2008; 138: 725– 731.
2. Weijzen PLG, Zandstra EH, Alfieri C, de Graaf C. Effects of complexity and intensity on sensory specific satiety and food acceptance after repeated consumption. Food Qual Pref 2008; 19: 349–359.
3. Dean Radin, PhD, 1 Gail Hayssen, 1 and James Walsh. Effects of intentionally enhanced chocolate on mood.
4. Arts IC, Hollman PC, Kromhout D. Chocolate as a source of tea flavonoids. Lancet 1999;354:488 (letter)
5. Manach C, Scalbert A, Morand C, Remesy C, and Jimenez L. Polyphenols: food sources and bioavailability. Am J Clin Nutr 79: 727–747, 2004.
6. Miller KB, Hurst WJ, Flannigan N, Ou B, Lee CY, Smith N, and Stuart DA. Survey of commercially available chocolateand cocoa-containing products in the United States. 2. Comparison of flavan-3-ol content with nonfat cocoa solids, total polyphenols, and percent cacao. J Agric Food Chem 57: 9169–9180, 2009.
7. Shively CA and Tarka SM Jr. Methylxanthine composition and consumption patterns of cocoa and chocolate products. Prog Clin Biol Res 158: 149–178, 1984.
8. Weisburger JH. Chemopreventive effects of cocoa polyphenols on chronic diseases. Exp Biol Med (Maywood) 226: 891–897, 2001.
9. Francois-Pierre J. Martin, Serge Rezzi,†,Emma Pere´-Trepat, Beate Kamlage, Sebastiano Collino,Edgar Leibold, Ju¨rgen Kastler, Dietrich Rein, Laurent B. Fay, and Sunil Kochhar. Metabolic Effects of Dark Chocolate Consumption on Energy, Gut Microbiota, and Stress-Related Metabolism in Free-Living Subjects.
10. K. Glanz and M. Schwartz, “Stress, Coping and Health Behavior,” in Health Behavior and Health Education: Theory, Research and Practice, 4th ed., eds. K. Glanz, B. Rimer, and K. Viswanath (San Francisco: Jossey Bass, 2008), 210–236.
11. Dr. Sangeeta Nagpal, Dr. Simran Grewal\*, Dr. Lily Walia, Dr. Vishavdeep Kaur. A Study to Access the Exam Stress in Medical College and Various Stressors Contributing To Exam Stress.
12. American College Health Association (ACHA), American College Health Association— National College Health Assessment II (ACHA-NCHA II) Reference Group Data Report Fall 2010, (Baltimore: ACHA, 2011), Available at www.acha-ncha.org/ reports\_ACHANCHAII.html.

13. R. L. Turner and D. A. Lloyd, “Stress Burden and the Lifetime Incidence of Psychiatric Disorder in Young Adults: Racial and Ethnic Contrasts,” Archives of General Psychiatry 61 (2004): 481–88; A. Väänänen et al., “Sources of Social Support as Determinants of Psychiatric Morbidity after Severe Life Events: Prospective Cohort Study of Female Employees,” Journal of Psychosomatic Research 58 (2005): 459–67.

1. V. R. Wilburn and D. E. Smith, “Stress, Self-Esteem, and Suicidal Ideation in Late Adolescence,” Adolescence 40 (2005): 33–46.
2. Almoosawi S, Fyfe L, Ho C, and Al-Dujaili E. The effect of polyphenol-rich dark chocolate on fasting capillary whole blood glucose, total cholesterol, blood pressure and glucocorticoids in healthy overweight and obese subjects. Br J Nutr 103: 842–850, 2010.
3. Arthur A. Stone & Kelly D. Brownell;10.1080/08870449408407469; ;pages 425-436; The stress-eating paradox: Multiple daily measurements in adult males and females;
4. <http://www.tandfonline.com/doi/abs/10.1080/08870449408407469#.UyKgMPnHlGQ>
5. 17. Sulkowski ML1, Dempsey J, Dempsey AG. Eat Behav. 2011 Aug;12(3):188-91. doi: 10.1016/j.eatbeh.2011.04.006. Epub 2011 Apr 20. Effects of stress and coping on binge eating in female college students.
6. Sunil Kochhar; Dark chocolate may help to reduce your stress levels; Mar 28, 2012; http://www.nestle.com/Media/NewsAndFeatures/dark\_chocolate\_low\_stress
7. American College Health Association, American College Health Association–National College Health Assessment II (ACHA–NCHA II): Reference Group Data Report Fall 2010 (Baltimore: American College Health Association, 2010), Available at www.achancha.org/reports\_ACHA-NCHAII.html.
8. S. Cohen et al., “Sleep Habits and Susceptibility to the Common Cold,” Archives of Internal Medicine 169, no. 1 (2009): 62–67. D. J. Gottlieb et al., “Association of Usual Sleep Duration with Hypertension: The Sleep Heart Health Study,” Sleep 29, no. 8 (2006): 1009–14. S. R. Patel et al., “Sleep Duration and Biomarkers of Inflammation,” Sleep 32, no. 2 (2009): 200–04; M. L. Okun, M. Coussons-Read, and M. Hall, “Disturbed Sleep Is Associated with Increased C-Reactive Protein in Young Women,” Brain, Behavior, and Immunity 23, no. 3 (2009): 351–54.
9. S. Banks and D. F. Dinges, “Behavioral and Physiological Consequences of Sleep Restriction,” Journal of Clinical Sleep Medicine 3, no. 5 (2007):519–28. 22. J. Ferrie et al., “A Prospective Study of Change in Sleep Duration: Associations with Mortality in the Whitehall II Cohort,” Sleep 30, no. 12 (2007): 1659–66; C. Hublin et al., “Sleep and Mortality: A Population-Based
10. Year Follow-up Study,” Sleep 30, no. 12 (2007): 1614–15. 23. B. Elamurugan. A study on stress level among engineering college students in villupuram district, Tamil Nadu. 24. http://www.psy.cmu.edu/~scohen/

25. Ramiro-Puig E, and Castell M. Cocoa: antioxidant and immunomodulator. Br J Nutr 101: 931–40, 2009