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Influence of Tea Catechins on the Digestive Tract

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Abstract Tea catechins undergo various metabolic changes after they are taken orally, though a large percentage are excreted intact with the feces. Epidemiological studies suggest a protective effect of tea against various human cancers, including colon and rectum. The bactericidal property of tea catechins plays several roles in the digestive tract. In the small intestine, catechins inhibit α-amylase activity, and a certain amount is absorbed into the portal vein. Although catechins are bactericidal, they do not affect lactic acid bacteria. Including tea catechins in the diet for several weeks decreases putrefactive products and increases organic acids by lowering pH. These changes were achieved in tube-fed patients by administering 100 mg of tea catechins (equivalent to a cup of green tea) three times daily with meals for 3 weeks. When catechin administration ceased, the effects reversed after 1 week. Catechins should be considered further in colon carcinogenesis studies. J. Cell. Biochem. Suppl. 27:52–58.

Key words: tea; green tea; tea polyphenols; Polyphenon®; tea catechins; EGCg; fecal flora

Next to water, tea is the most widely consumed beverage in the world. Epidemiological studies suggest a protective effect of green tea against various human cancers, including those of colon and rectum [1]. In the human stomach, tea catechins act on *Helicobacter pylori* (*H. pylori*), which causes digestive gastritis [2]. We investigated effects of tea catechins on the digestive tract.

TEA CATECHINS

The polyphenols of green tea are mostly composed of catechins, which constitute 10–15% of its dry weight and are major constituents of its soluble solid. Catechin was extracted from green tea and dried powder was obtained as shown in Figure 1. This powder was termed Polyphenon 60® and further refined into Polyphenon 60S. Figure 2 details the production process, while individual catechins are shown in Table I. The structural formulas of individual catechins are shown in Figure 3; (−)-epigallocatechin gallate (EGCg) constitutes almost half of the total catechins.

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FATE OF EGCg IN THE DIGESTIVE TRACT OF RATS

Stability of EGCg in the Digestive Tract In Vitro

The stability of EGCg in digestive organs was tested in vitro. Male Wistar rats (6 weeks of age) were sacrificed and the stomach, small intestine, and large intestine were removed. Fifty mg of EGCg was mixed with each organ's content and incubated at 37°C for 5 hours. Each treated sample was centrifuged after homogenization in 50% aq. acetone. The amount of residual EGCg in the supernatant was measured by the colorimetric method using a ferrous tartrate reagent. Table II shows the EGCg remaining in the contents of each organ. EGCg was mostly intact in the contents of the stomach and small intestine, but 20–25% was lost during incubation of the content of the large intestine. These results suggest that EGCg was subject to the influence of the intestinal flora.

Quantitative Change of EGCg in the Digestive Tract In Vivo

Fifty mg of EGCg was administered orally to rats, which were sacrificed 1, 2, 5, 8, 12, 16, and 20 hours after dosing. The stomach, small intestine, and large intestine, along with their contents, were removed and feces collected. The content of each organ was homogenized, centrifuged as above, and the amount of EGCg in the supernatant was measured the same way. As

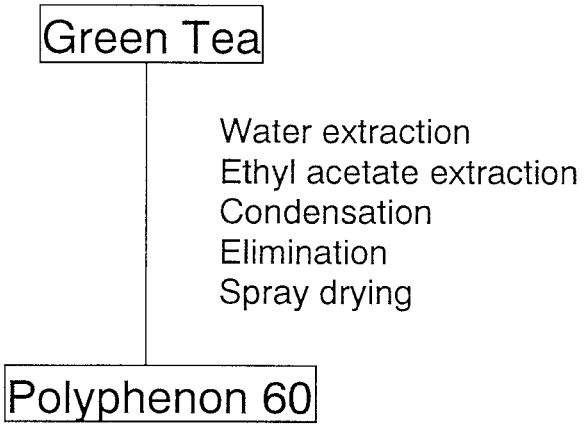


Fig. 1. Preparation of Polyphenol 60.

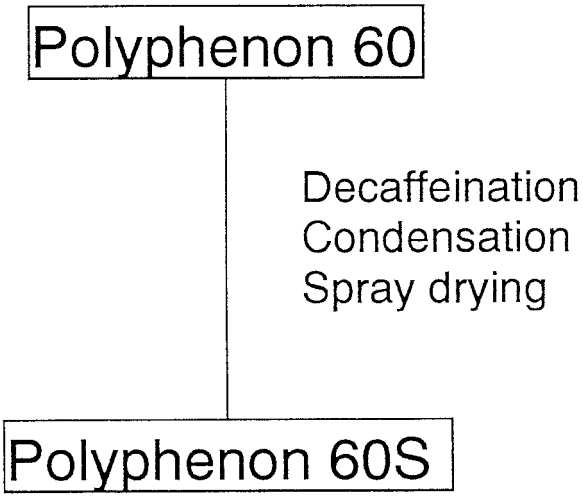


Fig. 2. Preparation of Polyphenon.

TABLE I. Composition of Catechins in Polyphenon 60 and Polyphenon 60S

Tea catechins	P-60	P-60S
(+)-Gallocatechin (+GC)	—	—
(−)-Epigallocatechin (EGC)	21.0	18.6
(−)-Epicatechin (EC)	7.3	9.3
(−)-Epigallocatechin gallate (EGCg)	29.2	36.1
(−)-Epicatechin gallate (ECg)	7.9	11.3
Total	65.4	75.3

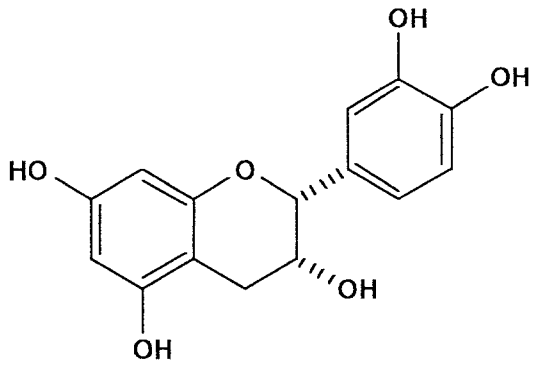
shown in Figure 4, EGCg in the stomach rapidly moved into the small intestine where some of it became unrecoverable. The amount of EGCg in the large intestine increased sharply after a few hours, peaking around 8 hours after ingestion. After 8 hours, EGCg remained only in the large intestine. During these hours about 10% was either absorbed or decomposed. After 12 hours, EGCg was recovered in the feces. Similar data was obtained when EGCg was administered in doses of 25 and 80 mg. Further, the volume of feces increased through catechin feeding, probably because of α-amylase inhibition by tea catechins [3]. From these experiments, it appears that catechins remain fairly stable throughout the intestinal tract, more than a trace amount of catechins might be absorbed into the body, and catechins will undergo interaction with the intestinal flora and decompose to a certain extent. Separately, we have identified and confirmed the existence of four kinds of individual tea catechins in the portal blood of rats [4]. Glucuronides or sulfides of catechins are also available in urine in trace concentrations (ng − μg/ml) [5]. Detailed study of orally administered catechins is underway.

EFFECT OF TEA CATECHINS ON THE INTESTINAL FLORA OF CHICKENS AND PIGS

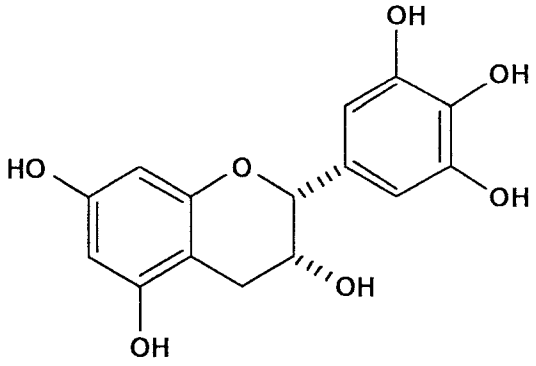
Tea polyphenols (catechins) have a potent antibacterial action against food-borne pathogenic bacteria, though they show little bactericidal effect against lactic acid bacteria such as lactobacilli or bifidobacterium [6]. To study the effects of daily tea catechin intake on the intestinal flora of the large intestine, the following experiments were conducted.

Effect of Catechins on the Intestinal Flora of Broiler Chickens

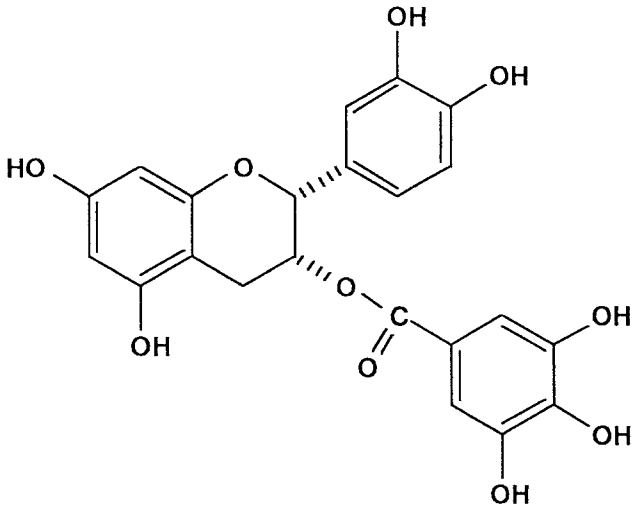
One group of 10,000 broiler chickens was fed a diet containing 0.2% Polyphenon G® (0.07% tea catechins) while the other group of 10,000 chickens was fed a basal diet without catechins for 60 days [7]. On day 61, there were no differences between these two groups in terms of body weight, food intake, and feed conversion ratio. Eight chickens per group were killed at 56 days; caecal samples were collected and the caecal metabolites as well as caecal flora were analyzed. In the catechin-fed group, the number of lactobacilli increased significantly while the count of Enterobacteriaceae decreased remarkably. Caecal concentrations of ammonia and ethyl phenol were significantly reduced in the catechin group. Caecal volatile fatty acids, acetic acid, and butyric acid significantly increased as shown in Figure 5, reflecting the increase in the number of lactobacilli. Tea catechins appear to improve intestinal flora.



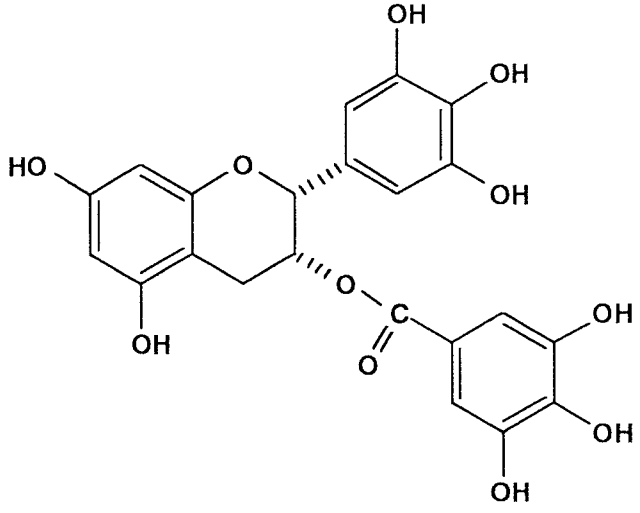
(-)-Epicatechin (EC)



(-)-Epigallocatechin (EGC)



(-)-Epicatechin gallate (ECg)



(-)-Epigallocatechin gallate (EGCg)

Fig. 3. Structural formulae of catechins.

Effect of Tea Catechins on the Intestinal Flora of Pigs

Eight pigs were fed the same catechin diet as the broiler chickens (0.07% tea catechins, corresponding to six 150 ml cups of tea a day for humans) for 2 weeks [8]. Feces were collected and analyzed after the first and second week of feeding, and 1 week after the completion of catechin feeding. Similar to the chickens, catechin feeding influenced the intestinal flora as well as intestinal metabolites. Figure 6 shows the decrease of putrefactive products during catechin feeding, and the sharp increase of these products after catechin feeding was stopped.

EFFECTS OF TEA CATECHINS ON THE BOWEL MOVEMENT AND FECAL FLORA OF HUMANS

Effects of Catechins on Bowel Movement

A group of 30 healthy volunteers were administered 500 mg of tea catechins in tablet form for 3 months [9]. Two doses of 250 mg each were taken every day after breakfast and dinner. Volunteers ranged in age from 20–70 (almost 50% were 40–50), with slightly more females than males. During and after the 3-month trial, there were no abnormalities in body weight, blood pressure, biological tests, and general check-ups. Questionnaires were collected before and after the trial. Those who indicated that their general condition was good increased from 19 to 30%. There was a slight increase in the number of people who woke up occasionally in their sleep. This might be caused by residual caffeine in the tablet (10% of the catechin content). The number of people having regular bowel movements increased from 51 to 81% (Fig. 7). Noteworthy is that 38% of the volunteers reported the condition of their stools improved during catechin intake.

TABLE II. Decomposition of EGCg in the Content of the Digestive Organs In Vitro

Selection of tract	Residual EGCg (%)
Stomach	100
Small intestine	85–90
Large intestine	75–80

Effects of Tea Catechins on the Fecal Flora of Tube-Fed Patients

The effects of tea catechins on fecal flora and fecal metabolic products were studied in 10 female and 5 male tube-fed patients, ranging from 51 to 93 years of age. They had varying ailments, mostly cerebral strokes, but none had complications of the gastrointestinal tract or endocrine organs. They received the same diet of 1,000 Cal of Ensure Liquid® (Dainabot, Ja-

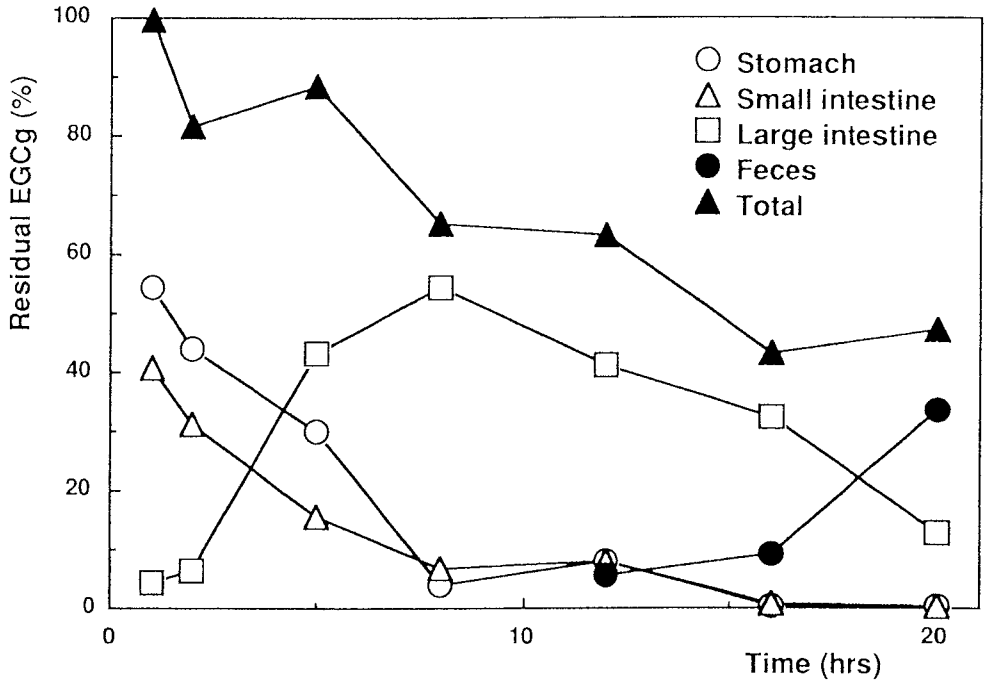


Fig. 4. Residual EGCg in the section of the digestive tract of rats administered 50 mg of EGCg.

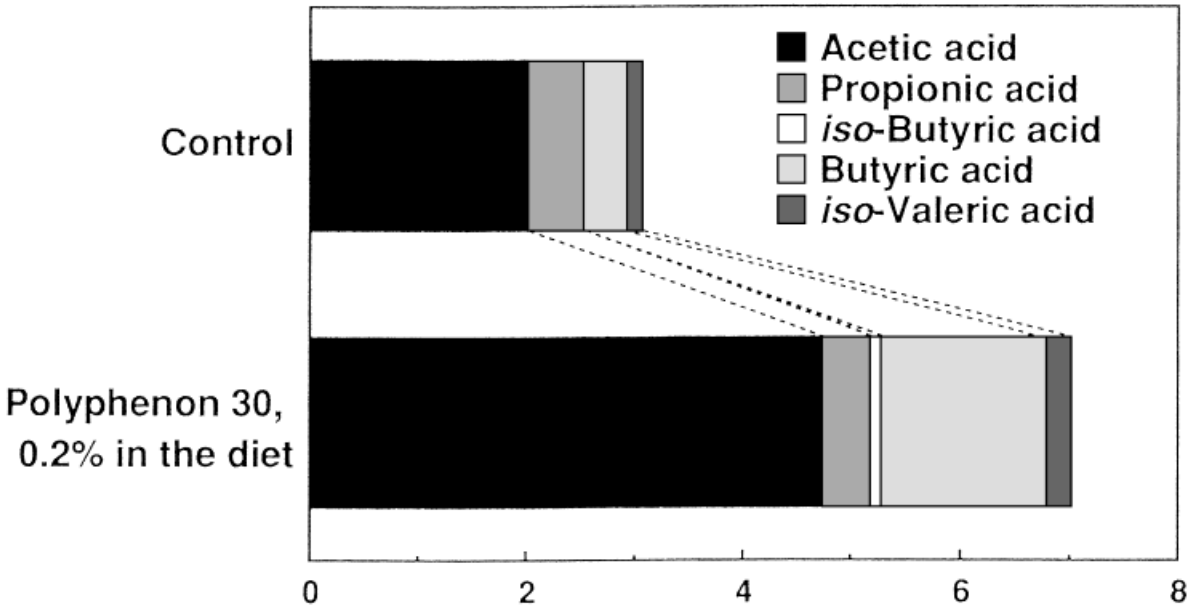


Fig. 5. Effect of tea catechin intake on organic acids of chicken caeca (feeding 56 days).

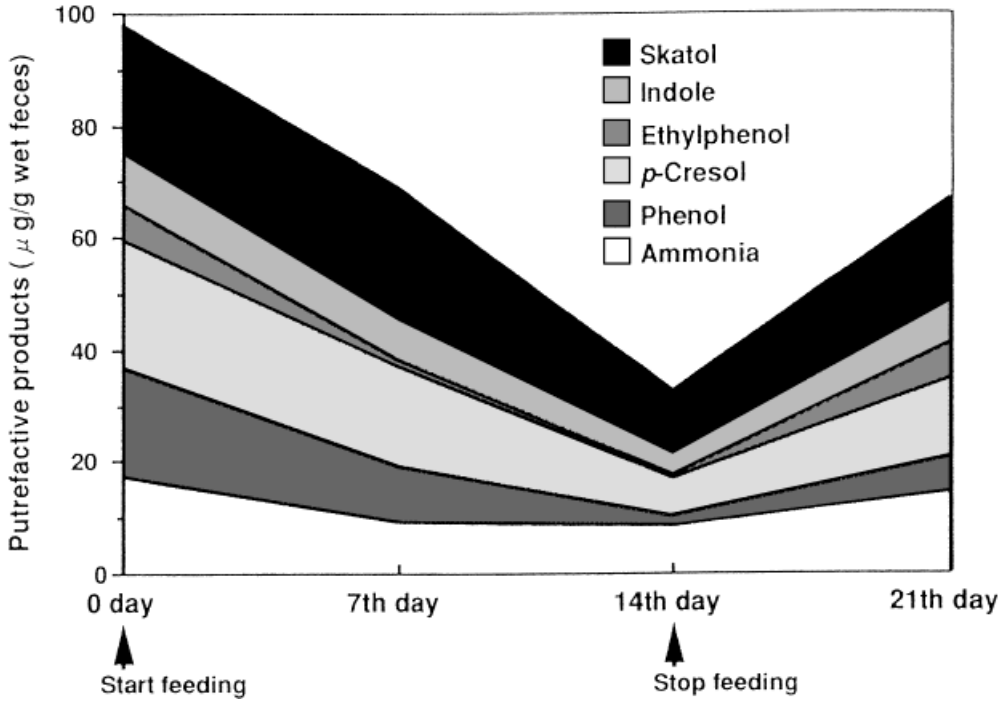


Fig. 6. Effect of tea catechin intake on odorous compounds in pig feces (0.07% catechins in the diet).

pan) per day. About 30 ml of soy sauce was supplemented a day for sodium intake. Tea catechin powder, Polyphenon 60® (containing 60% tea catechins), was provided by Mitsui Norin Co., Ltd., Japan. Three hundred mg of tea catechins (467 mg of Polyphenon 60®) was divided into doses of 100 mg and administered 3 times daily with Ensure liquid through nasogastric or gastric tubes for 3 weeks. One hundred mg of tea catechins is about the amount in two cups of green tea. Feces were collected on days 0, 7, 14, 21. Changes in bacterial flora and fecal metabolites were monitored. Tea catechin supplementation increased lactic acid bacteria

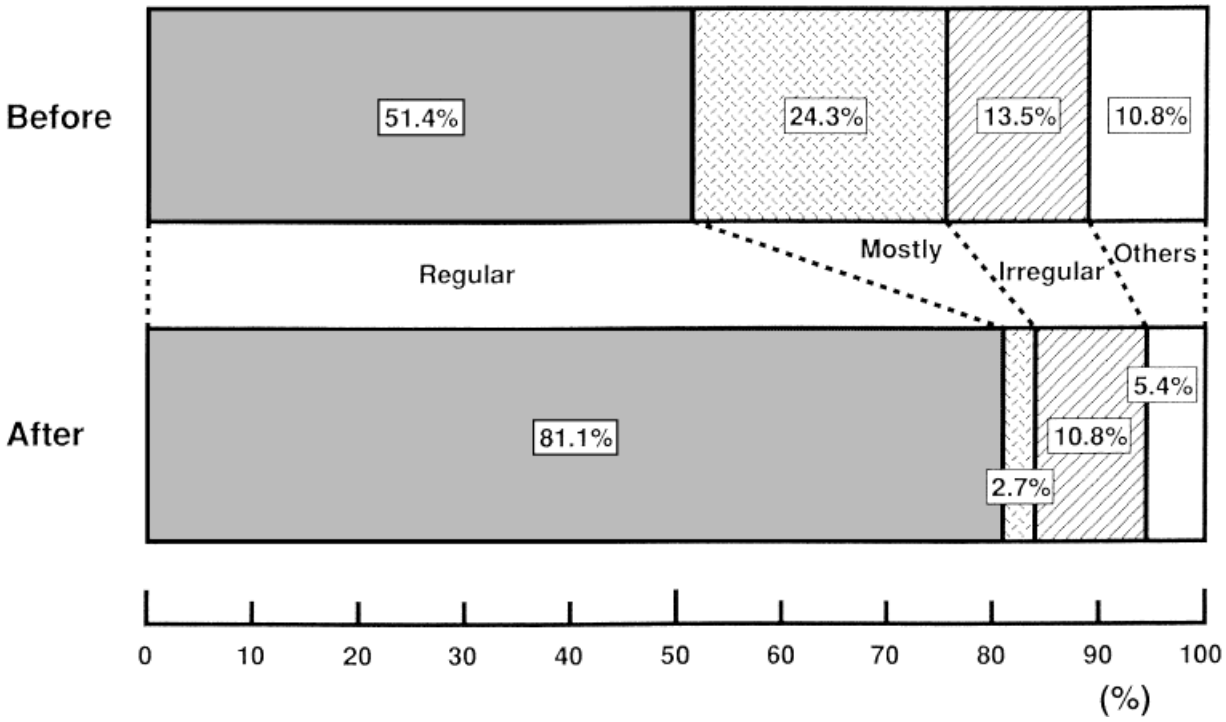


Fig. 7. Effect of dietary tea catechins (500 mg/day for 12 weeks) on bowel movement habits in human.

and decreased putrefactive bacteria, decreased odorous compounds and increased organic acids, as well as lowering pH (Fig. 8). The nursing staff reported that it was less onerous to change the diapers of immobilized patients undergoing catechin supplementation because of fewer obnoxious odors. Details were reported elswhere [10].

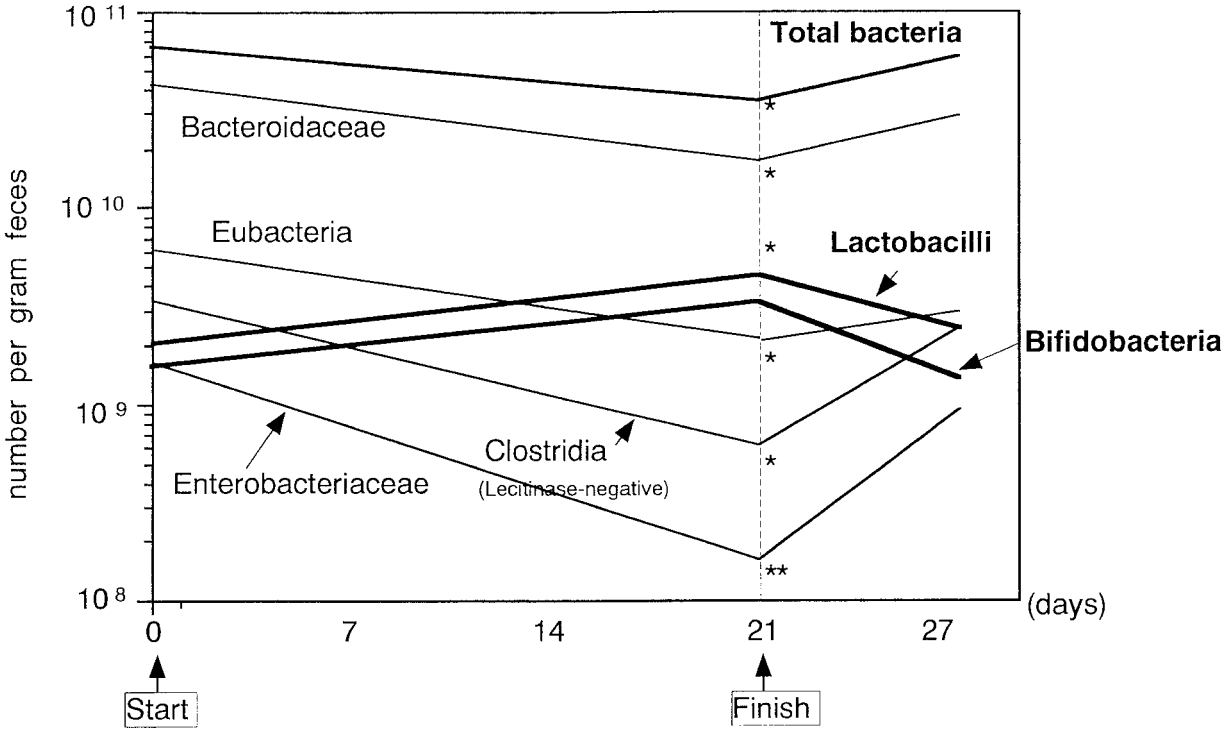


Fig. 8. Effect of Polyphenon 60 administration on fecal flora of 15 human volunteers.

CONCLUSION

Tea is one of the most popular drinks in the world. The habit of tea drinking has a long history and is geographically widespread. Any toxic effect of tea polyphenols is mitigated by the relatively low concentration in tea that is palatable to drink, and by water consumed throughout the day. Tea polyphenols (tea catechins) could benefit from more detailed study of their effects in age-related diseases such as cancer. Still to be clarified are to what extent tea catechins are absorbed and how they are metabolized inside the body. This paper has examined tea polyphenols in the digestive tract based on the assumption that a good proportion of ingested polyphenols will remain unchanged until excreted. Daily administration of tea catechins appears to exert a positive effect on the intestinal flora of humans as well as animals; when the dosage ceases, the effect is lost. The micro-floral condition of the intestine is said to play an important role in causation and prevention of various disorders. We plan further study on the intestinal influence of tea catechins.

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