IAEA-CN301-020

Surface Treatment of Special High-protein Products Using Low Energy Beams from Machine Sources

Slobodan B. Masic

Ivica T. Vujcic

.....

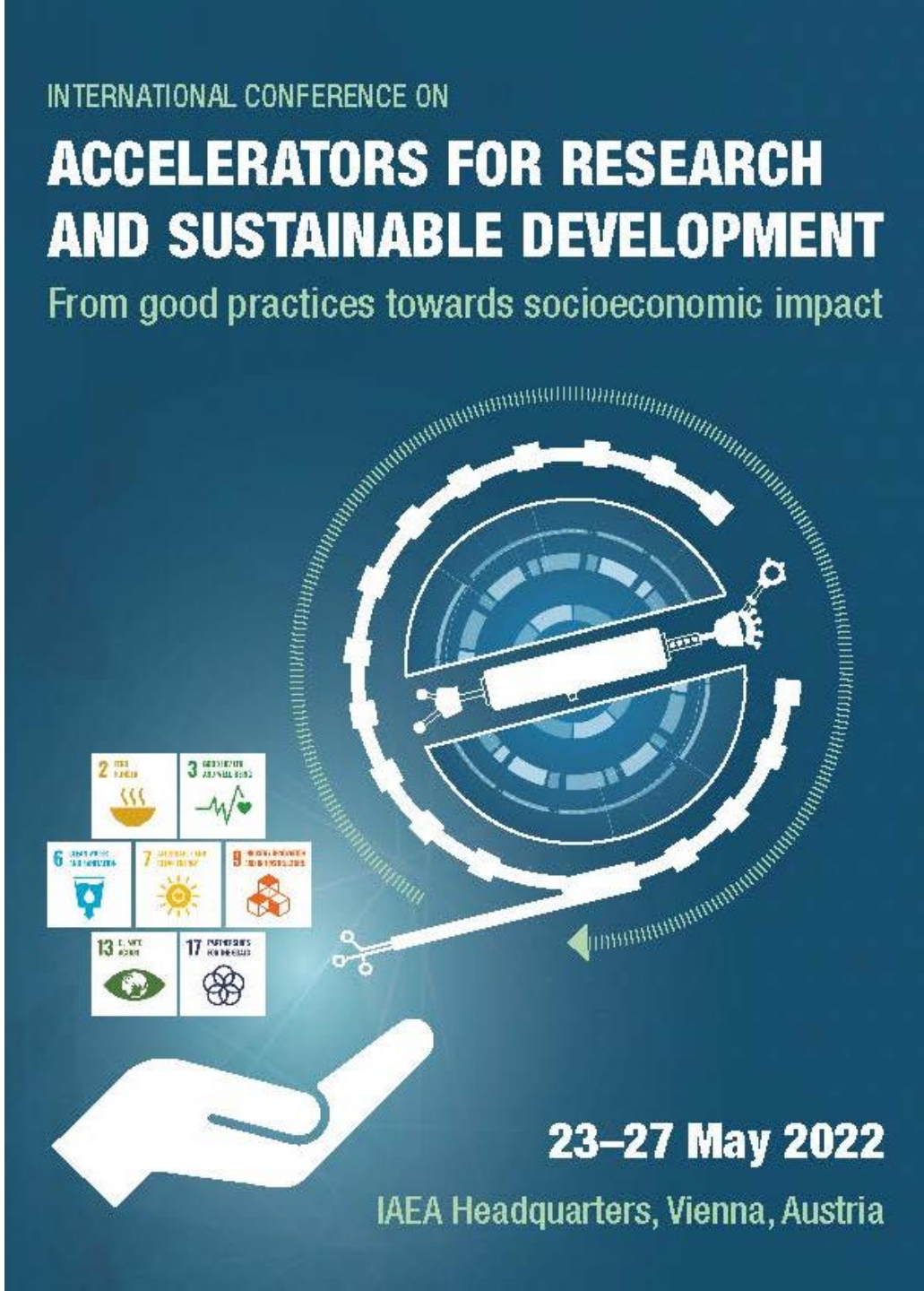
Department for Radiation Chemistry and Physics

Vinca Institute of Nuclear Sciences

Belgrade, Serbia

.....

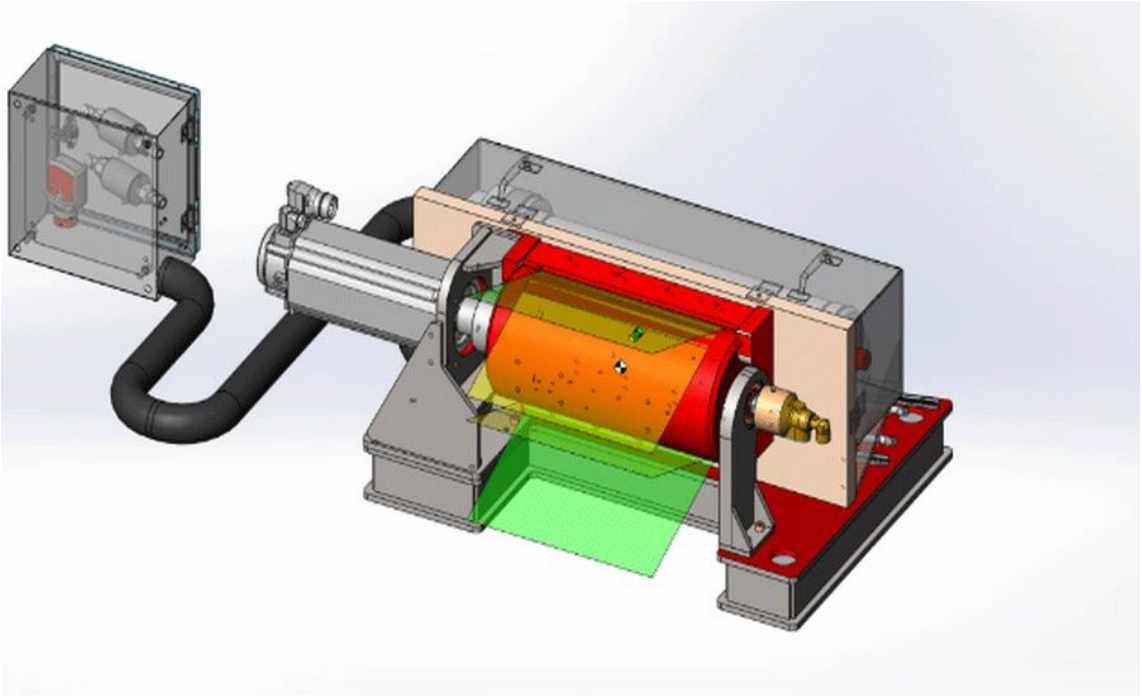
(slobodan.masic@gmail.com)



Introduction

- LEEB technology
- High protein products
- Gamma irradiation of high protein products
- LEEB irradiation of high protein products
- Conclusion

- Recent developments in low energy electron beam (LEEB) technology has revolutionized aseptic packaging.
- Advancements in electron beam technology are shrinking the footprint of the devices used to generate ionizing radiation.
- With the relatively recent development of reliable, compact, cost-effective, LEEBs, a new class of in-line applications is now possible.
- The benefits of high-speed, high efficacy treatments, with no chemicals and at room temperature, are now realized across a variety of packaging applications.
- Such developments are also attractive to the food industry.



- The aim of the paper is to analyze the influence of LEEB on the physical and chemical parameters of the preservation of high-protein foods suitable for diabetics.
- According to the Diabetes Registry, over 710,000 people in Serbia suffer from this disease.
- They need a special diet, with the lowest possible carbohydrate content. It is well known that proper and healthy food is a prerequisite for good health.
- In creating such products, it is of great importance to extend the shelf life of the product, to enable online sales, as well as export

- In cooperation with a local food company, we have developed high-energy products that would be ideal for diabetics, athletes, individuals on a particular diet and anyone who cares about their health.
- Some of developed high-protein products are: original protein evening bread, protein burgers, protein crackers, protein chips, protein biscuits, cocoa cream with no added sugars, protein bagels and scones, protein tortillas and pancakes, protein drinks.
- This products are innovative because they do not use traditional raw materials, but specially designed high-protein, whey. All the products are sugar-free.
- The products are treated with ionizing radiation, which guarantees the absolute absence of all microorganisms and harmful substances in said products, and significantly extends the shelf-life span.

- Irradiation was performed with gamma rays in a Radiation facility for industrial sterilization and conservation at the Vinca Institute of Nuclear Sciences in Belgrade.
- Radiation doses of 1 kGy, 3 kGy, 5 kGy, 7 kGy, and 10 kGy were used.
- The average irradiation dose rate was about 10 $kGy \cdot h^{-1}$.
- The delivered radiation dose's accuracy is controlled using the ECB/oscilloscope dosimetric system.
- The measurement of the absorbed radiation dose was performed at 20°C.

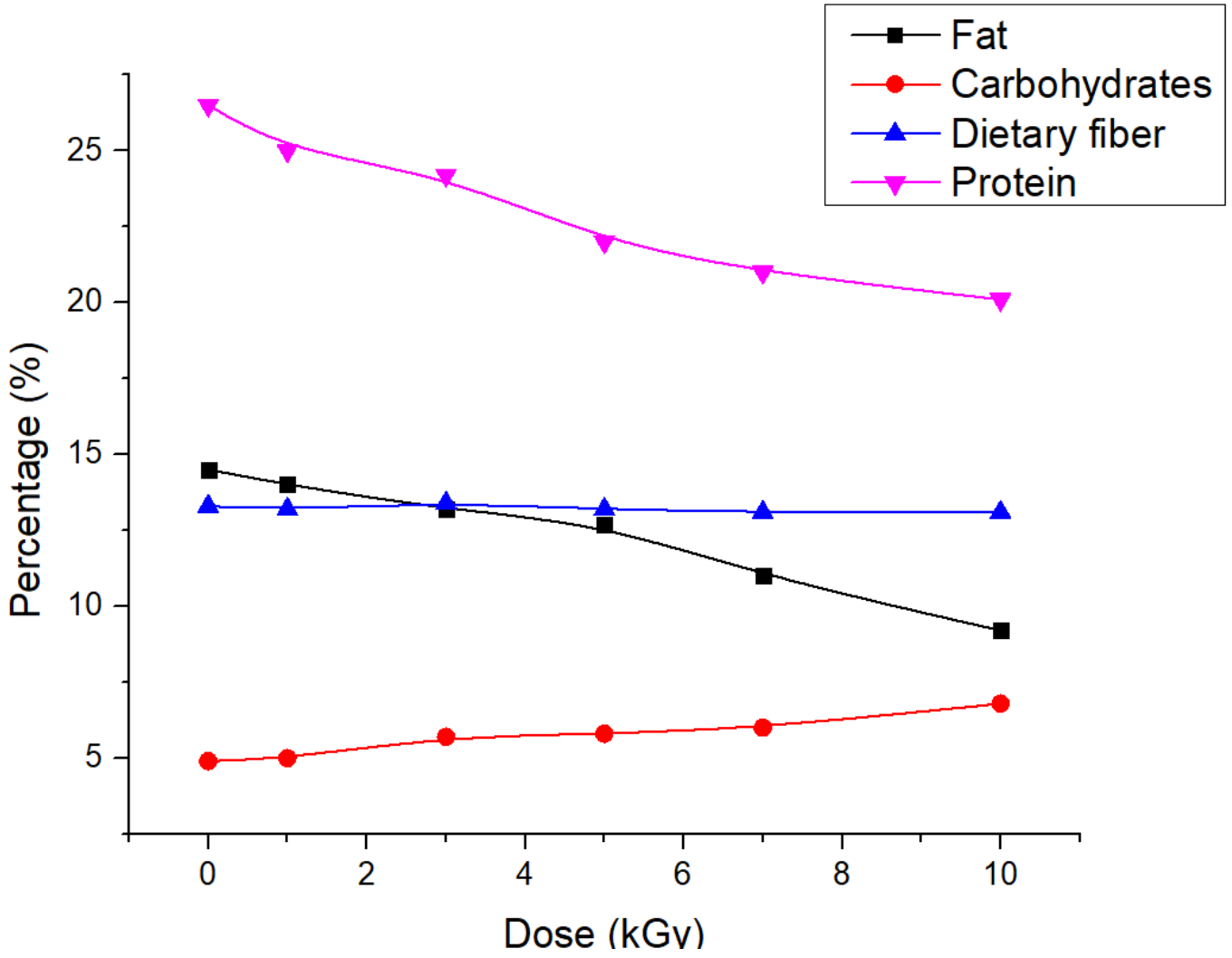
- It has been determined that treatment with ionizing radiation can affect the change in the nutritional values of the product.
- The table shows the nutritional values of high-protein bread before irradiation and after gamma irradiation with a dose of 10 kGy.

Nutritional values	Non-irradiated	10 kGy
Fat	14.5%	9.2%
Carbohydrates	4.9%	6.8%
(sugars)	1.6%	2.5%
Dietary fiber	13.3%	13.1%
Protein	26.5%	20.1%
Salt	1.1%	1.2%

- Decrease in fat content could be due the action of high energy radiation on lipid molecules causing lipid peroxidation
- The biggest problem is that the proportion of carbohydrates increases, and the proportion of protein decreases after exposure to gamma radiation at a dose rate of 10 kGy/h.
- Increase in carbohydrate content was due to breakdown of oligosaccharides when samples were irradiated.
- Decrease in protein content with gradually higher irradiation dose is because of high rate of metabolic activities.

Nutritional values	Non-irradiated	10 kGy
Fat	14.5%	9.2%
Carbohydrates	4.9%	6.8%
(sugars)	1.6%	2.5%
Dietary fiber	13.3%	13.1%
Protein	26.5%	20.1%
Salt	1.1%	1.2%

- The diagram shows the changes in the nutritional value of the product “Protein evening bread” depending on the radiation dose to which the samples were exposed.



- To avoid changes in nutritional value after irradiation, LEEB was used for preservation of high-protein products.
- The use of low energy electrons has advantages over the use of gamma-rays or higher energy electrons for the direct irradiation of food. These advantages arise from details of the interaction processes which are responsible for the production of physical, chemical, and biological effects.
- Factors involved include:
  - Depth of penetration,
  - Dose distribution,
  - Irradiation geometry,
  - Costs.

Specification of the used device

Dimensions and weight

Length	5,452	mm
Height	2,945	mm
Depth	1,726	mm
Processing unit weight	10,500	kg
Supply unit weight	1,750	kg

Remarks: ±10mm tolerance is acceptable by real measurements.
Figures will vary based on machine specifications.

Specifications

Voltage	With supply frequency 50 Hz: 400Y/230 VAC With supply frequency 60 Hz: 400Y/230 VAC + 460 VAC	
Power	≤30	kW
Product throughput (product dependent)	up to 1,000	kg/h
Air exhaust (depending on installation)	up to 8,100	m^3/hour
Ambient temperature	+5 ... +40	°C
Relative humidity, non-condensing (during operation)	10 ... 70	%

- The table shows the nutritional and microbiology values of high-protein bread before irradiation and after LEEB treatment.
- Irradiation of the product surface with a Low Energy E-beam (LEEB) appeared as a possible ideal solution.
- Such a treatment would neutralize the microorganisms.
- Microorganisms are located on the surface of the product and are formed mainly during the handling of the product.
- On the other hand, the change of the nutritional values of the product under the influence of high-energy ionizing radiation would be avoided.

	Non-irradiated	Irradiated with LEEB
Microbiological properties		
Total number of microorganisms	52000 $cfu \cdot g^{-1}$	0
Molds	420 $cfu \cdot g^{-1}$	0
Nutritional values		
Fat	14.5%	14.3%
Carbohydrates	4.9%	5.0%
of which sugars	1.6%	1.6%
Dietary fiber	13.3%	13.3%
Protein	26.5%	26.4%
Salt	1.1%	1.2%

Conclusions:

- Advancements in electron beam technology are shrinking the footprint of the devices used to generate ionizing radiation.
- With the relatively recent development of reliable, compact, cost-effective, LEEBs, a new class of in-line applications is now possible.
- The benefits of high-speed, high-efficacy treatments, with no chemicals and at room temperature, are now realized across a variety of packaging applications.
- Such developments are also attractive to the food industry.
- The use of LEEB in the treatment of special high-protein products for diabetics has shown great potential for further development and application.

Thank you

Acknowledgements

The authors are grateful to the IAEA for their financial support and assistance, as well as to the Ministry of Education, Science and Technological Development of the Republic of Serbia