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Ecological footprint evaluation of improved student's menus using fishery products

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Abstract. The ecological footprints (EF) analyses were conducted in order to evaluate the environment impact of improving actual catering system by replacing 50-100% of red meat products (beef) with local/regional fishy products in the weekly meals created for "Dunarea de Jos" University (UGAL) students in 2010. Product-specific EF was calculated from consistent and quality-controlled life cycle information of food products and services, including energy, materials, transport, waste treatment and infrastructural processes. The reducing of red meat products in the student's daily menus with 50% and the reducing of long food chain at the local/regional level determined a 36.24% average decreasing of actual menu EF and the replacing of red meat with fishy products a 72.2% reducing of Eco-menus EF. At least 20.83% less amount of money could be saved in the menu creations and if we replace one day in a week 50% meat with local fishy products and the average reducing EF for menu creation in an academic year could be in average 17.27%.

Key Words: Ecological Footprint Evaluation (EFE), catering, life cycle assessment (LCA), fishery products.

Résumé. L'analyse de l'empreinte écologique où menées afin d'évaluer l'impact sur l'environnement de l'amélioration réelle de restauration système en remplaçant 50-100% des produits de viande rouge (bœuf) avec local / régional des produits de poisson dans les repas hebdomadaire créé pour "Dunarea de Jos" de l'Université (UGAL) étudiant en 2010. Spécifiques au produit EF ont été calculés à partir de cohérence et de qualité contrôlée des informations du cycle de vie des produits et services alimentaires, y compris l'énergie, matériaux, transport, traitement des déchets et des processus d'infrastructure. La réduction des produits de viande rouge dans les menus quotidiens de l'élève avec 50% et la réduction de la longue chaîne alimentaire au niveau local / régional établi en moyenne 36,24% de baisse réelle menu EF et le remplacement de la viande rouge avec des produits de poisson de 72,2% la réduction de l'éco-menus EF. Montant au moins 20,83% de moins d'argent pourraient être sauvées dans les créations de menus et si l'on remplace un jour par semaine à base de viande de 50% de produits locaux de poisson et la réduction de la moyenne EF pour la création de menu dans une année scolaire pourrait être en moyenne de 17,27%.

Mots clés: évaluation de l'empreinte écologique (EFE), de la restauration, l'évaluation du cycle de vie (ACV) des produits de la pêche.

Introduction. The ecological footprint (EF) was initially conceptualised by William Rees (1992) and further developed by Mathis Wackernagel (1994). The EF estimates the ''minimum land necessary to provide the basic energy and material flows required by the economy'' (Wackernagel & Yount 1998, 2000; Wackernagel & Silverstein 2000; Petrescu et al 2010). EF provides a measure of the extent to which human activities exceed two specific environmental limits – the availability of bioproductive land and the availability of forest areas to sequester carbon dioxide emissions. The EF integrates (i) the area required for the production of crops, forest products and animal products, (ii) the area required to sequester atmospheric CO_2 emissions dominantly caused by fossil fuel combustion, and (iii) the area required by nuclear energy demand (Monfreda et al 2004).

In 2005 the global EF was 17.5 billion global hectares (gha), or 2.7 gha per person (a global hectare is a hectare with world-average ability to produce resources and absorb wastes). The total productive area (earth biocapacity) was 13.6 billion gha, 2.1 gha per person respectively. Humanity's footprint first exceeded the Earth's total biocapacity in the 1980s. The 2005 overshoot of 30% would reach 100% in the 2030 even if recent increases in agricultural yields continue (Flint 2001). This means that biological capacity equal to two planets would be required to keep up with humanity's resource demands and waste production (FAO 2002; Petrescu-Mag 2009).

With an average growth rate of 6.9% per annum, aquaculture is the fastest growing food production sector in the world. This rapid growth faces, however, some limitations in the availability of suitable sites and in the ecological carrying capacity of actual sources. The discipline of ecological engineering addresses and quantifies the processes that are involved with management of wastes as a resource (Coll et al 2006).

Ecosystem-based management (EBM) is an integrated approach that encompasses the complexities of ecosystem dynamics, the social and economic needs of human communities, and the maintenance of diverse, functioning and healthy ecosystems (Christensen & Walters 2004).

The public universities have a particular social responsibility in being role models for encouraging best environmental practice, due to their considerable influence on societal development. Recent studies concerning ecological footprints have been focussed in University settings, given their significant social responsibility. The demand for green product rises with the number of consumers who are sensitive to environment matter and especially their degree of sensitivity (Viebahn 2002).

The present paper research investigate the impact on menu EF of introducing more local fishy products and less red meat, at the same nutritional balance imposed by the EU regulation for healthy young's nutrition in canteens.

Material and Method. In order to evaluate the improving of student's daily menu EF by replacing 50-100 % of red meat products (beef) with local/regional fishy products in the weekly meals created for UGAL student's in 2010, this paper use the ecological footprint evaluation (EFE).

The EF was evaluated with the three main components (or modules):

(i) Gross footprint of raw materials (production surface footprint);
(ii) EF for food production and processing;
(iii) EF of food transports to final consumers.

According to the original calculation model of Wackernagel & Rees (2000) a modified calculation model for the EF is proposed in the present paper research by the following equation:

$$EF = \sum_{I=1}^{N} EF_i \bullet f_i \qquad (1)$$

In the equation (1), EF_i is the EF per menu item i (m^2); f_i are the ratio of natural item i in the menu formula.

The data of food origin and transportation system for EFE were obtained directly from the canteen management office of UGAL. The EFE were conducted for fresh fishy products with the following variables of food origin and transportation system:

(i) Local- low capacity isotherms, transportation cycle under 50 km;
(ii) National- big capacity isotherms, transportation cycle under 1000 km;

The environmental impact generated by the transportation system were calculated with the following original equation (2):

$$EF_T = EF_C + EF_{TS} + EF_{CO2} \qquad (2)$$

Where: EF_T is the EF value for transportation system adopted for the raw materials; EF_C is the EF value for the production of the fuel consumed in the transportation of the brute foods; EF_{TS} is the EF value for the transportation state in the refrigeration units; EF_{CO2} is the EF value involved by the pollution generated with the emission of CO_2 in course of the transportation cycle.

The EF_C value was calculated at a rate of 0.0027ha/l of biodiesel from rapeseeds with 45% oil content and at an average fuel consummation of 5%. In term of transportation chain, we calculated the EF per km at the average value of 0.00035 gha.

The EF_{TS} value was calculated as a consummation of 10% fuel to produce the energy for transportation in the refrigeration state of the raw foods.

The EF_{CO2} were considered as a 0.2% of the fuel consummation in the long transportation cycle with big capacity isotherms and 1.2% for low capacity transportation system, in order to eliminate the pollution emission of CO_2. In this circumstance, in case of low capacity isotherms EF_T were 0.00015 ha and 0.000148 ha in case of big capacity transportation system, calculated at the maximum transportation cycles, in km.

In the calculation of product-specific EF we consider all the quality-controlled life cycle information including energy, materials, transport, waste treatment and infrastructural processes.

60% of total UGAL Students have 5 meals on a week in the canteen and the fish products are the main course (150g) once in a week. In average, 702 meals with fishy products are designed in a week and the total consuming value in an academically year (9 months) is about 947.7 kg. The total consummation of red meat is 300g/student, week and in an academically year the canteen process 1895.40 kg. The UGAL student's daily meals were composed of hors d'oeuvre, main dish with garnish and salad and dessert (total 380g). The meal components evaluated in EFE were red meat, poultry, fish, vegetables (fresh fruit, garnish vegetables), milk products and bread. Four meals, two traditional (MC1, MC2) and two Eco (EC1, EC2) were composed and subsequently analysed under EFA experimental protocol:

MC1-Red Meat (beef) 50%; Veg-25%; Milk dessert 15%; Bread 10%.
MC2- Meat (poultry) 50%; Veg-25%; Milk dessert 15%; Bread 10%.
EC1-Red Meat (beef) 25%; Fish 25% Veg-25%; Milk dessert 15%; Bread 10%.
EC2- Fish 50%; Veg-25%; Milk dessert15%; Bread 10%.

The EC1 menu were designed for a reducing with 50% of the meat content and in EC2 case meat is completely eliminated in face of fishy products included in the main dish recipes.

The ratio Animal Origin Product/Vegetable Origin Product (AOP/VOP) was designed at 65/35%.

The increasing amount of regional organic foods (fish, vegetables, milk, products, bread) in EC1 and EC2 were of 25% and 50% respectively, compared with MC1, MC2.

In term of costs management, the calculation of costs reducing were realised with an average market acquisition value of 2.85 Euro/kg in case of red meat and 1.66 Euro/kg in fish product case.

Results and Discussion. The fishy ingredients used in the UGAL canteen (Horse mackerel *Trachurus trachurus*, Blue Fish *Pomatomius saltatrix*, Sprat *Sprattus sprattus sulinus* Antipa, Bonito *Sarda sarda*) are top quality, high nutritional value and with significant health benefits. The regular integration in the institutionalised canteens of the universities generated a reducing of the environmental impact, which is 2.69 times decreased compared with the red meat of local origin (Figure 1).

The proximity of Danube source give a better raw EF value for fish, reduced with 2% than national origin fishy products and the overall environmental impact will be decreased with 2.48% all the time when the local produced fish will be favourites in the canteen acquisition.

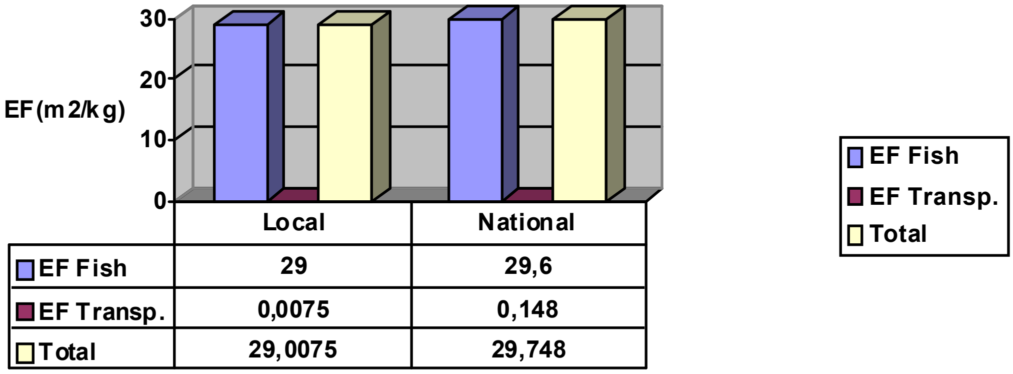


Figure 1. Ecological Footprint value (m^2/kg) for fishy products

On the national origin basis, the results of EFE for one menu item utilised as main course in the weekly cycled menus for UGAL students show that the regular use of local instead national origin fishy products determined a reducing of the EF for transportation cycle of 94.93 % (Figure2).

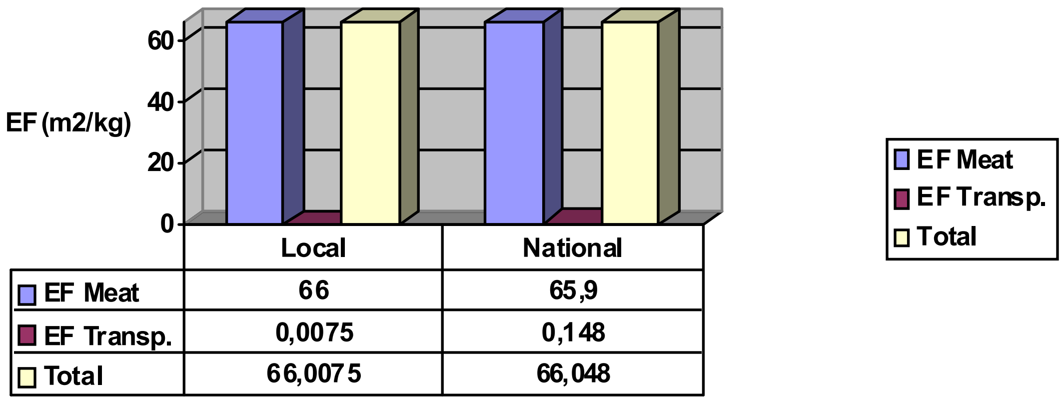
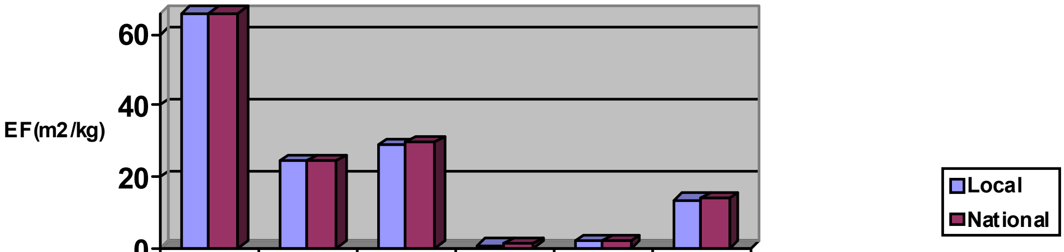


Figure 2. Ecological Footprint value (m^2/kg) for red meat products

In all cases, the items with national origin determined an important increase of the recipe item EF despite the more productive value of the primary cycle compensated by the increasing of the resources consuming with the transportation in the refrigerated state.

In the red meat case (beef), the EF value for raw brut products were reduced with 0.15% in case of national centralised farms. The high capacities of production farms due to high efficiency in the abatorization processing system but the transportation cycle with high capacity isotherms in the refrigerated state increase the meat EF with 0.148 units instead of 0.0075 in the local origin case (Figure 3).

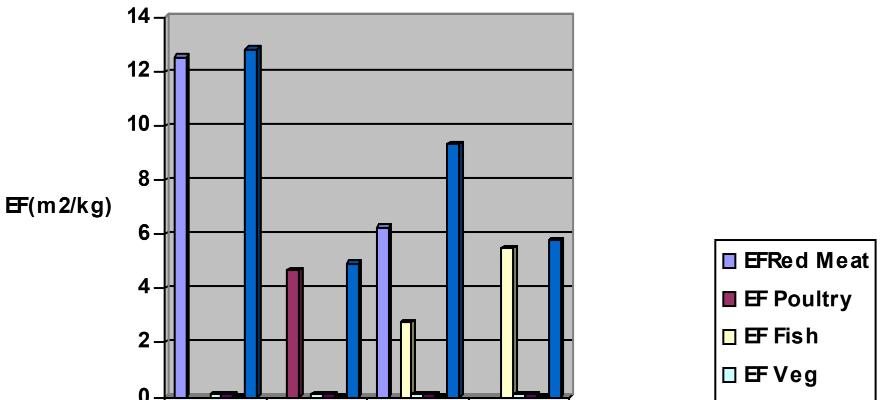


	Red	Poultry	Fish	Vegetabl	Milk	Bread
Local	66	24,5	29	1,2	2	13,85
National	66,05	24,54	29,74	1,5	2,13	14

Figure 3. Ecological Footprint value (m^2/kg) for menus natural ingredients with local and national origin

The EF for national common vegetables (potatoes, carrots, bean, fruits) is 1.5 units, with 20% greater than in the case of a local vegetables and with 13.33% increased in compare with the regional level (under 200km) source, respectively.

In the menu cases, the 50% replacing of red meat (beef) content in the daily menus with local fishy products in EC1 case and with 100% in EC2 case, on the conventional MC1 menu basis, generate a reducing of overall menu EF with 27.45% in EC1 case and with 54.83% in EC2 case (Figure 4).



	CM1	CM2	EC1	EC2
EFRed Meat	12,54	-	6,27	-
EF Poultry	-	4,655	-	-
EF Fish	-	-	2,755	5,51
EF Veg	0,114	0,114	0,114	0,114
EF Milk	0,114	0,114	0,114	0,114
EF Bread	0,052	0,052	0,052	0,052
Total	12,82	4,935	9,305	5,79

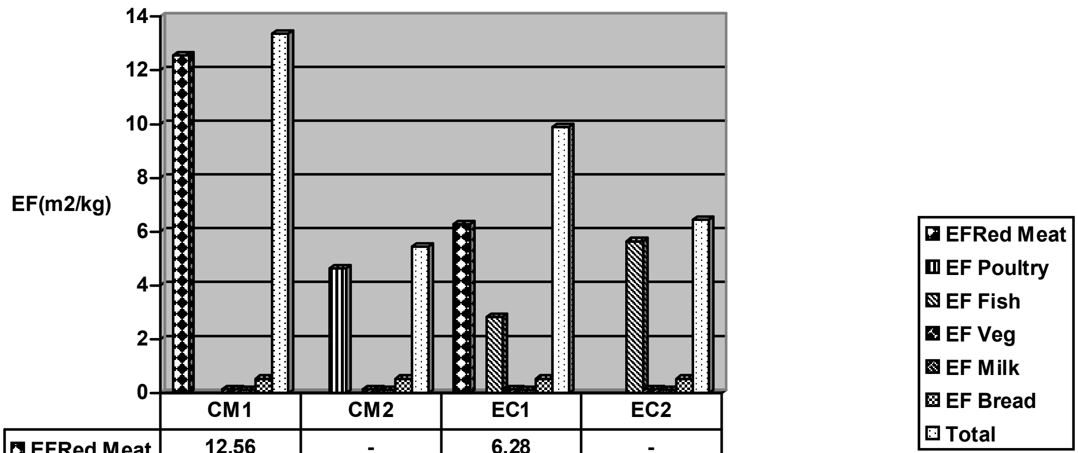
Figure 4. Ecological Footprint value (m^2/menu) for Conventional and Eco-friendly menus designed with local natural ingredients

In case of national origin ingredients, a part of the menu EF saved by the replacing of red meat with indigen fish is annulled by the increasing of the resources consuming with the transportation system. The EF reducing of overall menu EF decreased at 25.91% in EC1 case and with 51.79% in EC2 case at CM1 basis (Figure 5).

The total EF of final menu depends on the items ratio at the same origin and transportation system. Raw beef have the greatest EF amount in the all experimented menu and the vegetables the lowest value added to total EF of menu. The white meat of local origin has a reduced impact on the total menus EF because the poultry EF were with 62.87% reduced compared with red meat at the same origin and transportation system. For this reason, a replacing of red meat with poultry determined a reducing of MC2 EF with 61.54% compared with MC1. The replacing with fishy local products in EC2 case determined a reducing with almost 54.83%of the overall menu EF, because the fish EF is with 15.5% greater than poultry EF.

The menu formula MC2 show the best EF values if is composed with local origin ingredients. From the environmental, nutritional and financial point of views we recommended the EC2 formula at least once in a week and MC2 formula twice in every chart pre-planification of UGAL canteen.

In the situation in which the management of UGAL canteen decide to change the actual state of menu chart 2 MC1 formula +MC2+ EC1+ EC2/week with 2MC2+MC1+ EC1+ EC2/week, the canteen food EF module could be reduced with 17.27% in an academic year, with the promotion of the local acquisition circuits.



	CM1	CM2	EC1	EC2
EFRed Meat	12,56	-	6,28	-
EF Poultry	-	4,64	-	-
EF Fish	-	-	2,82	5,64
EF Veg	0,142	0,142	0,142	0,142
EF Milk	0,121	0,121	0,121	0,121
EF Bread	0,532	0,532	0,532	0,532
Total	13,355	5,437	9,895	6,435

Figure 5. Ecological Footprint value (m^2/menu) for conventional and Eco-friendly menus designed with national ingredients

The menus designed with all ingredients of national origin showed a increasing of the overall EF of 3.8-9.2% in CM1-CM2 menus cases, 5.9-10 % in EC1-EC2 menus cases, respectively. The transportation system in the refrigerated state of fish and milk due to a increasing of resources using measured with EF value of 94.93%. On the CM1 basis, there is the possibility to reduce the menu EF with 18.6% in the EC1 case and 19% in EC2 case. On the CM2 basis, the total EF reducing value for the complete menu were of 23.07% for EC1 menu and 51.79% for EC2 menu, respectively. In the same time, the price were consistently reduced for Eco-friendly menus which replace the red meat with local origin fishy products, with about 41.66% (from 1.80 Euro in case of CM1 menu to 1.05 Euro in EC2 case) in the same nutritional equivalence of the final menu.

Conclusions. The dominating components of ecological footprint were raw material production system and energy necessary for transportation. The reducing of red meat products in the student's daily menus with 50% and the reducing of long food chain at the local/regional level give a 36.24% average decreasing of EC1 menu EF and the replacing of red meat with fishy products a 72.2% reducing of EC2 menus EF. At least 20.83% less amount of money could be saved in the menu creations and if we replace one day in a week 50% meat with local fishy products and the average reducing EF for menu creation in an academic year could be 17.27%. In the same time, the catering systems create an important bridge between young's and the local products and the sustainable development of the regions will be encouraged.

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