

1 **The proportion of lycopene isomers in human plasma is modulated by lycopene isomer profile**
2 **in the meal but not by lycopene preparation**

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24 Running title: Fate of lycopene isomers during absorption in humans

25 **Key words:** lycopene, (Z)-isomers, carotenoids, isomerisation, absorption.

26

27 **Abstract**

28 Dietary lycopene consists mostly of (all-E) isomer. Upon absorption, (all-E) lycopene undergoes
29 isomerisation into various (Z)-isomers. Because these isomers offer potentially better health
30 benefits than the (all-E) isomer, the aim of the present study was to investigate if the profile of
31 lycopene isomers in intestinal lipoproteins is affected by the profile of lycopene isomers in the meal
32 and by the tomato preparation. Six post-prandial, cross-over tests were performed in healthy men.
33 Three meals provided about 70% of the lycopene as (Z)-isomers either mainly as 5-(Z), or 13-(Z),
34 or a mixture of 9-(Z) and 13-(Z) lycopene, while three tomato preparations provided lycopene
35 mainly as (all-E) isomer. Consumption of the 5-(Z) lycopene rich meal led to a high (60%)
36 proportion of this isomer in triacylglycerol-rich lipoproteins indicating a good absorption and/or a
37 low intestinal conversion of this isomer. By contrast, consumption of meals rich in 9-(Z) and 13-(Z)
38 lycopene isomers resulted in a low level of these isomers but high amounts of the 5-(Z) and (all-E)
39 isomers in TRL. This indicates that the 9-(Z) and 13-(Z) isomers were less absorbed or were
40 converted into 5-(Z) and (all-E) isomers. Dietary (Z)-lycopene isomers were, therefore, differently
41 isomerised and released in TRL during their intestinal absorption in men. Consuming the three
42 meals rich in (all-E) lycopene resulted in similar proportions of lycopene isomers in TRL: 60% (all-
43 E), 20% 5-(Z), 9% 13-(Z), 2% 9-(Z), and 9% unidentified (Z)-isomers. These results show that the
44 tomato preparation has no impact on the lycopene isomerisation occurring during human
45 absorption.

49 **Introduction**

50

51 Lycopene is an acyclic C₄₀ non-polar carotenoid, present in several dietary sources such as
52 tomato, watermelon, guava and apricot. Although being not a provitamin A, lycopene has been
53 shown to have multiple biological activities including decrease of risk of prostate cancer⁽¹⁾,
54 inhibition of cell proliferation, migration and invasion in breast of endometrial and liver carcinoma
55 cells⁽²⁻⁷⁾, and prevention of mutagenesis and chromosome instability^(8, 9). In addition, a variety of
56 epidemiological trials indicated that high intakes of lycopene containing foods (primarily tomato
57 products) or elevated blood lycopene concentrations are associated with a decreased risk of
58 cardiovascular diseases and prostate cancer⁽¹⁰⁻¹³⁾.

59 Lycopene has eleven conjugated double bonds and each of them could be either in an (E) or
60 (Z) configuration. (All-E)-lycopene is the predominant isomer in plants, representing about 80–97%
61 of total lycopene in tomatoes and related products⁽¹⁴⁾. In human body fluids and tissues such as
62 plasma, prostate, testis and skin, 25–70% of lycopene is found in various (Z) forms⁽¹⁵⁻²⁰⁾. The high
63 concentrations of (Z)-isomers *in vivo* trigger the hypothesis that they are more bioavailable and/or
64 that (all-E) lycopene is transformed into (Z)-isomers within the human body. Moreover, when a
65 tomato-based meal rich in the (all-E)-isomer is consumed daily over a few weeks, plasma lycopene
66 concentration increases and its main part (60%) is present as (Z)-isomers⁽²¹⁾. Recently, we have
67 demonstrated that lycopene isomerisation takes place in the enterocytes and not in the
68 gastrointestinal lumen⁽²²⁾

69 In terms of bioactivity, Shi & Le Maguer⁽¹⁴⁾ indicated that the biological potency of (Z)-
70 lycopene isomers is different from that of the (all-E) form. Böhm *et al.*⁽²³⁾ reported that some (Z)-
71 isomers have a stronger *in vitro* antioxidant activity than the (all-E) form. For these reasons, (Z)-
72 lycopene isomers are regarded as offering potentially better health benefits than the (all-E)-isomer.

73 In the present study, we investigated, in humans, the effect of meals enriched in lycopene on
74 the lycopene isomer profile of plasma triacylglycerol-rich lipoprotein (TRL) fractions. The main

75 objective was to compare the profile of lycopene isomers appearing in TRL following the ingestion
76 of tomato preparations rich in (Z)-lycopene isomers. Three different tomato preparations rich in Z-
77 lycopene (about 70% of total lycopene) were produced. One preparation was rich in 5-(Z) (65%),
78 one in 13-(Z) (42%) and one in a mixture of 9-(Z) (31%) and 13-(Z) (24%) isomers. Another
79 objective was to determine if the tomato preparation can affect the intestinal isomerisation of (all-E)
80 lycopene during absorption.

81 **Experimental methods**

82

83 **LYCOPENE PREPARATIONS**84 Tomato preparations rich in (Z)-lycopene isomers

85 *A tomato preparation rich in 5-(Z) lycopene* was produced by mixing 10 g of tomato oleoresin in
86 500 mL dichloromethane with 580 μ L Iodine solution (5.6 mg Iodine in 596 μ L methylene
87 chloride). The mixture was photoisomerised for 10 hours at room temperature. Photoisomerised
88 tomato oleoresin was further enriched in 5-(Z) lycopene by successive fractionation in ethanol and
89 in ethyl acetate. The solid fraction was then re-suspended in ethyl acetate (1:80 w/w) and the
90 suspension centrifuged at 16'900 x g for 5 min at room temperature. The solid fraction was
91 discarded and the tomato preparation enriched in 5-(Z) lycopene was obtained by distilling ethyl
92 acetate under reduced pressure at 30°C. This preparation provided 65% of total lycopene as 5-(Z)
93 isomer (Table 1).

94

95 *Tomato preparation rich in 13-(Z) lycopene isomer:* A suspension of tomato oleoresin in ethyl
96 acetate (1:10 v/v) was refluxed for 1 h under stirring. After cooling to room temperature the
97 precipitate (~10 % w/w of initial raw material) was filtered off. This precipitate contained mainly
98 (all-E) lycopene isomer. The isomerised tomato preparation was obtained by evaporating ethyl
99 acetate from the filtrate under reduced pressure at 30°C and by azeotropic distillation after addition
100 of water and ethanol (water/ethanol ratio: 8:2). This preparation provided 70% of total lycopene as
101 (Z)-isomers with 42% as 13-(Z) lycopene (Table 1).

102

103 *Tomato preparation rich in 9- and 13-(Z) lycopene isomers:* a similar process as the one described
104 for the tomato preparation rich in 13-(Z) lycopene was performed with the exception that the
105 heating duration has been increased up to 24 h. This preparation provided 72% of total lycopene as
106 (Z)- isomers with 31% as 9-(Z) lycopene and 24% as 13-(Z) lycopene (Table 1).

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107

108 Tomato preparations rich in (all-E) lycopene

109 Three tomato products, *i.e.* a commercial tomato paste packed in a 300-g tube (Thomy, Vevey,
110 Switzerland), a tomato oleoresin (Indena, Milan, Italy) and a lactolycopeneTM preparation (Indena,
111 Milan, Italy), contained about 95% of total lycopene as (all-E) isomer.

112

113 The lycopene isomer profiles of the tomato supplements are presented in Figure 1 and Table 1.

114 With the exception of tomato paste, the daily doses of test products were packed separately as
115 aliquots in light-protected containers, sealed under nitrogen and stored at -80°C during the course
116 of the study. The lycopene content and profile of isomers were shown to be stable for 6 months at -
117 40°C in the tomato products indicating that the storage conditions were adequate.

118

119 **SUBJECTS**

120 Thirty healthy men were enrolled in the study. A total of twenty-seven subjects, aged 24
121 (SEM 1) years, completed the study. Their mean starting body weight was 70 (SEM 1) kg and BMI
122 22.5 (SEM 0.3) kg/m^2 . Subjects were normolipidemic, *i.e.* they had a ratio of plasma cholesterol to
123 HDL cholesterol < 5.0 and plasma triacylglycerol concentrations < 1.5 mmol/L. Because of the
124 large amount of blood that was drawn during the study, subjects were required to have a blood
125 hemoglobin concentration > 1.3 g/L as inclusion criteria. The subjects did not use medication,
126 neither they had history of gastrointestinal disease or lipid metabolic disorders. Three volunteers
127 abandoned the trial before the end for the following reasons: unavailability, medical treatment
128 related to an eye injury, nausea related to the consumption of fatty meals.

129

130 The present study was conducted according to the guidelines laid down in the Declaration of
131 Helsinki and all procedures involving human subjects were approved by the ethical committee of
132 Marseille (Marseille, France). All subjects received information on background and design of the

133 study and gave written informed consent before participation. They were free to withdraw from the
134 study at any time.

135

136 **STUDY DESIGN**

137 The study was a randomized, 6-periods, 6-treatments cross-over clinical trial with a washout
138 period of 3 weeks minimum. Subjects and technicians were blinded while the investigator was
139 blinded for 5 tomato products but not for the tomato paste which was a commercial product.
140 Subjects were asked to refrain for 48 h before the post-prandial tests from eating lycopene rich
141 products: tomatoes (crude, cooked and tomato sauces including ketchup and harissa), pizza,
142 ratatouille, lasagna, pasta including tomato sauce, watermelon, pink grapefruits and guava. In
143 addition to this dietary restriction, the subjects ate a standard meal the evening before the post-
144 prandial tests consisting of green vegetables, a source of cereals (paste, bread or rice), lean meat or
145 fish, one low-fat natural yoghurt, one fruit and one mineral water. They should have consumed this
146 dinner in the evening between 19:00 and 20:00. These recommendations were checked by the
147 investigator on the post-prandial test day.

148

149 After an overnight fast, subjects arrived at the Clinical Pharmacology and Therapeutic Trial
150 Center of University of Marseille and consumed a standard meal consisting of semolina (70 g)
151 cooked in 200 mL hot water, white bread (40 g), egg whites (60 g), groundnut oil (40 g), natural
152 yoghurt (125 g), sugar (5 g) and water (330 g). This standard meal provided 842 kcal (3520 kJ) with
153 the following nutrient composition: protein (11.7 %), carbohydrates (39.3 %) and lipids (49.0 %). A
154 portion of one of the six lycopene preparations adapted to provide 25 mg of lycopene was
155 incorporated into the test meal just before its consumption. This meal was consumed within 30
156 min. No other food was allowed over the following 6 h, but the subjects were allowed to drink
157 bottled water with a maximum of 330 mL. Fasting blood was drawn from an anticubital vein by
158 venipuncture into an evacuated tube containing potassium EDTA/K₃ that was immediately placed in

159 an ice-water bath and covered with an aluminium foil to avoid light exposure. Blood samples were
160 collected 20 min and 5 min before consumption of the standard meal as well as after 2h, 3h, 4h, 5h
161 and 6h post-absorption.

162
163 This short post-prandial time frame, *i.e.* 6h, was chosen to assess lycopene isomerization
164 within the intestine with as low contamination by lycopene isomers coming from other organs
165 (mainly the liver) as possible. Indeed, during the post-prandial period, chylomicrons secreted by the
166 intestine, which contained lycopene coming from the meal, are transformed into chylomicron
167 remnants following triacylglycerol hydrolysis by lipoprotein lipase. These chylomicron remnants
168 are taken up by the liver. A fraction of dietary lycopene is then incorporated in VLDL and released
169 in the blood. It is not known, but possible, that an isomerisation of lycopene also occurs in the liver
170 leading to increase blood concentration of lycopene isomers. Because liver VLDL are starting to be
171 produced some hours after a fat meal intake, the longer the post-prandial period, the higher the level
172 in the blood of VLDL coming from the liver. As, technically, it is quite complicated to isolate the
173 chylomicrons remnants from the VLDL, we decided to collect the TRL during the initial post-
174 prandial period so that they contain mostly lipoproteins from intestinal origin.

175

176 BLOOD SAMPLE PREPARATION

177 Tubes containing the blood were protected from light, stored at 4°C and then centrifuged
178 within 2h (10 min, 4°C, 878 x g) to separate the plasma. On the test day, plasma (6 mL) was
179 overlaid with 0.9% NaCl solution and centrifuged for 28 min at 130'000 x g at 10°C in a SW41Ti
180 rotor (Beckman, Fullerton, CA, USA) in a L7 ultracentrifuge (Beckman). The upper phase
181 containing TRL, *i.e.* mainly chylomicrons and chylomicron remnants, was collected. Immediately
182 after recovery, TRL were divided into aliquots and immediately stored at -80°C prior to lycopene
183 isomer profile determination.

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185 **ANALYTICAL PROCEDURES**

186 The profile of lycopene isomers was determined according to the method described
187 previously by Schierle *et al.*⁽¹⁸⁾ for lycopene products (Figure 1), and according to the method of
188 Ferruzzi *et al.*⁽²⁴⁾ for TRL. The main lycopene isomers identified were 5-(Z), 9-(Z), 13-(Z) and (all-
189 E) lycopene. Minor compounds eluting between 24 and 48 min (Figure 1) were identified as (Z)-
190 lycopene by LC–MS/MS using an Applied Biosystems APCI 4000 LC–MS/MS (Foster City, CA,
191 USA). Following conditions were used: isocratic flow 1 mL/min; declustering potential, 130 V; 60
192 psi (414 kPa) N₂; capillary voltage 22 V; vaporiser temperature, 400°C; corona needle 5mA; the
193 fragmentation conditions used were those described by dos Anjos Ferreira *et al.*⁽²⁵⁾. The peak areas
194 of unidentified (Z)-lycopene isomers were summed up and reported as x-(Z) lycopene (Table 1).

196 **DATA ANALYSES**

197 The raw data consisted in TRL-lycopene isomer concentrations (expressed in mmol/L) of five
198 lycopene-isomers *i.e.* x-(Z), 5-(Z), 9-(Z), 13-(Z) and (all-E) measured at 6 time points (before and,
199 2, 3, 4, 5 and 6 hours after ingestion of the standardized meal containing lycopene) for each of the 6
200 different test meals and each of the 27 subjects. These raw data were averaged for the 27 subjects
201 and presented as mean +/- SEM for each time point (Figure 2). The baseline was the average of the
202 two lycopene concentrations measured in plasma samples collected before consumption of the
203 meal. As our goal was to determine lycopene isomerisation during the absorption phase, we
204 voluntarily have limited the measurement of lycopene isomer profiles to short period of time after
205 lycopene intake. Thus, we measured mainly lycopene present in chylomicrons in the TRL fraction
206 with only few lycopene present in the VLDL fraction coming from the liver. These purely
207 descriptive analyses confirmed that lycopene concentrations did not return to baseline 6 hours after
208 ingestion of test meal. In consequence, no formal kinetics modeling (*e.g.* area under the curve, T_{max}
209 or C_{max}) was further considered. In order to complete this descriptive data analysis and to simplify

210 the discussion of results, individual lycopene isomers were expressed as relative percentage of total
211 lycopene calculated as the sum of the five lycopene isomers, *i.e.* x-(Z), 5-(Z), 9-(Z), 13-(Z) and (all-
212 E) (Figure 3).

213

214 **Results**

215 Following the ingestion of the six standardized meals supplemented with lycopene, TRL-
216 lycopene concentrations increased promptly, reaching a first maximum concentration between 2 and
217 4 h and started to increase again after 5 h (Figure 2). Since lycopene isomer profiles were
218 determined over a short period of time only, the second maximum was not well characterized.
219 These two rises of lycopene concentrations are in agreement with the known lycopene absorption
220 processes and show a first appearance of dietary lycopene in chylomicrons (before 4 hours) and a
221 subsequent incorporation of dietary lycopene chylomicrons into newly released VLDL from the
222 liver (after 5 hours). In consequence, our choice for a short post-prandial time frame (0-6 hours),
223 which accounts for the appearance of lycopene in chylomicrons, is ideal to determine lycopene
224 isomerization within the intestine.

225 Interestingly, the profile of lycopene isomers expressed in percentage (Figure 3) did not vary
226 over the 6h post-absorption. Moreover, the inter-individual variability of concentrations (Figure 2)
227 and percentages of lycopene (Figure 3) was very small.

228
229 **PROPORTION OF LYCOPENE ISOMERS IN TRL AFTER CONSUMPTION OF TOMATO PREPARATIONS**
230 **RICH IN (Z)-LYCOPENE**

231 Consumption of a tomato preparation rich (65%) in 5-(Z) lycopene resulted in a close
232 proportion (60%) of this isomer in TRL suggesting a good absorption and a low isomerisation of
233 this isomer in the enterocytes (Figures 2A and 3A). The other lycopene isomers observed in TRL
234 consisted of 20% of (all-E), 9% of x-(Z), 7% of 13-(Z) and 2% of 9-(Z). Since, these (Z)-isomers
235 were not present in the diet, their appearance in TRL suggests that they were formed during
236 absorption by isomerisation of the (all-E) lycopene.

237
238 Only a low amount (9%) of the 13-(Z) isomer was measured in TRL following the intake of
239 a tomato preparation which contained 42% of this isomer (Figures 2B and 3B). Other lycopene

240 isomers measured in TRL were mainly the (all-E) (about 50%) and the 5-(Z) (25%) isomers,
241 suggesting that part of the 13-(Z) lycopene was isomerised into these isomers during absorption.

242

243 Eating the tomato preparation rich in a mixture of 9-(Z) and 13-(Z) lycopene induced a
244 release of lycopene in TRL containing mostly the (all-E) (42%) and 5-(Z) (27%) isomers (Figures
245 2C and 3C), suggesting that the 9-(Z) and 13-(Z) isomers were isomerised into the (all-E) and 5-(Z)
246 isomers.

247

248 **PROPORTION OF LYCOPENE ISOMERS IN TRL AFTER CONSUMPTION OF TOMATO PREPARATIONS**

249 **RICH IN (ALL-E) LYCOPENE**

250 Consumption of the tomato paste rich in (all-E) lycopene (about 95%) resulted in observing
251 various lycopene isomers in TRL, *i.e.* roughly 60% (all-E) and 40% (Z)-isomers, with about 18% of
252 5-(Z), 10% of 13-(Z) and x-(Z), and 2% of 9-(Z) (Figures 2D and 3D). The appearance of isomers
253 that were not detected in the tomato paste, *i.e.* 9-(Z), 13-(Z) and x-(Z), strongly suggests that part of
254 the (all-E) was isomerised during absorption.

255 The same profile of lycopene isomers in TRL was also observed with the two other tomato
256 preparations, *i.e.* lactolycopene and oleoresin, containing about 95% (all-E) lycopene (Figures 2E,
257 2F, 3E, 3F). These results indicate that the three tomato preparations rich in (all-E) isomer were
258 similarly isomerised during their absorption in humans and, therefore, that the lycopene food matrix
259 did not influence it.

260

261

262 **Discussion**

263 We have recently demonstrated that, during absorption, a significant isomerisation of (all-E)
264 lycopene into various (Z)-lycopene isomers takes place in the human enterocytes⁽²²⁾. The first
265 objective of the present study was to determine if the lycopene isomer profile in the blood
266 circulation was affected by the isomer profile in the meal.

267 Consumption of the tomato preparation rich in 5-(Z) lycopene led to a very high proportion
268 of 5-(Z) lycopene isomer in TRL (around 60%), which indicates either a good absorption, or a
269 greater thermodynamical stability⁽²⁷⁾ of this isomer, or both.

270 The consumption of either a preparation rich in a mixture of 9-(Z) and 13-(Z) or a
271 preparation rich in 13-(Z) lycopene was associated with the release of TRL which contained lower
272 proportions of these two isomers as compared to those present in the tomato preparations. These
273 results indicate either a low absorption of these isomers or an isomerization of these isomers into
274 more thermodynamically stable lycopene isomers, *i.e.* (all-E) and 5-(Z), during absorption. The
275 second hypothesis seems the most likely as the proportion of the (all-E) and 5-(Z) isomers measured
276 in TRL after intake of the preparation rich in 9-(Z) and 13-(Z) isomers was higher than in the
277 preparation itself.

278 **These results show that, although the human intestine is able to modify the profile of dietary**
279 **lycopene isomers which is finally found in the body, the resulting profile is not the same for all**
280 **isomer sources supplied but is depending on the initial relative proportions of these isomers existing**
281 **in the meal. This suggests that the mechanism of (E) to (Z) conversion can be overwhelmed by**
282 **offering high amounts of dietary lycopene (Z)-isomers e.g. 5-(Z). It is, therefore, possible to**
283 **modulate the profile of (Z)-isomers which enter the human body via the intestinal lipoproteins by a**
284 **lycopene isomer-rich diet.**

285 Besides, it is well-known that the bioavailability of (all-E) lycopene is dependent on the
286 tomato preparation⁽²¹⁾. In agreement with results reported in the literature^(15, 17, 26) we have shown
287 that consuming a tomato paste which contained mainly (95%) (all-E) lycopene resulted in secretion

288 of TRL containing 40% of lycopene (Z)-isomers^(21, 22), which suggests that part of the ingested (all-
289 E) lycopene was converted into (Z)-isomers. The secondary objective of this work was to assess
290 whether the preparation of all-E lycopene affects the isomerisation of the (all-E) lycopene during
291 intestinal absorption. Present results show that consumption of the three tomato preparations rich in
292 (all-E) isomer (tomato paste, (all-E) oleoresin and lactolycopene) resulted in a similar isomerisation
293 of the (all-E) lycopene. This shows that lycopene isomerisation occurring in the enterocytes is not
294 significantly affected by the lycopene preparation. Another key observation is that the main (Z)-
295 isomer recovered in TRL was the 5-(Z) lycopene (about 20% of the total lycopene content). This
296 suggests that either the 5-(Z) lycopene is specifically formed during isomerisation of the (all-E)
297 lycopene, or the 5-(Z) isomer, being more stable than the others⁽²⁷⁾, leading to its preferential
298 accumulation during absorption, or both.

299 Interestingly, there is a low inter-individual variation of lycopene isomerisation during
300 intestinal absorption, which is in agreement with previous results observed with tomato paste⁽²²⁾.
301 (Z)-lycopene isomers have been discussed for their specific bioactivity. Indeed, individual (Z)-
302 lycopene isomers exhibit different antioxidant activities⁽²³⁾ and some human organs like prostate⁽¹⁶⁾
303 and skin accumulate high amounts of (Z)-lycopene isomers. More research is needed to evaluate
304 how chronic supplementation with a diet enriched in (Z)-lycopene isomers will affect their
305 distribution in tissues and subsequently will modulate lycopene bioactivity in humans.

306

307 Acknowledgments

308 The present study was funded in full by the Nestlé Research Center, Lausanne, Switzerland.

309 M. R., P. L., C.J., P.B. and K. B. conceived and designed the present study. I. T., P. L., A-F. M. and

310 K. B. achieved the design and production of formulations of the lycopene products. C.J. coordinated

311 the trial and supervised the analytic aspects. C.J. and P.B. contributed

312 to the development of analytic methods, lycopene analysis and data collection. M. R., P. L., C.J.,

313 P.B., K. B. and A.R. analyzed the data. M. R. wrote the manuscript, and all authors were involved

314 in interpreting the results and in critical revision of the paper.

315 No author has any advisory board affiliations. There is no conflict of interest.

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406 **Figure legends**

407 Figure 1: HPLC chromatograms of the lycopene isomer profiles in the tomato paste rich in (all-E)
408 lycopene and in the three tomato preparations rich in (Z)-lycopene isomers.

409
410 Figure 2: TRL-lycopene isomer concentrations over 6h post-consumption of the standard meals
411 providing 25 mg lycopene from various sources. Results are presented as mean \pm SEM (nmol/L,
412 n=27). x-(Z) lycopene (\blacklozenge); 5-(Z) lycopene (\blacksquare); 9-(Z) lycopene (\blacktriangle);13-(Z) lycopene (\times); (all-E)
413 lycopene (*).

414
415 Figure 3: TRL-lycopene isomer profiles over 6h post-consumption of the standard meals providing
416 25 mg lycopene from various sources. Results are expressed as percentage of the total lycopene
417 (mean \pm SEM, n=27). x-(Z) lycopene (\blacklozenge); 5-(Z) lycopene (\blacksquare); 9-(Z) lycopene (\blacktriangle);13-(Z) lycopene
418 (\times); (all-E) lycopene (*).

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Version définitive du manuscrit publié dans / Final version of the manuscript published in : British Journal of Nutrition, 2011, First View, DOI: 10.1017/S0007114511004569

Table 1: Lycopene isomer profile of the six lycopene preparations. Results are expressed as percentage of total lycopene.

Lycopene preparation	X-(Z)	5-(Z)	9-(Z)	13-(Z)	(all-E)
Tomato paste	ND	4.1	ND	0.1	95.8
Tomato oleoresin	ND	4.1	ND	0.1	95.8
Lactolycopene	ND	4.1	ND	0.1	95.8
Tomato preparation rich in 5-(Z) lycopene	ND	65.3	1.3	ND	33.4
Tomato preparation rich in 13-(Z) lycopene	12.0	7.6	9.6	41.5	29.3
Tomato preparation rich in 9- and 13-(Z) lycopene	10.2	7.7	30.8	23.5	27.8

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Richelle, M., Lambelet, P., Rytz, A., Tavazzi, I., Mermoud, A.-F., Juhel, C., Borel, P., Bortlik, K. (2012). The proportion of lycopene isomers in human plasma is modulated by lycopene isomer profile in the meal but not by lycopene preparation. *British Journal of Nutrition*, 107 (10), 1482-1488. . DOI : 10.1017/S0007114511004569