Order number: 2

Attachment No. 3		**Subject program of the second cycle of studies**			
1.	Title of the teaching subject	Smart and sustainable packaging			
2.	Code	FE1M2			
3.	Study program	Food engineering – innovation, sustainability and technologies			
4.	Organizer of the study program (unit, i.e. institute, department, department)	Faculty of Technology and Metallurgy, University "St. Cyril and Methodius" in Skopje Department of Food Technology			
5.	Degree (first, second, third cycle)	Second cycle			
6.	Academic year / semester	Year	I	semester	I
7	Course load expressed in ECTS credits	7 ECTS			
8.	Teacher (in the case of multiple teachers designated responsible teacher*)	Dr. M. Temkov Dr. I. Mladenovska*			
9.	Language of instruction	English			
10.	Necessary prerequisites for listening and passing the subject	Knowledge of food packaging techniques and technologies, food preservation processes, food microbiology			
11.	Objectives of the subject program (competencies) and learning outcomes:	**Objectives of the program:** Getting to know the principles and technologies of intelligent food packaging. The role of packaging in extending shelf life, ensuring safety and improving consumer interaction. Designing the packaging systems incorporating smart materials and sensors. Assessing the sustainability and regulatory aspects of intelligent packaging solutions. **Learning outcomes:** 1. Students will gain a comprehensive understanding of the basic functions of food packaging, including its social benefits and drawbacks. 2. Students will be able to identify and apply the strategic elements of packaging development. 3. Students will learn how packaging affects food quality and determines shelf life, enabling them to assess the impact of packaging choices on product shelf life. 4. Students will be able to identify and explain new types, materials and systems of packaging, including sustainable, intelligent and active packaging solutions.			
12.	Detailed course content by chapter and unit with learning outcomes for each chapter	Definition and functions of food packaging Social benefits and disadvantages A strategic framework in packaging development • Product Requirements • Requirements for operating machines • Requirements for the distribution chain • Consumer demands			

<table>
<tr><td></td><td></td><td colspan="4">Quality of packaged food and shelf life
• Factors affecting shelf life
New types of packaging, materials and innovations in packaging systems
• The Internet of Packaging
• Intelligent packaging (smart sensors, RFID, NFC, QR codes, blockchain technology, indicators)
  • Time-temperature indicators
  • Gas indicators
  • Freshness indicators
• Radio frequency identification devices
• Nanotechnologies in packaging
• Active packaging – absorbers, emitters (examples, actions – oxygen scavengers, CO2 scavengers, ethylene scavengers, antimicrobial agent emitters, moisture absorbents, temperature controlled packaging)
• Edible films and coatings
• Biodegradable packaging
• Sustainable food packaging
• Packaging of food preserved by irradiation
Case studies of innovative sustainable packaging ideas</td></tr>
<tr><td>13</td><td>Interrelationship of subjects</td><td colspan="4">There is none</td></tr>
<tr><td>14.</td><td>Detailed description of teaching and working methods for the subject</td><td colspan="4">Interactive theoretical and practical teaching combined with independent work and individual consultations will be applied in all teaching chapters of the course to a varying extent, depending on the number of students. Individual and possibly group or team collaborative and cooperative methods of active learning will be used from the teaching methods. Developing skills for displaying and presenting research according to the latest relevant scientific research in the field of food chemistry and physics.</td></tr>
<tr><td>15.</td><td>Total available fund on time</td><td colspan="4">210 hours</td></tr>
<tr><td rowspan="3">16.</td><td rowspan="3">Forms of teaching activities</td><td>16.1.</td><td colspan="2">Lectures - theoretical teaching. hours</td><td>45</td></tr>
<tr><td>16.2.</td><td colspan="2">Exercises (laboratory, classroom), seminars, teamwork: lessons</td><td>21</td></tr>
<tr><td>16.3.</td><td colspan="2">Practice: classes</td><td>24</td></tr>
<tr><td rowspan="3">17.</td><td rowspan="3">Other forms of activities</td><td>17.1.</td><td colspan="2">Project assignments: lessons</td><td>40</td></tr>
<tr><td>17.2.</td><td colspan="2">Independent assignments: lessons</td><td>10</td></tr>
<tr><td>17.3.</td><td colspan="2">Home study - assignments</td><td>40</td></tr>
<tr><td>18.</td><td colspan="2">Conditions of signature</td><td colspan="3">Minimum 11 points from 19.1 and 19.2</td></tr>
<tr><td rowspan="4">19.</td><td colspan="5">Method of assessment</td></tr>
<tr><td>19.1.</td><td colspan="2">Tests: points</td><td colspan="2">10 points</td></tr>
<tr><td>19.2.</td><td colspan="2">Seminar work/project, written and oral presentation: points</td><td colspan="2">10 points</td></tr>
<tr><td>19.3.</td><td colspan="2">Final exam: points</td><td colspan="2">80 points</td></tr>
<tr><td rowspan="4">20.</td><td colspan="2" rowspan="4">Evaluation criteria (points/grade)</td><td colspan="2">up to 50 points</td><td>5 (five) (F)</td></tr>
<tr><td colspan="2">51 x to 60 points</td><td>6 (six) (E)</td></tr>
<tr><td colspan="2">61 x to 70 points</td><td>7 (seven) (D)</td></tr>
<tr><td colspan="2">from 71 to 80 points</td><td>8 (eight) (C)</td></tr>
</table>

			from 81 to 90 points	9 (nine) (B)	
			from 91 to 100 points	10 (ten) (A)	
21.	A method of monitoring the quality of teaching		Based on Article 10 para. 5 of the Guidelines for self-evaluation and assessment of the quality of UKIM in Skopje, anonymous surveys of students are carried out on the quality of the teacher and associate staff and an anonymous survey on the general conditions for studying		
22.	Literature				
	22.1.	Required reading			
		Ord. number	Author	Title	Publisher	Year
		1.	Avik Mukherjee, Santosh Kumar, Manjusri Misra, Amar K. Mohanty	Smart Food Packaging Systems: Innovations and Technology Applications	John Wiley & Sons Ltd.	2024
		2.	Monica Trif, Sneh Punia Bangar	Intelligent Packaging: Current Technologies and Applications (Developments in Food Quality and Safety)	Academic Press	2024
		3.	Swarna Jaiswal, Kalpani Y. Perera, Amit K. Jaiswal	Smart and Intelligent Food Packaging: Innovations and Insights	Academic Press	2025
	22.2.	Additional literature				
		Ord. number	Author	Title	Publisher	Year
		1.	Michela Temkov	Internal materials	TMF	
		2.	Irina Mladenoska	Internal materials	TMF	
		3.Scientific papers from renowned journals from the last five years in the field of intelligent packaging and new materials				