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FRIED POTATOES AND HUMAN CANCER

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A considerable public concern about cancer risk from acrylamide-rich foods followed the announcement that high concentrations of acrylamide are found in fried potatoes and potato chips and, more generally, in starch-containing foods cooked at high temperatures. From a series of hospital-based case–control studies conducted in Italy and Switzerland between 1991 and 2000, we have analyzed the relation between intake of fried/baked potatoes and cancer risk. The cancer sites considered were oral cavity and pharynx (749 cases, 1,772 controls), esophagus (395 cases, 1,066 controls), larynx (527 cases, 1,297 controls), large bowel (1,225 colon and 728 rectum cases, 4,154 controls), breast (2,569 cases, 2,588 controls) and ovary (1,031 cases, 2,411 controls). All cancer cases were incident and histologically confirmed. Controls were subjects admitted to the same network of hospitals of cases for acute, non-neoplastic conditions. All the odds ratios (OR) for the highest *vs.* the lowest tertile of intake ranged between 0.8–1.1. We found no evidence of interaction with age, gender, alcohol and tobacco use. Our data provide reassuring evidence for the lack of an important association between consumption of fried/baked potatoes and cancer risk.

Key words: *acrylamide; cancer risk; case–control studies; fried potatoes*

Fried and baked potatoes are an important source of acrylamide in foods. Consequently, consumption of fried and baked potatoes has been used as an indicator of acrylamide intake, although a number of other starchy foods may contain consistent levels of acrylamide, and fried/baked potatoes account for a modest proportion of acrylamide intake only.

Acrylamide is a vinyl monomer that improves the aqueous solubility, adhesion and cross-linking of polymers. An International Agency for Research on Cancer (IARC) Working Group evaluated acrylamide in 1994 and, even though there was inadequate evidence for carcinogenicity in humans from a limited number of occupational studies, it classified the substance as "probably carcinogenic to humans" on the basis of sufficient evidence for carcinogenicity in experimental animals and mechanistic considerations.[1] A considerable public concern about cancer risk from acrylamide in foods followed an announcement by the Swedish National Food Administration that high concentrations of acrylamide are found in fried potatoes and potato chips and, more generally, in starch-containing foods cooked at high temperatures for a long period.[2–9] These findings have been confirmed by scientists in Norway, Switzerland and the United Kingdom. The issue was discussed in an urgent World Health Organization Expert Consultation, which concluded that the new findings constitute a serious problem, and called for additional research.[6–8]

A debate is open on the opportunity of advising the general public to reduce the intakes of the most contaminated and least nutritious foods,[9] *i.e.*, French fries and potato chips. Thus analyzing the relation between consumption of fried/baked potatoes and cancer risk may give suggestions on the issue.

We address this concern using extensive data from a series of published large case–control studies of cancer of various sites, conducted in Italy and the Swiss Canton of Vaud between 1991–2000.

MATERIAL AND METHODS

Data were obtained from a series of coordinated hospital-based case–control studies with the same design, questionnaire and inclusion criteria, that were described extensively elsewhere.[10–15] In brief, the first study, on cancer of the oral cavity and pharynx, was conducted between 1991–97 in Pordenone, Udine, Rome, Latina and in Switzerland and included 749 cases (median age 57 years) and 1,772 controls (median age 57 years) matched on age, gender and study centre. The second study, on cancer of the esophagus, was conducted between 1992–99 in Milan, Pordenone, Padua, Udine and Switzerland and included 395 cases (median age 60 years) and 1,066 controls (median age 60 years) matched on age, gender and study centre. The third study, on laryngeal cancer, was conducted between 1992–2000 in Milan, Pordenone, Gorizia, Udine and Switzerland and included 527 cases (median age 61 years) and 1,297 controls (median age 61 years) matched on age, gender and study centre. The fourth study, on large bowel cancer, was conducted between 1992–96 in Milan, Pordenone, Gorizia, Genoa, Forlì, Rome, Latina and Naples and included 1,225 cases of colon cancer (median age 62 years), 728 cases of rectal cancer (median age 62 years) and 4,154 frequency matched controls (median age 58 years). The fifth study, on breast cancer, was conducted between 1991–94 in the same areas of the fourth study and included 2,569 cases (median age 55 years) and 2,588 unmatched controls (median age 56 years). The sixth study, on cancer of the ovary, was conducted between 1992–99 in Milan, Pordenone, Gorizia, Padua, Udine, Rome, Latina and Naples and included 1,031 cases (median age 56 years) and 2,411 frequency matched controls (median age 57 years). All cancer cases were incident and histologically confirmed. Controls were patients hospitalized for a wide spectrum of acute non-neoplastic conditions (overall, 24% had traumas, 29% non-traumatic orthopedic disorders, 21% acute surgical conditions, and 27% miscellaneous other illnesses).

Cases and controls were aged ≤79 years, and were identified and questioned by trained interviewers during their hospital stay,

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TABLE I – OR AND 95% CI FOR SELECTED CANCERS ACCORDING TO WEEKLY CONSUMPTION OF FRIED/BAKED POTATOES IN ITALY AND SWITZERLAND, 1991–2000

Cancer site	No. cases:No. controls	Frequency of consumption			*p*-trend
		0[1]	1	>1	
Oral cavity/pharynx[2]	749:1,772	1	1.1 (0.8–1.4)	1.1 (0.9–1.4)	0.40
Oesophagus[2]	395:1,066	1	1.2 (0.9–1.8)	1.0 (0.7–1.5)	0.93
Larynx[2]	527:1,297	1	1.1 (0.8–1.5)	1.1 (0.8–1.5)	0.56
Large bowel[3]	1,953:4,154	1	1.0 (0.9–1.2)	0.8 (0.7–1.0)	<0.05
Colon[3]	1,225:4,154	1	1.0 (0.9–1.2)	0.8 (0.7–1.0)	<0.05
Rectum[3]	728:4,154	1	1.0 (0.8–1.2)	0.9 (0.7–1.0)	0.14
Breast[4]	2,569:2,588	1	1.1 (1.0–1.3)	0.9 (0.8–1.1)	0.42
Ovary[4]	1,031:2,411	1	1.4 (1.1–1.7)	1.1 (0.9–1.3)	0.35

[1]Reference category.–[2]ORs adjusted for age, gender, study center, education, body mass index, energy intake, alcohol consumption and smoking habit.–[3]ORs adjusted for age, gender, study center, education, body mass index, energy intake, alcohol consumption, smoking habit and physical activity.–[4]ORs adjusted for age, study center, education, body mass index, energy intake, and parity.

in the same network of teaching and general hospitals in the areas under surveillance. The proportion of refusals was less than 5% in cases and controls in all studies.

The same structured questionnaire was used in all studies, including information on socio-demographic factors, anthropometric variables, smoking, alcohol and other lifestyle habits, a problem-oriented medical history, physical activity and history of cancer in relatives. Information on diet referred to the previous 2 years and was based on the same validated and reproducible food frequency questionnaire (FFQ),[16,17] comprising 78 foods, food groups or recipes, and allowing the estimation of energy intake. Among the items in the FFQ, 2 questions referred specifically to consumption of fried/baked potatoes. It was asked for the weekly frequency of consumption of fried/baked potatoes, as well as for their usual portion size. No information was obtained on the common degree of browning of potatoes, nor on their acrylamide contents.

Odds ratios (OR), and their corresponding 95% confidence intervals (CI), for successive levels of fried/baked potatoes (0; 1; >1 portion/week, *i.e.*, approximate tertiles among controls) were computed using unconditional multiple logistic regression (in frequency matched studies, *i.e.*, breast, ovarian and colorectal cancers) or conditional one (in studies matched on age, gender and study centre, *i.e.*, upper aero-digestive tract cancers).[18] All regression models included terms for age, study centre, gender, education, body mass index and energy intake. Further adjustments were made for parity (breast and ovary), alcohol and smoking habits (upper aero-digestive tract and large bowel) and physical activity (large bowel).

RESULTS

Table I shows the multivariate OR, and their 95% CI, for increasing tertiles of consumption of fried/baked potatoes, and the corresponding *p*-values for linear trend. None of the OR for the highest tertile of intake was significantly different from the null value, and all the estimates ranged between 0.8–1.1. An inverse trend in OR with increasing consumption of fried/baked potatoes was observed for colon cancer and for large bowel cancer overall ($p < 0.05$).

We have evaluated possible interactions of fried/baked potato consumption with a number of variables in relation to cancer risk at various sites. Variables investigated were age, gender, tobacco and alcohol use. No evidence for interaction was found (data not shown).

DISCUSSION

In these populations consumption of fried/baked potatoes is rather infrequent as compared to other standards, such as in the United States. Thus, it is possible that in our studies the associations, as well as dose–response relationships, between fried/baked potatoes and the risk of cancer could not be remarked due to low thresholds. When we estimated the OR for the approximately 10% of the subjects reporting consumption of more than 2 portions per week of fried/baked potatoes, however, no significant excess risk of cancer at any site was evident. The inverse association between potato intake and large bowel cancer risk became more evident (OR = 0.7, 95% CI = 0.5–0.8), though this finding is likely to be attributed to chance alone.

The strength of the evidence presented for a lack of a positive association between consumption of fried/baked potatoes and risk of cancer at several sites stems from the large size of the studies, the high participation rate, the allowance for several potential confounding factors, including education and energy intake,[19] and the reliance on a validated and reproducible FFQ.[16,17] The correlation coefficient (*r*) for reproducibility of questions on consumption of fried/baked potatoes was 0.52.

These findings are limited to southern European population groups, that use different cooking processes and added lipids in comparison to northern Europeans and Americans.[20] There is no indication, however, that the lipid used is a crucial factor in the generation of acrylamide during the frying or baking of potatoes. Thus, our data provide reassuring evidence for the lack of an important association between moderate consumption of fried/baked potatoes and cancer risk at the investigated sites.

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