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A new prototype to perform the fork method of the International Dysphagia Diet Standardisation Initiative (IDDSI) in a texturometer

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Abstract

Dysphagia is a condition defined by the difficulty in chewing and swallowing foods, which can be associated with malnutrition, dehydration, chest infection, and potential risk of death. The International Dysphagia Diet Standardisation Initiative (IDDSI) developed standard methods intended to be simple to classify foods and beverages into different levels, which are related with the different needs of patients. Although interesting, those methods lack scientific data and reproducibility. This work developed a prototype to be coupled in a texturometer to perform the IDDSI fork test. The probe was designed in CAD and cut in aluminium sheets by a CNC machine, being then assembled. Its geometry was designed to hold and press a fork, imitating the thumb in the original test, and its project is available to every laboratory interested in assembling and testing it – thus allowing comparison among works. Some examples of applications are described, including cooked vegetables (potato and carrot), a fresh fruit (banana) and a model food (starch gel).

Keywords: dysphagia; dysphagic; IDDSI method; texture; food for special needs.

1. Introduction

There is a relevant proportion of the society with difficulties in chewing and swallowing, affecting their health and well-being. This condition, known as dysphagia, is often associated with malnutrition, dehydration, chest infection, and potential risk of death [1]. Dysphagia affects a relevant percentage of elderly population and it has recently been shown to be a problem in patients who passed through intubation and extubation due to Covid-19 [2,3]. Moreover, it is a common complication after stroke, head, and neck cancer, also associated with Parkinson's and Alzheimer's diseases [1,4,5].

A dysphagic diet must consider the texture of foods, which must be connected with the capacity of chewing and swallowing of each patient. In fact, to reduce the impact of dysphagia, a strategy is to modify the texture of solid foods and the consistency/viscosity of liquid foods. Consequently, it is important to evaluate the texture of foods to aid dysphagic people and allow scientific and technological development in this field.

Consequently, the International Dysphagia Diet Standardization Initiative [6,7] developed simple methods to evaluate and classify foods and beverages into different levels, which are related with the different needs of group of patients.

The fork test [6,7], for example, is conducted by pressing down the food sample with a fork until blanching of the thumbnail. The pressure exerted by the thumb, in such case, is related with the one exerted by the tongue during swallowing (approximately 17 kPa) – and blanching occurs when the pressure overcomes mean arterial blood pressure, justifying the method [1,8]. Although simple, this method is effective, being used by different recent articles. However, by performing the method in a texturometer, the instrumental analysis assures higher reproducibility, standardization, and more information to be studied towards improving our understand of the interaction food-body to help dysphagic people.

In fact, a recent work provided a clever and elegant approach to develop this concept, by proposing a probe to connect forks and spoons in a texturometer, then performing an instrumental method for IDDSI standard fork pressure test [9]. However, although useful, the design of the proposed probe was not provided in the article, impairing other laboratories to produce similar equipment for comparison studies. Moreover, the probe was produced using an aluminium block, probably using a lathe, and other project possibilities can be done with simpler tools. Finally, new prototypes are always desired in order to expand the experimental possibilities and studies.

Consequently, we developed a new prototype to perform the fork method of the International Dysphagia Diet Standardisation Initiative (IDDSI), able to attach forks and spoons in a texturometer (or universal mechanical testing machine). This prototype was developed using CAD and cut in aluminium sheets by a CNC machine, and the project is made available to everyone interested in assembly it.

2. The prototype development and evaluation

The prototype was created based on the work of Pematilleke, Kaur, Adhikari and Torley [9], and following the ideas:

- Instead of using a single piece of aluminium, which must be moulded in a more expensive and complex machine (such as a lathe), the prototype was based in connecting different pieces of aluminium sheets (2017A alloy, 3 mm of thickness) to an aluminium standard extrusion profile (6061 alloy, transversal section of 30x30 mm and 100 mm long).
- The structural cohesion of a project based in many pieces, in comparison with a single rigid block, can be questioned. The malleability of aluminium, in comparison with other stronger materials, can also be questioned. However, the products evaluated using the prototype, namely food products for dysphagic diets, are far weaker than the materials applied in the prototype or those connections. Therefore, the concept here proposed can be considered valid.
- Each aluminium sheet was cut in a CNC machine, following a design developed using CAD. With this project (Appendix 1), any laboratory is able to produce a similar prototype, by uploading the files in a CNC machine and then connecting the pieces according to the project. The fork is then attached to the prototype.
- The prototype was developed to be adapted to different forks and spoons. Therefore, those cutleries can be fixed in the prototype by simple connections, and this region can be moved (in special the angle) to adapted different geometries.
- The prototype was connected in a texturometer (Texture Analyzer TA.XT Plus, Stable Micro Systems Ltd., Surrey, UK; with a load cell of 50 kgf / 490.3 N), then evaluating some examples of food products to demonstrate its applicability.

Figures 1 and 2 show the prototype, considering its projects with details and actual images (with a fork attached, and with the system attached to a texturometer during assays). The complete project is available on Appendix 1.

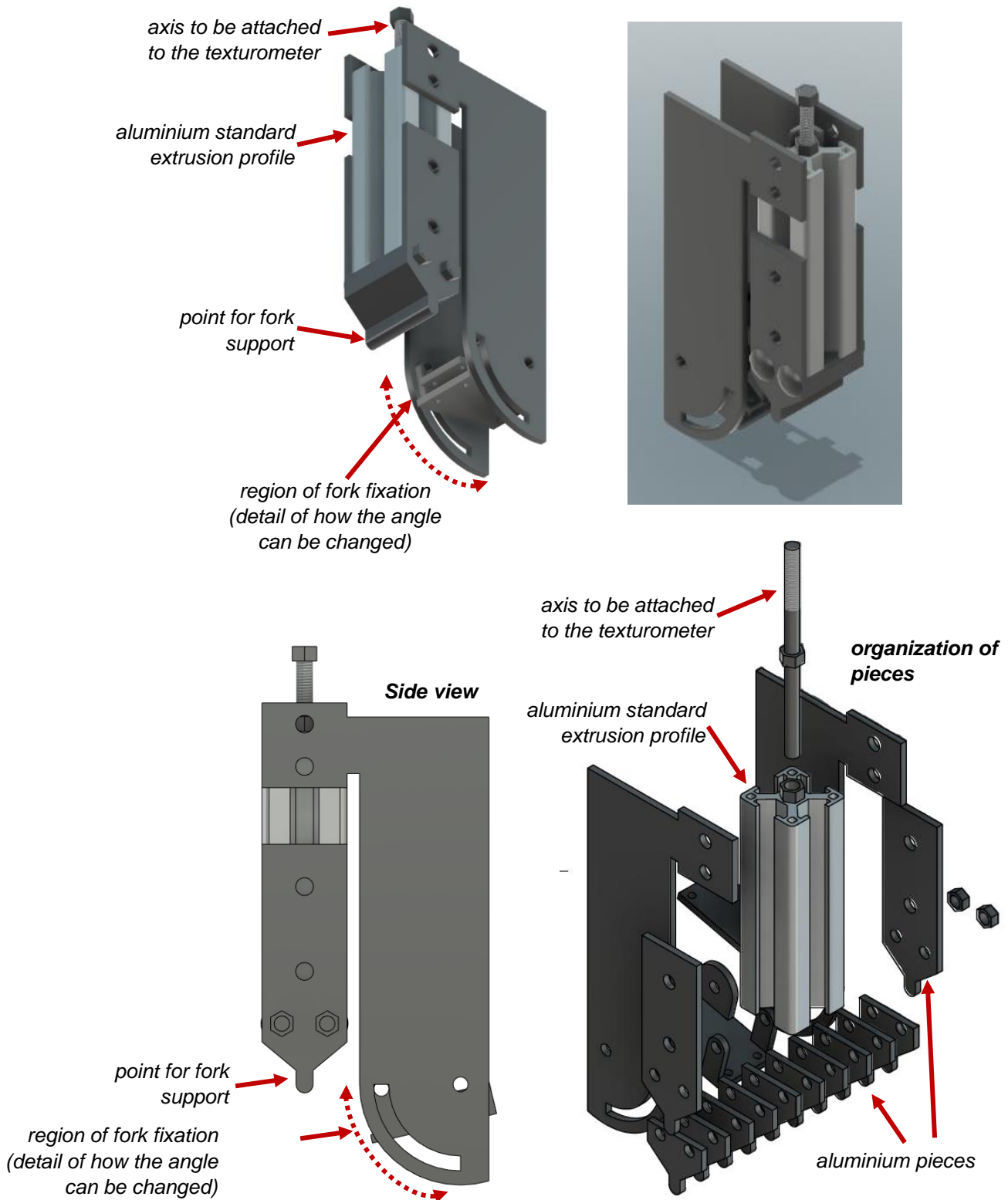


Figure 1: Representative images of the prototype project (presented on Appendix 1).



Figure 2. Actual images of the prototype, with a fork attached (up) and the system attached to a texturometer (down; Left: fork touching the carrot cube. Right: fork penetrating the starch gel).

Figures 3 and 4 show the results obtained by evaluating two cooked vegetables (potato and carrot), a fresh fruit (banana) and a model food (maize/corn starch gel) as examples of application. The potato slices were boiled for 25 min for cooking, while carrot slices were boiled for 30 min. Banana slices were direct cut. Starch gels were produced as model foods, being produced using maize/corn starch (a suspension of 3 g starch (14% moisture basis) in 25 g of distilled water, heated at 6 °C/min until gelatinization at 95 °C for 5 min, being then cooled to 50 °C at 6 °C/min, being kept at this temperature for 2 min and then gelation at 5°C for 24 h). All the samples were cut into cubes of 1.5 cm side, as suggested by [6,7].

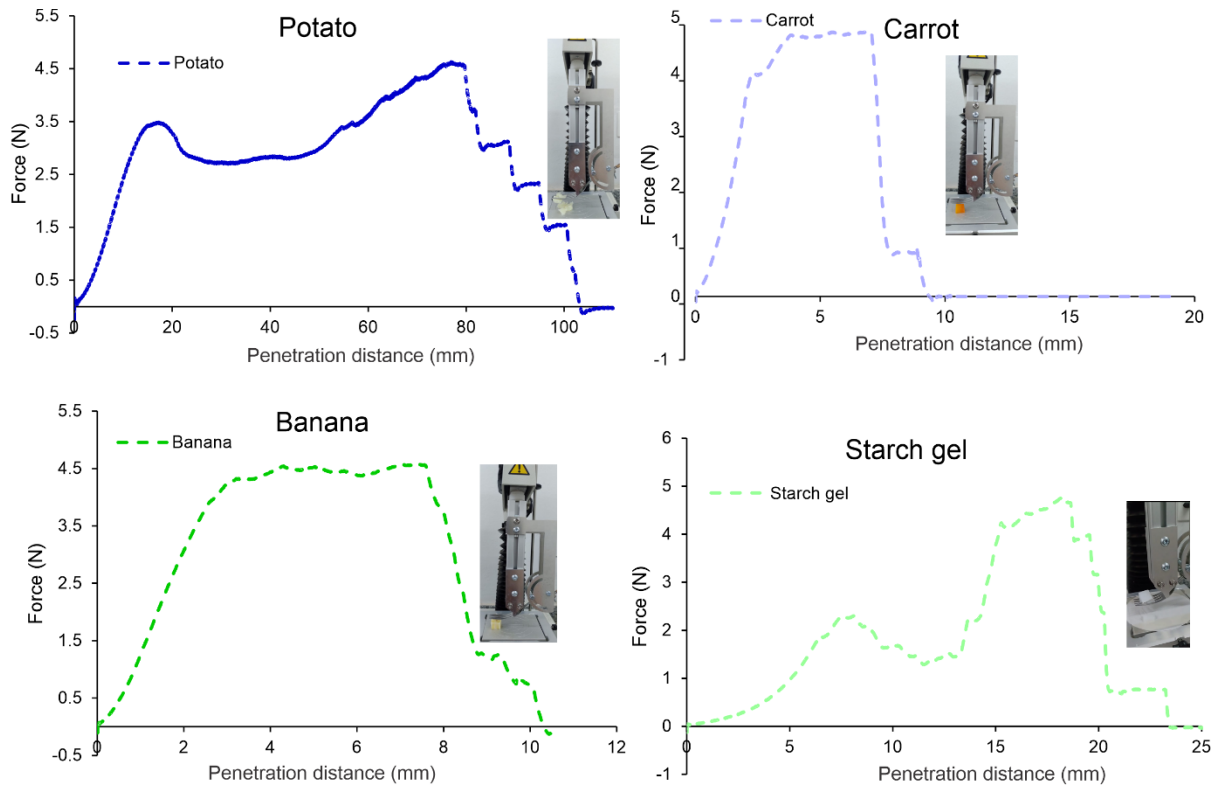


Figure 3. Penetration force versus distance obtained in the IDDSI fork pressure test with the new prototype (inserted images). Curves for different samples are presented: potato slices boiled for 25 min, carrot slices boiled for 30 min, banana slices *in natura*, and maize starch gel.

The analysis consisted of pressing the selected food with the fork attached to the Texture Analyzer (Figure 2) until reaching a force needed to blanch the thumbnail (determined using a scale as 4.8 N). Upon reaching this force value, the fork remained pressing the sample for 5 s, then returned to the initial state, simulating the analysis described by the IDDSI, and following the proposals of [9]. However, we highlight other protocols can be applied.

By using the prototype attached to a texturometer, more information than those obtained from the IDDSI standard method can be obtained.

For instance, Figures 3 and 4 show that although both potato and starch gel could be entirely penetrated by the fork in the test, potato needed more energy than starch gel (being the fork penetration energy determined as the curve below the force versus displacement curve). On the other hand, in the test conditions, both carrot and banana could not be fully penetrated by the fork - obtaining a lower energy compared to the other two foods, but with a different interpretation and classification for dysphagic diets.

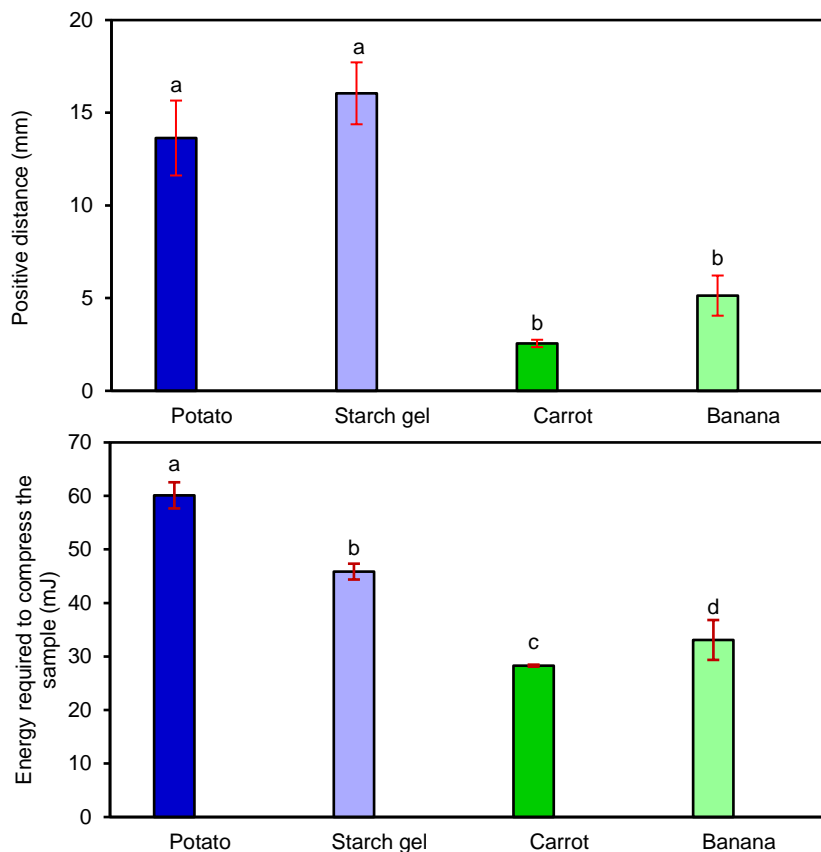


Figure 4. The energy required to penetrate the sample to 4.8 N using a fork attached to a texturometer, and the associated penetration distance. Vertical bars indicate the standard deviation. Different lowercase letters indicate there were significant differences ($p < 0.05$) among samples.

Therefore, the proposed prototype is a simple project that can be attached to a texturometer, allowing researchers to obtain more information than using the IDDSI standard method. It is important to highlight this accessory is compatible with the texturometer we had access to, but is not specific for this equipment nor model. Any mechanical testing machine can be used, when the appropriate load cell is applied, only changing the piece to attach the prototype to the equipment.

Further improvements are possible, and we encourage researchers to do so making available their projects, in order to expand the studies and development in the field towards improving the quality of life of the population.

3. Conclusions

This work developed a prototype to be coupled in a texturometer (or mechanical testing machine) to perform the IDDSI fork test with high accuracy, reproducibility and enhancing the quantity of data each experiment can provide. Its project is available to every laboratory interested in assembling and testing it. We just ask to refer to this project when applying our prototype in your work.

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