

Potential of hardy kiwifruit (*Actinidia arguta*) for fruit spread production. A first insight

Potenzial der Mini-Kiwi (*Actinidia arguta*) für die Herstellung von Fruchtaufstrich. Ein erster Einblick

Potenziale dei Baby Kiwi (*Actinidia arguta*) per la produzione di composte. Una prima valutazione

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ABSTRACT

Hardy kiwifruits represent an unexplored agricultural resource for South Tyrol which could be of particular interest to the region by contributing to agricultural biodiversity and the valorisation of minor crops in the area. The main limitation of this crop is its short shelf-life as a fresh raw material, which is related to its intrinsic perishability. Processing hardy kiwis into canned products could be a valid strategy for encouraging the production and spread of this crop throughout the territory, enabling food products derived from it to be available all year round. This study evaluated the suitability of hardy kiwifruits for processing into spreads. Results indicate that no pectin needs to be added to ensure that the fruit spread has a pleasant texture, and browning over time occurred slowly, despite the preserve not being stabilised with antioxidant agents, suggesting that the shelf-life of such a preserve might be quite long. Finally, from a preliminary sensory evaluation, consumers rated the preserve positively with regard to its texture, sweetness and flavour, and it obtained a positive overall evaluation from an organoleptic point of view, indicating that this crop has potential for use in the production of fruit spreads.

KEYWORDS

Baby kiwi, food processing, consumer test, colour change, fruit preserve

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INTRODUCTION

Actinidia arguta, also known as hardy kiwifruit or baby kiwi, is a frost resistant vine that produces fruits that tend to be of smaller size than common kiwifruits (*Actinidia deliciosa*). Since their peel is smooth and hairless, fruits can be eaten whole, raw or processed into juices or jams.

Hardy kiwifruits stand out due to their high vitamin C content [1] [2] [3] [4] [5] [6] and level of phenolic and antioxidant compounds [2] [7], which are associated with potential health benefits [8]; additionally, they are a source of essential minerals [5] [6] [7] [8] [9], contain a notable amount of lutein [10] [11], and are considered to be the richest food source of myo-inositol [12] [13] [14]. Thus, with good reason, hardy kiwifruits are defined as a healthy food [15] [16].

Their health-promoting characteristics, including strong antioxidant, medicinal and anti-inflammatory properties, low calorie content, rich chemical composition in phenolics, minerals, carbohydrates and volatile

compounds, widely reviewed by Baranowska-Wójcik et al. 2018 [17] and Pinto et al. 2020 [18], make them an interesting constituent of a healthy diet.

Differences concerning the quality of hardy kiwifruits depend on numerous factors, including genotypes, harvest year [15], as well as agronomic factors (climate, fertilisers and stress), ripeness and storage conditions [7] [9]. All these parameters affect physical and chemical characteristics such as firmness, acidity, colour, mass, shape, sugar content and the sensory quality of the fruit [15].

From a sensory point of view, some studies have been published that focus on *A. arguta*. In general, their skin is described as soft, sour, astringent with an irritating note, while the pulp is soft, jelly-like, fruity and sweet [15]. Aromas that have been reported for hardy kiwifruits include general fruit and vegetables, fuzzy kiwi, green banana and strawberry, while basic tastes include sweet, sour and astringent [7]. Through an electronic tongue analysis, Song et al. 2022 [5] were able to de-

tect differences among 67 accessions of *A. arguta* fruits from north-east China with regard to sourness, sweetness, umami, bitterness and astringency and to correlate instrumental data with a sensory evaluation of the same attributes. Storage time and conditions and, to a lesser extent, harvest maturity affect their sensory quality [7] [19]. Concerning the intent to purchase hardy kiwifruits, Fisk et al. 2008 [20] observed that most consumers “definitely would” consume hardy kiwifruits, while only 5% would “probably not” or “definitely not” consume them.

One major problem with hardy kiwis concerns their relatively short shelf-life: they quickly soften during storage and, therefore, in order to ensure that their quality remains acceptable over a period of at least one month, they need to be stored under refrigerated conditions [2].

One possible solution to the problem of the rapid deterioration of this product, is to process it into food preserves. However, studies of kiwifruits have revealed that due to the instability of numerous qual-



Issai



Maki



Super Jumbo



Red Beauty



Fresh Jumbo

Fig. 1: *A. arguta* varieties used for this study.

ity characteristics of this fruit, common processing methods can cause browning, loss of aroma and of the green colour [21].

This paper evaluated the suitability of *A. arguta* fruits for processing into fruit spread. Fruits of five different varieties were mixed and used to produce the fruit spread. This then underwent a further sensory evaluation through a preliminary test, and a study on colour changes was also conducted over a period of 110 days.

MATERIAL AND METHODS

FRUIT CULTIVATION, SAMPLING AND STORAGE

Fruits from the cultivars *Issai*, *Red Beauty*, *Maki*, *Super Jumbo* and *Fresh Jumbo* (Fig. 1) were grown in the trial plots belonging to the Laimburg Research Centre located in the municipality of Merano (farm: "Martebner"; 46°38'23.9"North; 11°11'00.2"East; 360 m a.s.l.) in South Tyrol, Italy. All pergola-trained plants were treated in the same way in terms of watering and fertilisation and no pest

controls were applied. The field received standard horticultural care according to the Integrated Production Regulations.

Approximately 1 kg of samples, all of similar size and free from disease or pest damage, were randomly collected for each variety on 14/09/2022. Samples were then placed in refrigerated containers and immediately transported to the Laimburg Research Centre.

Fruits were harvested at their optimal maturity stage, and, since the amount of fruit collected was low, fruits belonging to the above-mentioned five cultivars were mixed in order to obtain a homogeneous sample which was immediately stored at -30 °C before further processing.

TOTAL SOLUBLE SOLIDS AND PH

Total soluble solids (TSS), expressed in °Brix, were measured by means of a refractometer (PAL-BX/RI, Atago, Tokyo, Japan). Acidity measurements were carried out at room temperature with a

portable pH meter (Seven2Go, Mettler Toledo, Columbus, OH, USA) equipped with a rounded-tip sensor for liquid samples (InLab Expert Pro ISM, Mettler Toledo, Columbus, OH, USA). Analyses were carried out in triplicate on fruit puree immediately after production.

RECIPE DEVELOPMENT AND FRUIT SPREAD PREPARATION AND STORAGE

For the preparation of the fruit spread, hardy kiwis were thawed and mashed using a domestic immersion blender, without removing the skin or seeds. Two recipes were developed, one with added pectin and one without pectin.

The initial recipe was formulated based on prior research concerning strawberry jam [22] and consisted of fruit puree with 1.5% pectin added (AF 710, Herbstreith & Fox KG pectin factories, Neuenbürg, Germany) and an amount of saccharose necessary to reach 30% of Brix on the total weight based on the starting amount of total soluble solids of the fruit. The same amount of sucrose was added to the fruit

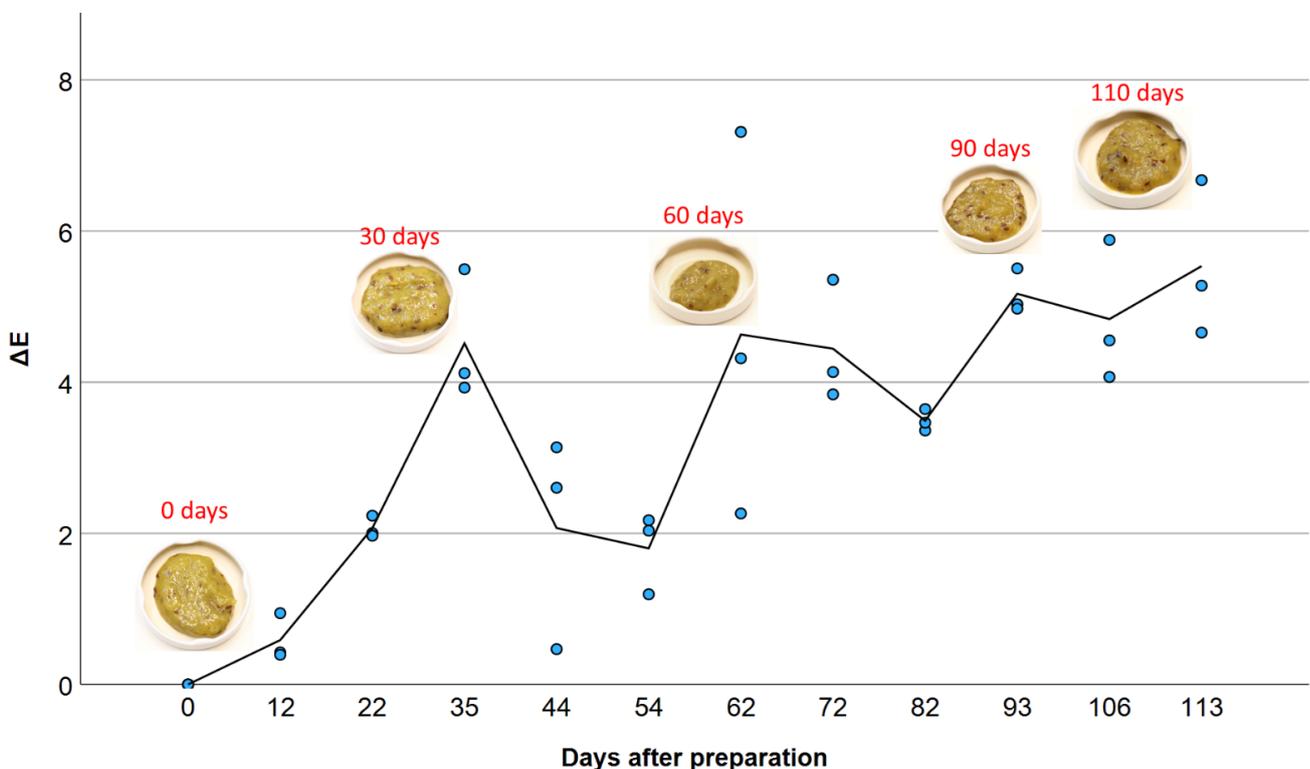


Fig. 2: Total colour difference (ΔE) between the fruit spread immediately after preparation (0 days) and the ones stored at room temperature in the dark over 110 days.

spread without pectin, whose only ingredients, therefore, were hardy kiwifruits and saccharose.

Processing was carried out 1 kg of puree at a time, heated in a steel saucepan placed on an induction plate and stirred continuously with a steel whisk. Using an airtight thermistor thermometer (HI 93510, Hanna Instruments, Ronchi di Villafranca Padovana, Italy), the temperature of the preparation was monitored throughout the procedure. Once 40 °C was reached, for the fruit spread with pectin, an aliquot of sugar was added to the puree, while, once 65 °C was reached, the remaining sugar mixed with pectin was added slowly while shaking vigorously. Once the product reached 90 °C, it was transferred hot into 30 g glass jars which were then pasteurised at 85 °C for 3 min at the core. For the recipe without pectin, sugar was added as soon as the preparation reached 40 °C, with the further steps being the same as those for the first recipe. Samples intended for tasting were stored under refrigerated conditions (4 °C) until tasting, while those to be used for shelf-life analyses were stored at room temperature, in the dark. Only preserve without pectin was used for colour analyses and sensory testing.

Tab. 1: Demographic information of the 37 participants taking part in the tasting of the fruit spreads.

Age (years)	Number of participants
<18	1
18-35	19
36-50	12
>50	5
Gender	Number of participants
Male	20
Female	16
Other	1
Jam consumption frequency	Number of participants
< Once/week	6
Once/week	11
> Once/week	9
Every day	11

COLORIMETRIC MEASUREMENT

For the colorimetric analyses, a portable colorimeter (Chroma Meter CR-400, Konica Minolta, Tokyo, Japan) was used, and the colour was measured in the CieLab space using the parameters L*, a*, b*. Analyses were carried out on the fruit spreads without pectin (both immediately after preparation and during storage) by dipping the head of the colorimeter for a few mm into the sample taken about halfway through the jar after stirring its content. Measurements were made in triplicate (one per jar) on three jars. The colour change of the fruit spread over time was monitored by collecting colour measurements approximately every 10 days from the date of production.

SENSORY ANALYSIS

After storage at 4 °C for 5 days, the 30 g glass jars containing the fruit spreads without pectin were given to consumers to take home. The informal tasting was performed as a home-use test, as the conditions were not controlled, and aimed at gaining some data in order to determine how to further develop the product. The questionnaire was filled out between 5 and 80 days from the date on which the fruit spreads were prepared.

It was therefore not possible to control the storage conditions during this period.

The questionnaire was conducted using Compusense® and was accessible via a QR-code. The participants were asked to rate the sweetness and density of the fruit spreads using a 1 to 5 JAR scale, where the middle (3) corresponded to “Just about right”, while the lower end points corresponded to “Not sweet enough / not dense enough” (1) and the higher end points (5) to “Much too sweet / much too dense” for sweetness and density, respectively. For the analysis of the JAR scale data, a penalty analysis was performed in order to determine the impact of a single attribute (sweetness or density) on the overall liking of the product. Furthermore, participants were asked to rate the product regarding its aspect, flavour, texture and overall using a 1 to 9 hedonic scale, where 1 corresponded to “Dislike extremely”, 5 to “Neither like nor dislike” and 9 to “Like extremely”, respectively. The demographics of the 37 participants were profiled and are reported in Table 1.

DATA ELABORATION

Figures were generated using Microsoft Excel, Microsoft PowerPoint (Microsoft Office 2016) and SPSS (IBM SPSS Statistics 27). Sensory analysis data were acquired using Compusense® software.

RESULTS AND DISCUSSION

PRODUCTION OF THE HARDY KIWIFRUIT SPREAD

As described in materials and methods, two recipes were developed, one with and one without pectin. During the preparation of the fruit spread with pectin an excessive viscosity was immediately observed. This was probably related to the fact that the peel of hardy kiwis itself contributes to the puree having a viscous consistency. For this reason, it was decided to produce the fruit spread without pectin for further sensory and colorimetric analyses. This alternative recipe resulted in a product with a texture similar to that

of common jams or fruit spreads based on a preliminary visual evaluation during its production. To assess the acceptability of the texture among consumers, the product was tasted in order to determine whether a re-adjustment of the recipe was needed to improve its texture. Although the recipe could be further modulated in order to reach the desired sweetness, texture and taste, the fact that the peel of hardy kiwis positively contributes to the pleasant texture of the fruit spread gives the advantage of not needing to add pectin to improve its consistency. Undoubtedly, a more in-depth study, such as a rheological analysis of the fruit spread in comparison with a commercial product, would objectively support the experimental data empirically observed in this preliminary study.

COLOUR CHANGE ASSESSMENT

Since the fruit spread with pectin had already been excluded based on a rapid evaluation of its consistency, only the preparation without pectin was considered for the colour evaluation.

The relevance of colour for kiwifruit jams or spreads is related to the sensitivity of this type of fruit to thermal processing (including pasteurisation) which determines enzymatic and non-enzymatic browning: these phenomena are possibly due to the thermal degradation of chlorophylls and are accelerated by the release of intracellular acids and enzymes, which come into contact with chlorophyll-protein complexes, causing discolouration [23] [24]. Additionally, their high content of phenolics can lead to browning and development of strong astringency after processing into juices [25]. Though no specific studies on *A. arguta* were found, it is supposed that similar issues to those reported in other kiwifruits could be faced when processing hardy kiwifruits into preserves.

For all these reasons, colour was considered as a quality reference parameter for fruit spreads and measured over a period of 110 days (approx. 3 and a half months). Colorimetric measurements were carried out in the CIELab space, within which colour is expressed by the combination of three coordinates,

indicating brightness (L^*), red to green variation (a^*) and yellow to blue variation (b^*). Furthermore, the total colour difference, expressed as ΔE , was calculated and plotted against time (Fig. 2).

A colour variation was noted over the experimental period, as corroborated by the increasing values of ΔE over time, showing a tendency to browning of the fruit spread. The colour of the spreads underwent rapid change within the initial 30 days. Subsequently, the values remained relatively stable until day 90 of the experiment, at which point another increase became apparent. Considering that a ΔE up to the value of 3 is only slightly perceptible to the naked eye [26], the preserves showed excellent stability up to 90 days, resulting in ΔE of around 4. Between 90 and 110 days the ΔE value increased up to a maximum of 5.5, which, in theory, is a difference visible to the naked eye, however, further investigations should be conducted, via targeted sensory evaluation, to establish whether this change is still considered to be acceptable by consumers. The colour change observed in this study was

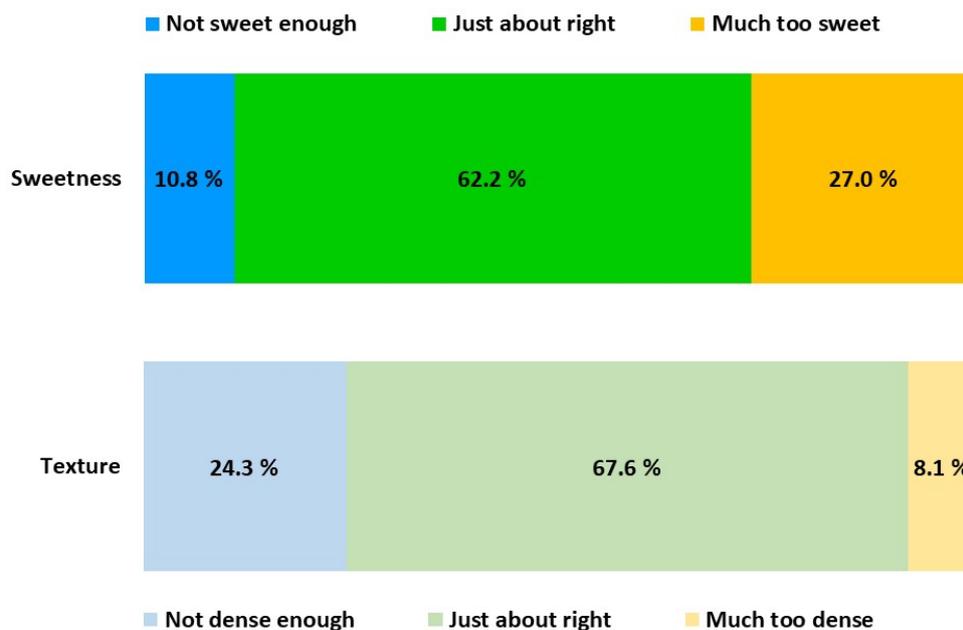


Fig. 3: Just-about-right (JAR) profile of sweetness and density of hardy kiwifruit spread. In each segment, the percentage of participants who gave the corresponding answer is indicated.

much lower than that found in other fruit derivatives, such as strawberry preserves [22]. The processing techniques and instrumentation used, and storage conditions tested in the previous study were similar to those of the present one. This indicates that hardy kiwifruits lend themselves very well to processing in comparison with other fruits and enable the preparation of spreads with a colour that tends to remain stable over time, with only slight variations naturally occurring as no antioxidant or stabilising agent is added.

TASTING RESULTS

The participants were asked to rate the sweetness and density of the fruit spread using a 1 to 5 just-about-right scale. The percentages corresponding to the fractions of the participants that found the product to be not sweet/dense enough (blue/pale blue, respectively), just about right (green/pale green for sweetness and density, respectively) and much too sweet/dense (orange/pale orange, respectively) are shown in Figure 3.

Most of the participants found the

fruit spread to be appropriate both in terms of sweetness and density (62.2 and 67.2%, respectively). Still, it was important to understand whether the rating of one of these attributes as non-ideal (ratings different from just about right) affected the overall liking score for the product for these participants. A penalty analysis was therefore performed to highlight the non-ideal features of the product that caused a drop in overall liking rating of more than 1 point on the 1 to 9 hedonic scale and that were relevant for more than 20% of the participants. Such an analysis can in fact highlight critical points of the product that have to be addressed during product development. Results showed that no attribute had such an effect on a relevant portion of the population (over 20%), with the fruit spreads having a suitable sweetness and density and requiring no further tailoring in the future for these two aspects (data not shown). Participants were also asked to rate how much they liked the product (for aspect, flavour, texture and overall liking) on a 1 to 9 hedonic scale. The results are shown in Figure 4).

The mean for all attributes is well above the average, being close to 7 (“Moderately like”) for flavour, texture and overall liking. The attribute showing the lowest mean score and the highest variability is the aspect, which is close to 6 (“Like slightly”). This might be due to the green colour of the fruit spreads, which is not a common colour for jams and is often associated with a sour taste due to a colour-taste synaesthesia process [27]. The scores obtained by the other attributes underline how the product, with particular regard to its flavour and texture, outperforms its not particularly appealing aspect.

It is important to consider that the above-mentioned tasting was performed mainly to obtain an idea of the acceptability of the product, in particular regarding its sweetness and texture, and further experiments are needed to develop and test one or more final fruit spread recipes. In particular, it will be important to perform a consumer test under controlled conditions, with the sample evaluated at the same time by all participants. Furthermore, data on the acceptability of the prod-

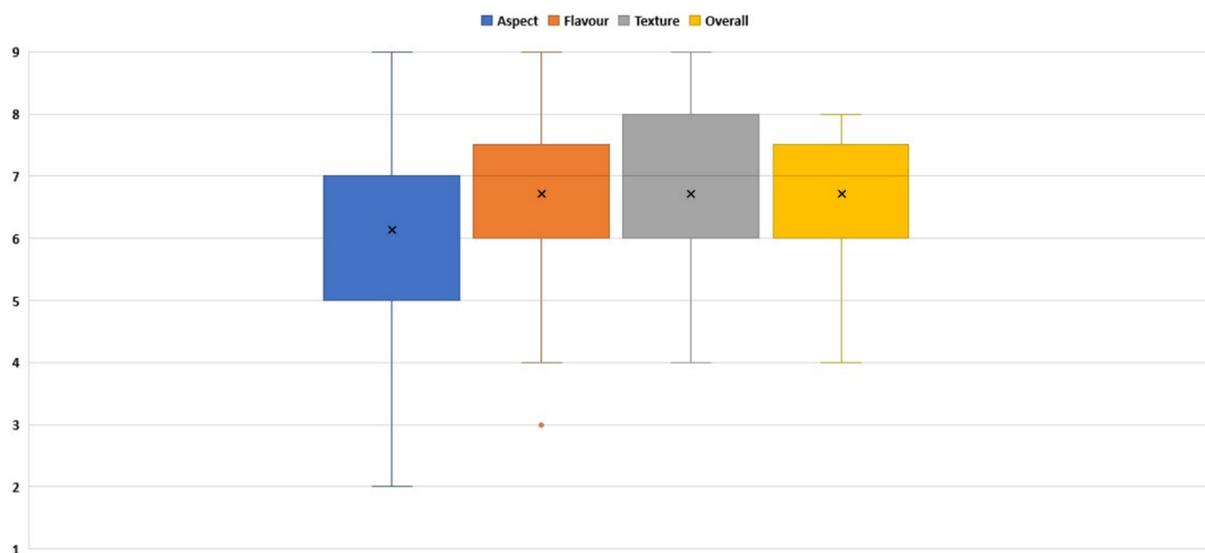


Fig. 4: Acceptance scores for aspect, flavour, texture and overall liking on a 1 to 9 hedonic scale for the fruit spread analysed. Means for each category are indicated with an X.

ucts' colour at different time points after preparation will be needed in order to determine the sensorial shelf-life of the fruit spread.

Overall, the fruit spread presented here seemed to be liked by the consumers. In particular, the sweetness and density appear to be appropriate for the product, making hardy kiwis a promising fruit for producing fruit preserves.

CONCLUSIONS

Based on this preliminary study concerning the suitability of hardy kiwifruit for processing, it was observed that this fruit crop may represent a new resource for the production of niche, innovative and

healthy food products. Indeed, their soft and edible peel can be processed thus minimising waste and making it possible to avoid adding pectin in order to obtain a fruit spread with a pleasant consistency, as confirmed by a preliminary non-standardised consumer test. Sensory data also indicated that the overall acceptability of the product was good, as well as its sweetness and flavour. Even without adding antioxidants or colour stabilisers, the browning of the fruit spreads occurred much more slowly than that observed in previous studies under similar conditions on strawberries. This was surprising, since generally green products tend to have problems with colour stability due to

chemical reactions that occur during storage. This work has provided an initial insight into a new product and lays the groundwork for further in-depth studies and expansion of the topic. The results are indeed promising and, based on technological aspects and sensory evaluations, hardy kiwifruit appears to be a promising crop for canning.

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ZUSAMMENFASSUNG

Die Mini-Kiwi stellt eine unerforschte landwirtschaftliche Ressource für Südtirol dar, die für die Region von besonderem Interesse sein könnte, da sie einen Beitrag zur landwirtschaftlichen Biodiversität und zur Aufwertung von Nischenkulturen in diesem Gebiet leistet. Die größte Einschränkung dieser Kultur ist die kurze Haltbarkeit der Früchte, die mit ihrer leichten Verderblichkeit zusammenhängt. Die Verarbeitung von Mini-Kiwis zu Konserven kann eine sinnvolle Strategie sein, um die Produktion und die Verbreitung dieser Kultur im gesamten Gebiet zu fördern, so dass Produkte aus der Frucht das ganze Jahr über erhältlich sind. In dieser Studie wurde die Eignung von Mini-Kiwis für die Verarbeitung zu Fruchtaufstrichen untersucht. Die Ergebnisse lassen darauf schließen, dass kein Pektin zugesetzt werden muss, um einen Fruchtaufstrich mit geeigneter Konsistenz zu produzieren. Zudem zeigte sich, dass die Bräunung im Laufe der Zeit langsam erfolgt, obwohl die Fruchtaufstriche nicht mit Antioxidantien stabilisiert wurden, was darauf hindeutet, dass die Haltbarkeit eines solchen Aufstrichs recht lang sein könnte. Eine vorläufige sensorische Bewertung ergab, dass der Fruchtaufstrich von den Verbrauchern hinsichtlich ihrer Textur, ihrer Süße und ihres Geschmacks geschätzt wurde und aus organoleptischer Sicht eine positive Gesamtbewertung erhielt, was auf ein Potenzial dieser Frucht für die Herstellung von Fruchtaufstrichen hindeutet.

RIASSUNTO

I baby kiwi rappresentano una risorsa agricola inesplorata per l'Alto Adige che potrebbe essere di particolare interesse per la regione, contribuendo alla biodiversità agricola e alla valorizzazione delle colture minori dell'area. Il limite principale di questa coltura è la sua breve conservabilità come materia prima, dovuta all'intrinseca deperibilità di tale prodotto. La trasformazione dei baby kiwi in conserve può essere una valida strategia per incentivare la produzione e la diffusione di questa coltura sul territorio, che consentirebbe di avere disponibilità di prodotti alimentari a base di questo frutto durante tutto l'anno. In questo studio è stata valutata l'idoneità dei baby kiwi alla trasformazione in composte. I risultati indicano che non è necessario aggiungere pectina per ottenere una consistenza gradevole della composta e che l'imbrunimento nel tempo è un processo che avviene lentamente, nonostante la conserva non sia stata stabilizzata con agenti antiossidanti, indicando che la shelf-life di tale conserva potrebbe essere piuttosto lunga. Infine, da una valutazione sensoriale preliminare, la conserva è stata apprezzata dai consumatori per quanto riguarda la consistenza, la dolcezza e il sapore e ha ottenuto una valutazione complessiva positiva dal punto di vista organolettico. Ciò suggerisce che questa coltura agricola ha un potenziale per la preparazione di composte di frutta.

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