A study of prospective Turkish science teachers' knowledge at the popular biotechnological issues

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Received 18 Oct., 2006
Revised 14 Dec., 2006

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Summary

The purpose of this study was to determine the knowledge level of popular biotechnological issues of prospective Turkish science teachers. A questionnaire was

administered during 2005-2006 academic year to 194 students in the Department of Science Education of a university in Turkey. The questionnaire covered six biotechnological issues such as biotechnology, agrobiotechnology, human health and pharmacy, environment and biotechnology, and food production with biotechnology. Results showed that whereas department of science education students had an approximate consistent knowledge of describing biotechnology and human health/pharmacy that almost all students had an inadequate knowledge about other biotechnological issues. Finally, the results were compared with other studies in the world.

Keywords: biotechnology education, science education, biotechnological issues

Introduction

Modern biotechnology covering numerous areas such as medicine, pharmacy, food industry, agriculture and biology is of increasing interest in Turkey as well as elsewhere in the world. New biotechnological advancements are followed and carried out in new research at universities and institutes in Turkey not withstanding that the basic problem is encountered amongst the technical staff.

Students' interest to the biotechnological knowledge as well as study areas related to biotechnology could begin in primary school and high school years. On the other hand, the knowledge level of teachers considering biotechnological concepts, processes and issues is not known clearly in Turkish context. Beyond the knowledge levels of science and biology teachers, teachers should have capacity to use and show some biotechnological equipments and materials in schools. As Harms (2002) stated, science teachers have a responsibility to inform their students of several aspects of biotechnology both scientifically and technically.

Many studies have been carried out to develop and evaluate biotechnology education programs and models for students and science teachers in worldwide. The goal of the researches on the development of biotechnology education was to raise an awareness of the importance of biotechnological processes and bioethics, especially in developed countries (Olsher & Dreyfus, 1999; Chan & Lui, 2000; EIBE, 2003; France, 2000; Dunham et al., 2002; Dibartolomeis & Moné, 2003; Lewis et al.., 2003; Rota & Izquierdo, 2003). In contrast to developed countries, the curricula of primary and high

schools and faculties (colleges) of education seem to have comparatively inadequate biotechnology components in Turkey. The development of biotechnology education programs and models for science teachers and students is of importance since the concepts of biotechnology are of significance to all science and biology teachers using good curriculums and instructional strategies (Dunham et al., 2002). On the other hand, there is a question still to be answered whether undergraduate science education student teachers are to meet with satisfactory subject knowledge, and with practical and pedogogical skills to teach different aspects of biotechnology and to encourage their students to understand not only the scientific context but also the conceptual, ethical, moral and social issues of biotechnology within the framework of a wider curriculum (Marchant & Marchant, 1999; Thomas et al., 2002).

The purpose of this study was to determine the knowledge level of Turkish students of the department of science education in relation to popular biotechnological items, such as stem cell technology, and genetically modified corps. Similar studies have been carried out to determine the perception and knowledge level of biotechnology processes and bioethics amongst adults' and pupils' in other countries (Macer et al., 2000; Dawson & Schibeci, 2003; Cavanagh et al., 2005; Eurobarometer, 2005; Biotechnology Australia, 2005). The results of the Turkish students of the department of science education' perceptions of biotechnological issues were compared with other studies in the world.

Materials and Methods

"The Biotechnological Issues Questionnaire" was administered to 194 science education undergraduate students (prospective science teachers) in a Turkish university during the 2005-2006 academic years (See in the appendix). The questionnaire contains 20 questions relating to knowledge of popular biotechnological issues. The responses of students for each item in the questionnaire correspond that if the meaning of a statement is correct, it is expected to be checked the true box, if the meaning of a statement is not correct, the answer is to be the false box. Finally, if they have any idea about a statement, they chose the neutral box. The data was analyzed by using SPSS (Statical Package for the Social Sciences, ver.13.0) for the frequency, percentage of each statement, according to responses of students based on the questionnaire employed in this study.

Results

All responses of the students to biotechnological issues are shown in the following Table 1.

Table1. Responses to the questions relating to knowledge about biotechnology (See the appendix for the details of questions)

Questions #	True		Neutral		False		Total	
	f	%	f	%	f	%	f	%
1	175	**90.2**	15	7.7	4	2.1	194	100
2	118	60.8	50	25.8	26	**13.4**	194	100
3	99	**51.0**	40	20.6	55	28.4	194	100
4	83	42.8	48	24.7	63	**32.5**	194	100
5	111	**57.2**	30	15.5	32	16.5	194	100
6	57	29.4	105	54.1	32	**16.5**	194	100
7	53	**27.3**	93	47.9	48	24.7	194	100
8	116	59.8	54	27.8	24	**12.4**	194	100
9	130	**67.0**	44	22.7	20	10.3	194	100
10	62	**32.0**	105	54.1	27	13.9	194	100
11	145	**74.7**	34	17.5	15	7.7	194	100
12	14	7.2	128	66.0	52	**26.8**	194	100
13	92	47.4	74	38.1	28	**14.4**	194	100
14	35	18.0	117	60.3	42	**21.6**	194	100
15	91	**46.9**	44	22.7	59	30.4	194	100
16	42	**21.6**	115	59.3	37	19.1	194	100
17	11	5.7	160	82.5	23	**11.9**	194	100
18	70	36.1	81	41.8	43	**22.2**	194	100
19	60	**30.9**	85	43.8	49	25.3	194	100
20	102	52.6	71	36.6	21	**10.8**	194	100
Average	**83.33**	**42.93**	**74.6 5**	**38.47**	**35**	**18.04**	**194**	**100**
Average % of true statements		**49.88**		**31.18**		**17.84**		**100**
Average % of false statements		**35.98**		**45.77**		**18.25**		**100**

These general averages do not correspondence to the real percentage of how the students give the right answers to the statements because the answers of ten of twenty statements are true and the answers of the other ten statements are false. In the

result, the half of the students (49.88%) say "true" the true of ten statements but the percentage of the students said "not true" the true of ten statements was also high (35.98%). In the false statements, 18.25% percent of the students said "false" the false of ten statements but 45.77 % of the students were not sure the false statements "false" or "true".

After giving the general results of students' responses to biotechnological issues covering the mean of biotechnology, agricultural biotechnology and benefits, health, environmental biotechnology, and issues, questions are classified under five different areas of biotechnological issues and matters in Tables 2, 3, 4, 5, and 6.

Students' responses to the questions related to the knowledge of biotechnological issues are shown in the Table 2.

Table 2. Students' responses to the questions related to the knowledge of describing biotechnology

Questions #	True		Neutral		False		Total	
	f	%	f	%	f	%	f	%
1	175	**90.2**	15	7.7	4	2.1	194	100
2	118	60.8	50	25.8	26	**13.4**	194	100
13	92	47.4	74	38.1	28	**14.4**	194	100
17	11	5.7	160	82.5	23	**11.9**	194	100

Most of the students answered first, second and 13th questions (using one-cellular microorganisms, side effects of biotechnological methods, if or not biotechnological methods only transfer genes from one organism to another organism) correctly (90%; 60.8%; and 47.4%, respectively), but 82.5% of students answered 17th question (biotechnology was described as cytogenetics), as neutral. The authors suggest that most of the students have misconception about cytogenetics and biotechnology.

Fourth, seventh and fourteenth questions cover agricultural biotechnology and its benefits (Table 3).

The responses indicate that the knowledge level of the majority of students in the department of science education is below 50% in the statements covering agricultural biotechnology and its benefits.

Table 3. Students responses to the agricultural biotechnology and its benefits

Questions #	True		Neutral		False		Total	
	f	%	f	%	f	%	f	%
4	83	42.8	48	24.7	63	**32.5**	194	100
7	53	**27.3**	93	47.9	48	24.7	194	100
14	35	18.0	117	60.3	42	**21.6**	194	100

Responses to Questions concerning knowledge of human health and pharmacy (Questions of 3rd, 5th, and 11th) were answered "true" by most of the students indicating that they had a good knowledge of these biotech issues (Table 4). On the other hand, the 12th question elicited a neutral response indicating that students had inadequate knowledge of how stem cells were obtained by using biotechnology.

Table 4. Questions related to the knowledge of human health and pharmacy

Questions #	True		Neutral		False		Total	
	f	%	f	%	f	%	f	%
3	99	**51.0**	40	20.6	55	28.4	194	100
5	111	**57.2**	30	15.5	32	16.5	194	100
11	145	**74.7**	34	17.5	15	7.7	194	100
12	14	**7.2**	128	66.0	52	26.8		

8, 16 and 19th questions refer environment and biotechnology (Table 5).

Table 5. Questions refering to environment and biotechnology

Questions#	True		Neutral		False		Total	
	f	%	f	%	f	%	f	%
8	116	59.8	54	27.8	24	**12.4**	194	100
16	42	**21.6**	115	59.3	37	19.1	194	100
19	60	**30.9**	85	43.8	49	25.3	194	100

The majority of undergraduate science education students (59.8%) estimate correctly to use organic waste for being fuel with biotechnological process. But, almost all students didn't know genetically modified plants adverse effect biodiversity.

Statements using biotechnology for food production were 6, 9, 10, 15, 18 and 20th questions and the results could be seen in the Table 6.

Table 6. Statements using biotechnology for food production

Questions #	True		Neutral		False		Total	
	f	%	f	%	f	%	f	%
6	57	29.4	105	54.1	32	**16.5**	194	100
9	130	**67.0**	44	22.7	20	10.3	194	100
10	62	**32.0**	105	54.1	27	13.9	194	100
15	91	**46.9**	44	22.7	59	30.4	194	100
18	70	36.1	81	41.8	43	**22.2**	194	100
20	102	52.6	71	36.6	21	**10.8**	194	100

It was seen that most of the students did not know anything about using biotechnology for production of organic acids, enzymes, primary products such as carbohydrate, alcohol, amino-acid and ketone. Ninth and fifteenth statements about traditional biotechnology were correctly answered by most of the students; however 52% gave false responses to the use of the yeast.

Discussion

This study describes a questionnaire administered to the students of the department of science education over a midsize university in Ankara, Turkey. The authors conclude that the students of the department of science education students have barely good knowledge of describing biotechnology and human health/pharmacy. Furthermore, almost all of the students have inadequate knowledge about other biotechnological issues such as genetically modified crops that cause a loss of biodiversity. Moreover, the students of the department of science education have no knowledge of this biotechnological issue. Furthermore, the majority of the students of department of science education knew anything about food production using biotechnological processes for yoghurt, wine and vinegar.

Michael, Grinyer and Turner (1997) have stated that the growing literature related to the public understanding of science with reference to some socio-economic, cultural,

institutional and personal factors has begun to show the reception and assimilation of scientific knowledge including biotechnology mostly theoretically in the contextual base. From this point, it could be also inferred that the public understanding of biotechnology is related to the outcomes of biotechnological studies but the deep understanding of biotechnology like the other areas in scientific studies seems to be limited. Additionally, this study indicates that the knowledge level of undergraduate science teaching students is limited to the well known topics and outcomes of biotechnology but not to the detailed level of biotechnological knowledge.

According to Eurobarometer 2005, at the EU level 65% of citizens believe that biotechnology and genetic engineering would have a positive effect on their way of life in the next 20 years. Within the EU, the highest ranking countries for their positive perceptions were: Hungary 74%, Spain and Denmark (both 72%), the Czech Republic and Estonia (both 71%), followed by Sweden and Italy (both 70%). Additionally, most of the Turkish general public's (62%) had good opinions on biotechnology and genetic engineering (Eurobarometer, 2005). It is difficult to make a direct connection with the study we conducted but the public opinion of Turkish people is very high but the knowledge level of undergraduate science education major students seems to be not very high (Table 1).

EU citizens were asked whether they would approve of developing genetically modified crops in order to increase the variety of regionally grown food. 37% declared that they would never approve of this while 31% would approve of this provided that it was highly regulated and controlled (Eurobarometer, 2005). It was suggested that the national results showed that respondents were less condemning of GMCs for this purpose (Eurobarometer, 2005). Responses "never" of the six of the surveyed countries were Croatia (60%), Switzerland (58%), Cyprus (56%), Greece (54%), Slovenia (53%), France (52%). 29% of Turkish citizens stated that they would never approve of GMCs (Eurobarometer, 2005). In this study, it was seen that almost all of the students had inadequate knowledge about genetically modified crops that cause a loss of biodiversity in worldwide (21.6 %), and question of the most common genetically modified plants, such as corn, soybeans that threat the biodiversity of Turkey (30.9%).

Macer et al. (2000) found that the public's responses towards the acceptance of biotechnology in Europe and USA public opinions were similar to in Japan and Oceania. In addition, New Zealand (%46) and Australia (59%) saw biotechnology as worthwhile less, than 72-75% in Israel, Russia, Japan and India, about 90% in Thailand. In our study, it is observed that 42.8 % of undergraduate science education students felt that biotechnological methods show certain successful results in agricultural struggle.

Dawson and Schibeci (2003) found that 14% of Western Australian high school students approved of all the stated uses of biotechnology and acceptance of the use of organisms in biotechnology were about 90% microorganisms, 71-82% plants, 42-45% humans and 34-40% animals at Western Australian High Schools. In our study, it was observed that 90.2 % of undergraduate science education students knew about using microorganisms for biotechnology, but only 13.4% of students had some knowledge if the microorganisms generated by using biotechnological methods may have any side effects on the health of human, animal and plant.

Cavanagh et al. observed that 75.9 % of Australian respondents agreed that the yeast used to produce beer contains living organisms and 19.5% respondents felt that it was impossible to transfer animal genes to plants. In our study, it is found that 10.85 % of science education students knew that the yeast used to bioprocess. It was seen that 47.4% of students knew that biotechnological methods merely based on transferring genes from one organism to another.

According to Biotechnology Australia (2005), stem cell research and treatment, genetically modified foods were perceived as useful by the majority of respondents (89.7 % and 63.7 %). Respondents felt that the use of gene technology in human transplants (76.8%) and producing medicines (72.5%) would be useful. In this study, we saw that 51.0% of respondents knew that stem cells could transform to any tissue cells and 57.2% of students knew that producing antibiotics was field of pharmacy.

Finally, it is concerned that Turkish the students of the department of science education seem to have inadequate knowledge about biotechnological issues such as describing biotechnology, agricultural biotechnology and its benefits, human health and pharmacy, environment and biotechnology, and using biotechnology for food production. Therefore, appropriate and consistent knowledge of biotechnological

issues and innovative developments, and possible negative affects should be maintained to the public in order to get them to be more conscious of these issues.

Implications for Education

Since 1950's, new explorations on the genetic materials of living organisms have opened new application ways on the biotechnology area so that biotechnology and genetic engineering have become one of the most challenging areas for the coming century in scientific and technical studies. Even in our daily life we can observe many samples and influences of biotechnological applications, such as GM foods.

As a result, it is impossible to be away from those subjects covering biotechnological contents in school science curriculums and teaching programs. Lately, science, technology and society approaches gradually have influences on science teaching programs. The effects of biotechnology as well as other technological applications have begun to be widely discussed in schools. School science curriculum programs should clearly show the importance of biotechnological applications for humanity and put extra emphasize some common misunderstandings and misconceptions on biotechnology. Additionally, in service science and biology teachers as well as teacher candidates in science and biology area should have the capacity to understand biotechnological concepts and to inform their students in biotechnological applications and issues.

This study shows that even undergraduate science education major students in Turkish context seem to have inadequate knowledge on biotechnological concepts and applications. Therefore, science teaching programs in Turkey should put extra emphasize biotechnological content areas. The programs covering biotechnology help in-service and pre-service science teachers be aware of the biotechnology.

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APPENDIX

The Biotechnological Issues Questionnaire

QUESTIONS	TRUE	NEUTRAL	FALSE
1. A number of one-cellular microorganisms could be used in biotechnology, such as, bacteria, algae, protozoa, and viruses.			
2. The biotechnological products produced by transgenic microbes have no harmful effects at al.			
3. Only the embryonic stem cells are potentially able to differentiate into all cell types			
4. Biotechnological methods show 100% certain successful results in agricultural fight for weeds and vermin.			
5. Producing antibiotics is mainly related to the field of pharmacy but potentially biotechnological methods should be used to produce antibiotics.			
6. Organic acids, such as citric acid and lactic acid could not be obtained with the way of biotechnological methods.			
7. It could be possible that the plants produced by means of the tissue culture method could provide the same amount of plant products.			
8. With the biotechnological ways, it is not possible to change organic garbage to the energy.			
9. Yoghurt, wine, and vinegar could be the samples of biotechnological products.			

10. Primer products such as, carbohydrates, amino acids, and alcohols could be produced by means of the biotechnological methods used genetic engineering techniques.			
11. The number of organ transplantations could be decreased in the future because of potentially using stem cells.			
12. Stem cells could be obtained with the recombinant DNA technology.			
13. Biotechnological methods merely based on transferring genes from one organism to another.			
14. Until now, all plants are produced with plant tissue culture techniques.			
15. The producing ethyl alcohol with fermentation could be a kind of biotechnological procedure.			
16. Genetically modified plants could have side effects on the biological diversity in worldwide.			
17. Cytogenetics is field that focuses on fast production and improvement, changing of organisms.			
18. Commercially obtained enzymes could be only produced from plants.			
19. The most common genetically modified plants, such as corn, soybeans could threat the biodiversity of Turkey.			
20. The yeast is not used in biotechnological methods.			