Relating fruit and vegetable consumption in households with residue generation and utilization in the city of Heraklion, Crete, Greece

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SUMMARY

Questionnaires regarding the amount of nine kinds of fruit and ten kinds of vegetable (including potatoes) consumed on a weekly basis were distributed to 82 different households in the city of Heraklion (population approximately 200,000), capital of the island of Crete, at the southernmost point of Greece. The city is the fourth largest in the country, in which, according to the answers collected through the questionnaires, the educational level of parents was 24.4%, 50.0% and 25.6% with primary, secondary and higher education, respectively. Families with higher parental education consume more fruit (283 g/person day⁻¹) than families having a secondary and primary parental educational level (265 and 195 g/person day⁻¹, respectively). As far as vegetables (excluding potatoes) are concerned, families with secondary and higher parental education consume more (357 and 311 g/person day⁻¹, respectively) than primary educated parents and their family members, who, however, consume larger quantities of potatoes (206 g/person day⁻¹) than the other two groups. While these values are higher than the minimum amount of fruit and vegetables suggested by the World Health Organization, they are lower than the amounts suggested as optimum for a healthy diet. The mean residues produced from these foods per person participating in the survey were estimated at 202 g/day. Based on this value, a city of the size of Heraklion produces a total of more than 40,000 kg/day of waste derived from fruit and vegetables. An integrated educational and environmental programme aiming to improve people’s dietary habits as well as promote waste source separation schemes, would result in increasing both the amount of fruit and vegetables consumed as well as the amount of similar ‘green kitchen residues’ that would be recycled through composting instead of being lost as land-fill. It is estimated that the
high-quality compost which could be produced through a complete implementation of such a programme would allow the production of more than 3500 ton of high-quality compost annually.

INTRODUCTION

The way in which consumer behaviour has developed and been shaped in the last two decades in Greece has seriously affected both public health and the environment. The abundance of goods has promoted an improvement in living standards, the reduction of pestilential diseases and has increased life expectancy (NSS 2004). Unfortunately, at the same time, it has increased the incidence of other dangers such as cardiovascular diseases and obesity (Voukiklaris et al. 1996; Panagiotakos et al. 2002; Pitsavos et al. 2003). Greece is probably the only European country that has recorded increasing rates of morbidity and mortality from chronic diseases such as cardiovascular diseases (Kesteloot et al. 2002). Longitudinal data from the Cretan cohort of the Seven Countries Study showed a substantial increase in serum cholesterol, blood pressure and body mass index between 1960 and 1991 (Kafatos et al. 1997).

It is well recognized that the key tactic for confronting these public health problems is through health and nutrition education campaigns aiming to improve dietary practices, health beliefs and attitudes (Manios et al. 2002; Warren et al. 2003; Sahyoun et al. 2004). Considerable improvements to health standards are possible using a systematic information and education campaign concerning diet (Panagiotakos et al. 2002; Manios et al. 2002; Warren et al. 2003; Sahyoun et al. 2004). Experience has shown that, through this practice, important results can be achieved using simple solutions, such as for example convincing consumers to increase their consumption of vegetables and fruits (Ou et al. 2001).

At the same time (mid-1980s), solid waste management and, more specifically, Municipal Solid Waste (MSW) management had evolved into one of the most serious environmental (and social) problems in the country. Even now, 20 years later, it remains one of the most important problems (Agapitidis and Frantzis 1998). Under pressure from European legislation, such as the 1600/2002/EU and 99/31/EU directives (concerning sustainable development and landfill operations), and the need to achieve promised reductions in greenhouse gases, the Greek political and environmental leadership is looking for measures which will help accomplish these goals.

Waste minimization and source separation is globally considered as one of the most promising and sustainable solutions to waste management problems, especially if accompanied by recycling and reuse practices (Beccali et al. 2001; Tjell 2003). However, Greek society is barely educated and trained for such policies, which are confronted by skepticism. Once more, people must be subjected to a relevant systematic information and education campaign, this time concerning issues such as source separation and recycling of household wastes.

Summarizing all the above, it is obvious that both the necessary changes in the way Greek people eat and handle their wastes can be achieved mainly through education and information campaigns. This research team believes that it is possible to integrate these two requirements into a common Programme for Health and Environmental Education, with the intention of changing people’s consumer behaviour in an effort both to improve their dietary activities and alter waste production and disposal habits, towards a healthier, environmentally friendly and sustainable society. The Greek Ministry of Education has funded the design and pilot application of such a programme for a medium-sized city.

It is of great importance for the success of such an effort that as much data as possible be obtained on the existing state of people’s dietary conduct, as well as the effect of that conduct on waste production. The aim of this work was to record the existing vegetable and fruit consumption in such a medium-sized city, as well as the residues generated from such sources. This would allow us to determine the level of improvement that should be imposed in order to achieve optimum vegetable and fruit consumption (Trichopoulou et al. 2003). It will also allow us to estimate: (a) the existing amount of residues produced through the consumption of fruits and vegetables, (b) the effect that such a campaign will have on the
composition of municipal wastes, and (c) the amount of high-quality compost that could be produced from utilizing these wastes now and in the future.

**METHODOLOGY**

Heraklion is the capital of the island of Crete (Region of Crete), at the southernmost point of Greece. The city, the fourth largest in the country, has a population of over 200,000. Despite its urban character and its financial profile, which is based mainly on tourism, the city strongly interacts with the agricultural communities surrounding it. This creates a mixed socio-economic human mosaic, in which many people work in the city but retain a part-time farming occupation, mainly related to olive oil production.

Gibson (1990) regarded as household food consumption the total amount of food available for consumption in the household, excluding that eaten away from home, unless taken from home. Accordingly, in this study, the total amount of vegetables and fruit available for consumption was regarded as the total amount of vegetables and fruits that were either purchased in the market, produced in the household and/or received as gifts, a very popular custom in Crete. The household vegetable and fruit consumption estimation used in this study does not provide information on the consumption of vegetable and fruits by specific individuals within each household. Instead, vegetable and fruit consumption per person was calculated irrespective of age or sex.

A total of 82 families, comprising 286 people, were randomly selected from all the different parts of the city. The survey took place in spring 2002, April and May. In each family the mother was contacted and given the relevant questionnaire with detailed instructions on how to fill it in (Dwyer and Hetzel 1980). The amount of nine different kinds of fruit and ten different kinds of vegetable (including potatoes) and the date on which these were purchased, harvested or received was recorded for a period of 3 to 5 weeks. The amount of fruit and vegetables stocked in the house was not taken into consideration. The recording period started on the day of first acquisition of fresh fruit or vegetables and ended with the last recorded acquisition. The mean number of days between each acquisition was calculated for each household, based on the recorded data, and used to estimate the consumption period. The consumption period was equal to the recording period plus the mean number of days between acquisitions. For example a family recorded its first acquisition on the 12th of April and its last on the 6th of May. The mean intervening acquisition period was 4 days. In this example, the recording period was 25 days, while the consumption period was 29 days. At the end of the consumption period, the amount of each kind of fruit or vegetable introduced into the household was added up and divided by person and by day. Great importance was placed on the amount of potatoes consumed in each household.

The level of education (primary, secondary and higher) of the parents was also recorded in the questionnaire. If there was a different level of education between mother and father, the father’s educational level was used. Each family, from this point onwards in the paper, will be characterized by this educational level.

As far as the residues produced from the various fruits and vegetables are concerned, these were determined by the Solid Waste and Wastewater Management Laboratory of the TEI of Crete. Three kilograms of each kind of fruit and vegetables identified in the questionnaire were brought to the lab, where three different individuals prepared them (cleaning, peeling, etc.) for consumption in the same way as in the households. The three people involved were isolated from each other in an effort to minimize any effect on their behaviour. The wastes produced were weighed and a mean value produced.

**RESULTS AND DISCUSSION**

Table 1 presents a comparison of the educational level of the parents whose families took part in the survey, with the educational level of the citizens of Heraklion [1991 population census (NSS 2004)] and the population of Heraklion Prefecture [2001 population census (NSS 2004)]. The NSS has not yet published the relevant 2001 population census analysis for the city alone, so we are using the two existing sources of data for comparison. The prefecture analysis includes the population (with a large percentage of elderly people) living in villages and mainly small agricultural communities, with a considerably larger number of just primary educated inhabitants than found in the city. This
The assumption allows us to consider that the households selected provided a representative picture of the city’s population at the present time. The number of members of each family group is also presented in Table 1.

The estimated mean amount of vegetables and fruits allocated to each member of each family with a specific parental educational level is presented in Table 2. Table 3 presents the mean amount of wastes derived from preparing each kind of fruit.
and vegetable for consumption. Through these values, the amount of residue produced by the fruits and vegetables allocated to each person on a weekly basis were calculated (Table 2). By deducting these two values it is possible to estimate the net amount of fruit and vegetables consumed by each person on a weekly and a daily basis. Table 4 presents this net amount for each person belonging to a family with a specific parental educational level. The mean population value in which the population percentage dispersion (Table 1) has been taken into account was $325, 253$ and $168$ g/person day$^{-1}$ of vegetables, fruits and potatoes, respectively.

Families with a higher education consume larger amounts of fruit than those with a primary level of education. Their consumption also exceeds that of families with secondary education (Figure 1). Results regarding vegetable (not including potatoes) consumption are similar, with secondary education families recording the highest values, followed by higher educated families (Table 4). The primary education families record both the lowest non-potato vegetable consumption values and the significantly highest potato consumption values (Table 4).

What these findings indicate is that quality of food and good dietary practices, which nowadays

### Table 3
Mean residue production from preparing the various kinds of vegetables and fruits for consumption

<table>
<thead>
<tr>
<th>Vegetables</th>
<th>Residues (kg/kg of vegetable)</th>
<th>Fruits</th>
<th>Residues (g/kg of fruit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potatoes</td>
<td>0.146</td>
<td></td>
<td>0.199</td>
</tr>
<tr>
<td>Dry onions</td>
<td>0.324</td>
<td></td>
<td>0.292</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>0.055</td>
<td></td>
<td>0.285</td>
</tr>
<tr>
<td>Courgettes</td>
<td>0.127</td>
<td></td>
<td>0.270</td>
</tr>
<tr>
<td>Lettuce</td>
<td>0.321</td>
<td></td>
<td>0.617</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>0.205</td>
<td></td>
<td>0.145</td>
</tr>
<tr>
<td>Fresh beans</td>
<td>0.056</td>
<td></td>
<td>0.016</td>
</tr>
<tr>
<td>Eggplant</td>
<td>0.074</td>
<td></td>
<td>0.198</td>
</tr>
<tr>
<td>Cabbages</td>
<td>0.103</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 4
The amount of vegetables, fruit and potatoes consumed by each person of each group per day (g/person day$^{-1}$), together with the mean population value

<table>
<thead>
<tr>
<th>Educational level</th>
<th>Primary</th>
<th>Secondary</th>
<th>Higher</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetables</td>
<td>273</td>
<td>357</td>
<td>311</td>
<td>325</td>
</tr>
<tr>
<td>Fruits</td>
<td>195</td>
<td>265</td>
<td>283</td>
<td>253</td>
</tr>
<tr>
<td>Potatoes</td>
<td>206</td>
<td>151</td>
<td>167</td>
<td>168</td>
</tr>
</tbody>
</table>

Figure 1 Estimated distribution of ‘green kitchen residues’ production based on parental educational level and the estimated total amount produced in the city of Heraklion on a daily basis.
are recorded as increased vegetable and fruit consumption, are closely connected to the level of education. There is similar work indicating this close connection between socioeconomic status levels and dietary practices (Panagiotakos et al. 2002; Pelto and Backstrand 2003; Gordon-Larsen et al. 2003). Based on the fact that humans can consume a rather specific amount of food on a daily basis regardless of financial and social status, it can be suggested that well-educated families are consuming more fruits and vegetables than less educated families (Costacou et al. 2003). Additionally, these results strongly indicate that education is a means of shaping and improving dietary and therefore public health standards.

Trichopoulou et al. (2003) suggest that the optimum vegetable, fruit, including nuts (nuts were not monitored in this survey) and potato amounts which should be consumed on a daily basis are 550, 362 and 89 g/person, respectively, in order to minimize the risk of chronic diseases. The mean vegetable and fruit consumption recorded for the city of Heraklion was below these levels, whereas potato consumption was considerably higher. However, the vegetable and fruit total (576 g/person day$^{-1}$) exceeds the minimum consumption of 400 (250 + 150) g/person day$^{-1}$ suggested by the World Health Organization (WHO 2003). Trichopoulou et al. (2001), in a relative survey conducted in European countries, mention that Greece was the top country in vegetable and fruit consumption, estimated at 617 (350 + 267) g/person day$^{-1}$.

Through the information presented in Tables 2 and 3, regarding residue generation from fruits, vegetables and potatoes, the amount of waste per person per day for the three educational levels can be calculated using the same methodology applied in estimating the amount of vegetables consumed per person and day. The mean amount of fruit and vegetables residues generated per person per day in the city of Heraklion according to this survey was 155 g (61 and 94, respectively), while the residues generated by potato consumption were 47 g. If these two numbers are added together, a total of 202 g/person/day is reached, representing the ‘green kitchen residues’.

The total amount of household waste produced in Heraklion per person and day is estimated at 1.2 kg, of which approximately 48% or 576 g is kitchen and garden waste (Manios and Siminis 1988; Manios 2003). The 202 g of waste (potatoes, fruits and vegetables) calculated through this work represent about the 35% of the total organic wastes. The remaining organic fraction consists of residues of other food sources before cooking, the remains of the cooked food, and green waste. In Greece, food residues (kitchen biowaste) are generally estimated at about 350 g/person day$^{-1}$ (Manios and Siminis 1988; Tchobanoglous et al. 1993; Manios 2003), which should be considered as steady, even when other fractions of the wastes increase with time (Fishbein et al. 1992). According to this, the organic waste fraction in Heraklion an be synthesised as the following: 155 g fruit and vegetable residues, 47 g potato residues, 148 g other food sources and cooked food residues, and 226 g green waste per resident and day.

In Belgium the organic fraction of domestic waste in urban areas similar to the city of Heraklion was slightly above 300 g, or 35% of the total waste. This value includes kitchen, fruit and garden waste. This small quantity of biowaste can be considered as a result of the limited consumption of vegetables and fruits (mainly), the use of precooked food, or both (Gellens et al. 1995). In relevant surveys that took place in Malaysia, the mean kitchen residue fraction of domestic waste was 38%, whereas in Turkey the mean value was over 45% (Metin et al. 2003; Kathirvale et al. 2004). These results support the findings of the present survey.

If a health, nutrition and environmental intervention programme was to apply to the city of Heraklion, it would mainly focus on how to increase fruit and vegetable consumption, and more likely reduce potato consumption. It would simultaneously promote a source separation scheme, at the core of which would be ‘green kitchen residues’. Figure 1 presents the estimated total amount of waste produced by the three parental educational level groups for the whole of the city (estimated population of 200,000), as well as the total amount produced. According to these estimations, more than 40 tons of such wastes are produced in the city on a daily basis, the great majority of which are ending up in local landfills, resulting in important environmental problems as well as increased handling cost.

Figure 2 presents an estimate of the amount of ‘green kitchen waste’ produced if the educational programme were to reach, shape and improve the dietary habits of the 25%, 50%, 75% and 100% of the city’s population to the optimum standards.
recommended by Trichopoulou et al. (2003). The difference between total population implementation of the programme and the existing situation is under 15%. A source separation scheme would allow the utilization of these amounts for the production of compost. It is estimated that the compost produced from such source-separated wastes would be equal to approximately half the amount of incoming waste. The ratio for high-quality compost, which is produced through a 10 mm screening, would be smaller and equal to one quarter of the raw materials. If the source separation scheme were to be fully implemented for the whole city of Heraklion, it is estimated that over 3500 tons of high-quality compost could be produced, equalling one third of the commercial compost imported to the island annually.

CONCLUSIONS

A source separation scheme applied in the city of Heraklion and mainly focusing on kitchen waste would allow a substantial decrease in the total amount of waste disposed of in landfills (by at least 40%), allow the municipality to attain European waste management standards, reduce landfill gases and lead to the production of high quality compost (up to 3500 t/year). The education and information campaign required for achieving such goals will be more successful if it combines efforts to change waste management habits as well as dietary practices, which are also below optimum levels.

The survey showed that vegetable and fruit consumption should be increased substantially in order to reach the estimated optimum levels recommended for decreasing the risk of chronic diseases. This would result in significant changes to public health as well as composition of the waste, and especially the kitchen waste fraction. Since such an improvement is considered necessary, national and local authorities should take appropriate measures to support both the implementation of the required educational programmes and the technical and infrastructure changes in the waste management mechanisms enabling source separation and composting of the organic fraction.

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